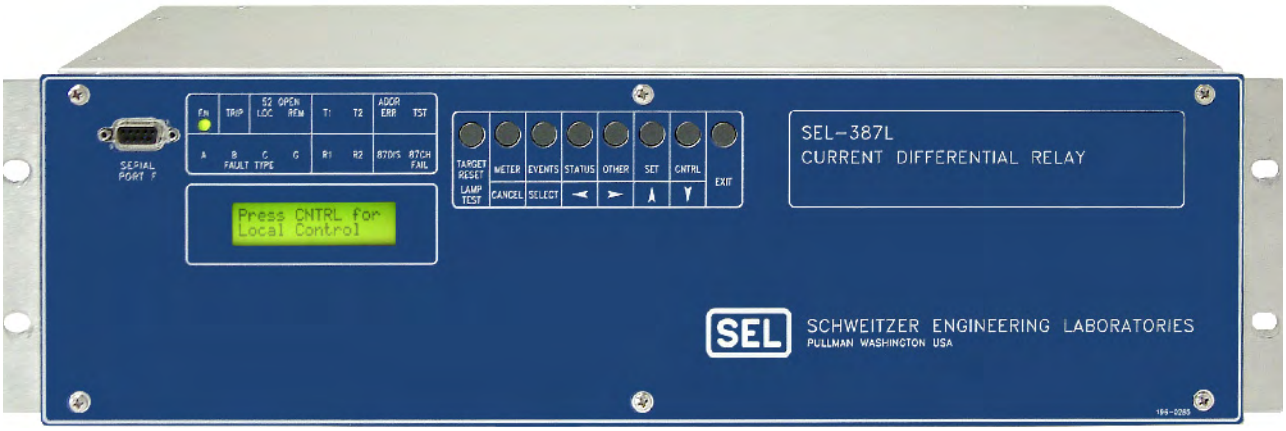
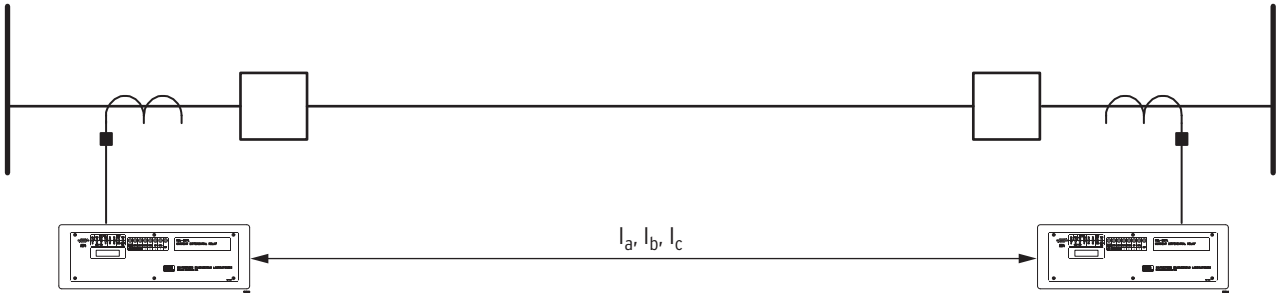
SEL-387L Line Current Differential Relay

Zero Settings Relay



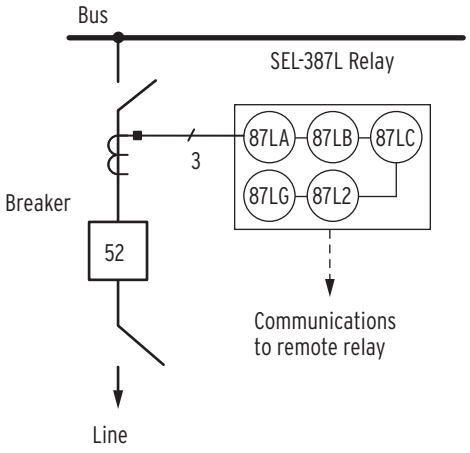
Install the relay, select the communication addresses, and the SEL-387L is ready to protect transmission lines and cables of any voltage.



Major Features and Benefits

- **Zero Settings.** Proven differential protection requires no settings for complete phase and ground fault protection.
- **Fast.** Subcycle operation for severe faults with security for CT saturation.
- **Sensitive.** Negative- and zero-sequence differential elements detect high-resistance ground faults while remaining secure for external faults.
- **Secure.** Alpha plane restraint principle provides security for CT saturation and channel asymmetry.
- **Complete.** Select models with direct fiber interface or IEEE C37.94 synchronous optical interface. Channel monitoring provides measurement of communication quality and prevents misoperation due to channel failure.

Functional Overview



- Proven Phase, Negative-, and Zero-Sequence Differential Protection
- One Fiber-Optic Communications Channel
- Complete Communications Channel Monitoring and Reporting
- Preconfigured Contact I/O
- Comprehensive Metering
- ACSELERATOR® SEL-5030 Software
- Event Reports With Oscillography
- Sequential Events Recorder
- DNP3 Level 2 Slave Protocol*

* optional

Figure 1 Functional Diagram

Application Examples

Simple Two-Terminal Line Protection

Connect the current transformers and the preprogrammed TRIP contacts, select the channel transmit and receive address, and the SEL-387L is ready to protect virtually any two-terminal transmission line. In this configuration, the relay detects internal high resistance ground faults as great as 133 ohms secondary (5 A relay, nominal voltage 66.4 V secondary) and trips for most bolted faults in less than one cycle.

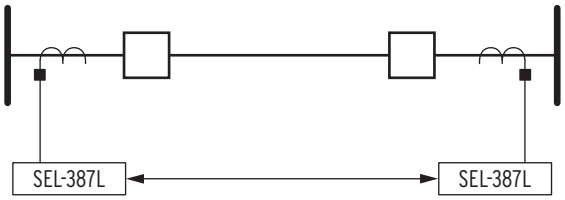


Figure 2 Simple Two-Terminal Differential Protection

Advanced Two-Terminal Line Protection

Connect the SEL-387L to the SEL-311L Relay for more challenging applications and to accommodate unequal current transformer ratios as shown in *Figure 3*. This connection is also useful for applications with an industrial owned substation at one end of a line. All settings are made at the SEL-311L. The SEL-387L acts as a remote data acquisition terminal for the SEL-311L, which protects the line and sends a high-speed transfer trip signal to the SEL-387L with less than one-half-cycle tripping delay. Make required settings adjustments in the SEL-311L. The overall protection scheme inherits the SEL-311L settings.

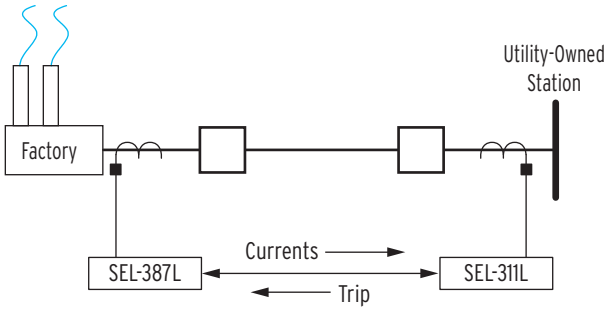


Figure 3 SEL-387L/SEL-311L Provide More Application Flexibility

The SEL-387L and the SEL-311L work together to simplify and secure industrial feeder and cogeneration intertie protection. You set and control the SEL-311L, and it performs all line protection, so you know protection is not compromised by settings errors in the remote SEL-387L (patent pending).

Multiplexed Communications Channel

Use the SEL-387L for secure differential protection with multiplexed communications. With no settings, the relay accommodates channel asymmetry and communication delays without compromising security or dependability.

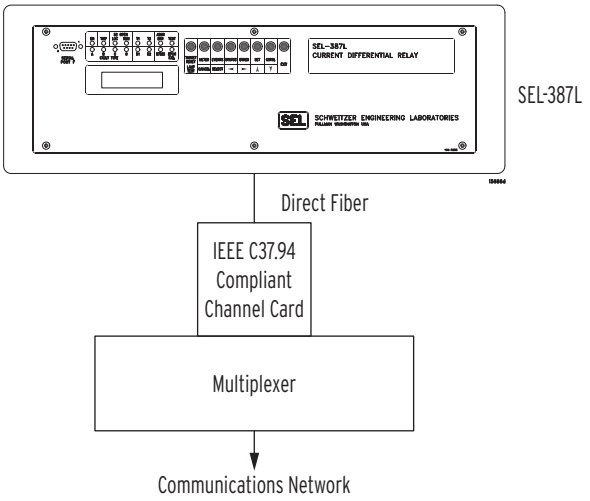


Figure 4 Connect the SEL-387L Directly to Any Multiplexer System That Incorporates an IEEE C37.94 Compliant Channel Card

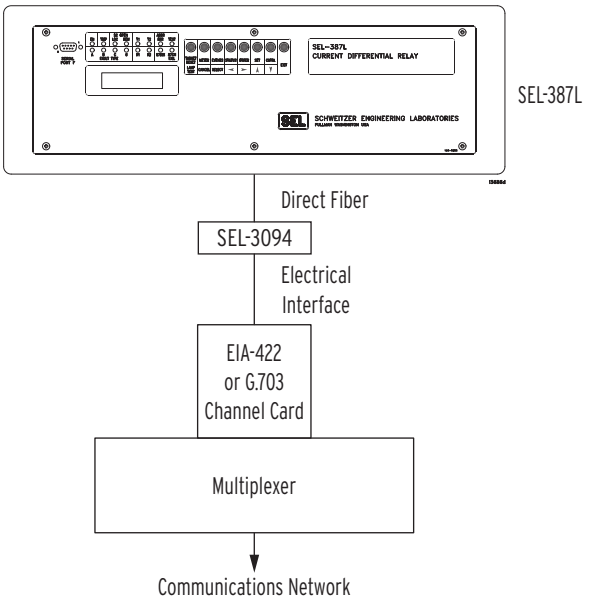


Figure 5 Use the SEL-3094 Protocol Converter to Connect the SEL-387L to Multiplexers Using EIA-422 or G.703 Input Channel Cards

Three-Terminal Line Protection

Protect three-terminal lines using two SEL-387L relays and one SEL-311L (*Figure 6*). No settings are needed for SEL-387L relays. They detect a transmitted bit from the SEL-311L and switch to a "follower" mode with the SEL-311L as the "leader." The SEL-311L performs all the measurements and sends a transfer trip signal to the two SEL-387L relays.

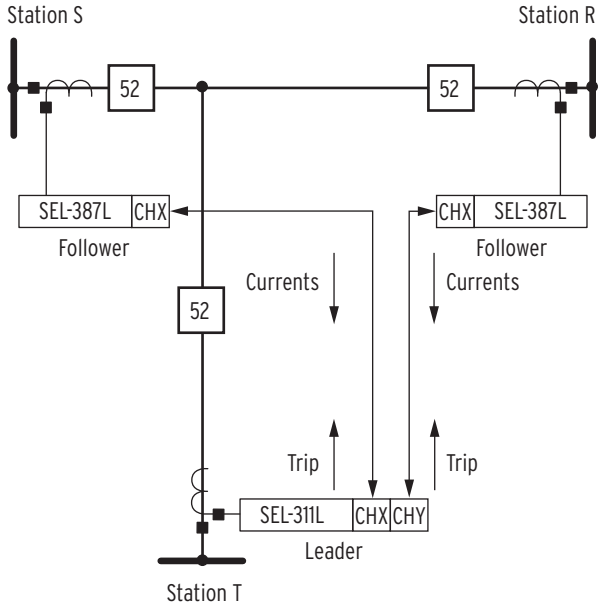


Figure 6 Use Two SEL-387L Relay and One SEL-311L Relays for Three-Terminal Line Protection

While the SEL-387L is simple to use, it is also flexible. Preprogrammed **TRIP** and **CLOSE** inputs allow safe, simple local breaker control through latching **TRIP** and **CLOSE** outputs. Further simplify the dc system connections by eliminating trip and close seal-in relays. The high-speed **TRIP** and **CLOSE** contacts used in the SEL-387L safely interrupt trip and close current up to 10 A.

Two secure, high-speed transfer contacts and several serial communications protocols allow remote control operations, or remote contact status indication. Assert input **T1** or **T2** in the local SEL-387L and output **R1** or **R2** closes less than 10 ms later in the remote relay. The transfer contacts are secure enough for direct tripping and closing operations per IEC-60834-1. *Figure 7* shows the contact I/O available on the SEL-387L rear panel.

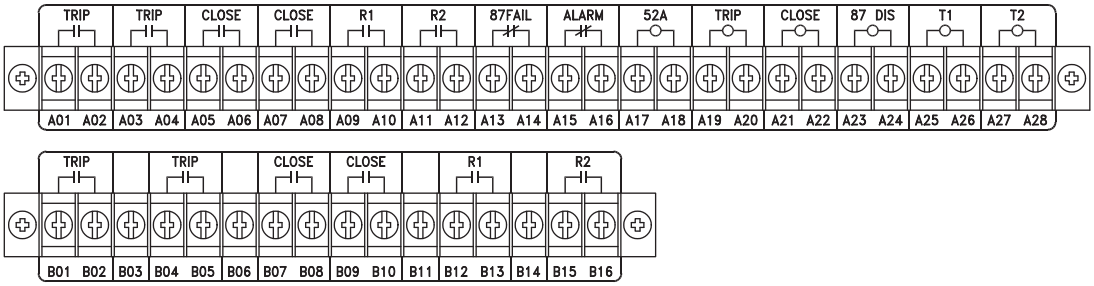


Figure 7 SEL-387L Contact I/O

Protection Features

The SEL-387L employs sensitive and secure unbalance elements, 87L2 and 87LG, to detect high-resistance ground faults that produce more than 10 percent I_{NOM} difference current. *Figure 8* shows the ground fault resistance coverage as a function of load current for a 5 A nominal relay. To ensure that the unbalance elements do not operate on charging current unbalance during external ground faults on longer lines and cables, select equal CT ratios at both line terminals so line charging current is less than 10 percent of I_{NOM}.

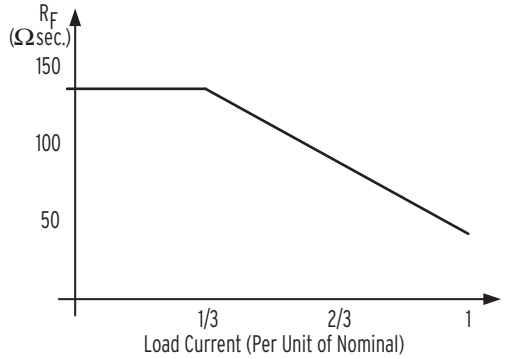


Figure 8 Ground Fault Sensitivity

Fast, secure phase elements, 87LA, 87LB, and 87LC, detect bolted phase faults that produce more than $1.2 \bullet I_{NOM}$ of difference current. *Figure 9* shows the operate time, including high-speed outputs, for a 5 A nominal relay.

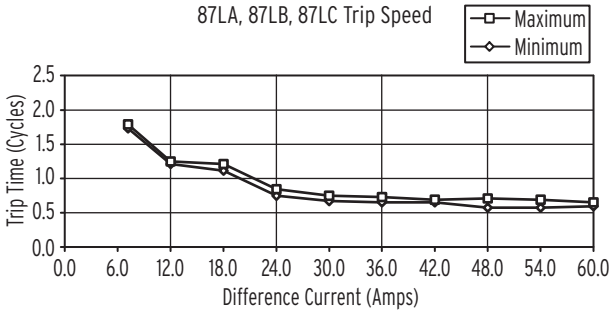


Figure 9 Current Differential Element Trip Times

Line Current Differential Communications

The SEL-387L is available with the following fiber-optic current differential communications interfaces:

- IEEE C37.94 compliant multimode fiber-optic interface
- 1300 nm multimode or single-mode interface
- 1550 nm single-mode fiber-optic interface

The IEEE C37.94 compliant multimode fiber-optic interface is included at no extra charge. This interface connects directly between the relay and any compliant multiplexer with no wires and no confusing timing or clock edge settings.

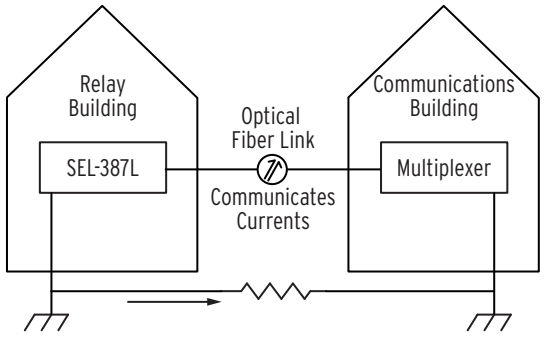


Figure 10 IEEE C37.94

Use fiber optics between the relay and multiplexer to prevent communication errors, equipment damage, and hazardous conditions due to ground potential rise, as shown in *Figure 10*.

Use the SEL-3094 to convert the relay fiber interface into a standard electrical interface to connect to multiplexers that do not support the IEEE C37.94 standard.

Choose the 1300 nm multimode or single-mode interface for direct fiber applications up to 80 km. The 1550 nm single-mode fiber-optic interface supports direct fiber connections up to 120 km.

The relay continuously monitors communications for correct data transmission and channel delay. Channel quality reports, shown in *Figure 11*, include short- and long-term unavailability, and round trip channel delay. Use this information to accurately assess protection and communications system reliability and make appropriate changes for maximum system reliability.

```
=>>COMM X L <Enter>
SEL-387L Date: 2003/05/26  Time: 09:27:03.269
EXAMPLE: BUS B, BREAKER 3
FID=SEL-387L-R100-V0-Z001001-D20030625       CID=BAFD
Summary for 87L Channel X
Channel Status Alarms
    ROKX = 1    DBADX = 0    RBADX = 0    AVAX = 0
For 2003/05/24 13:37:01.631 to 2003/05/26 09:27:04.248
COMMUNICATION LOG SUMMARY        COMMUNICATION STATISTICS
    # of Error records  29          Last error          Data Error
    Data Error          20          Longest failure           4.685 sec.
    Dropout              9          Lost Packets, prev. 24 hours      407
    Test Mode Entered    0          One Way Delay (Ping-Pong)   0.4 msec.
Error                  Recovery
#   Date       Time          Date       Time          Duration  Cause
  1 2003/05/26 09:23:54.041  2003/05/26 09:23:54.042     0.001  Data Error
  2 2003/05/26 09:23:53.888  2003/05/26 09:23:54.040     0.152  Dropout Error
  3 2003/05/26 09:23:53.885  2003/05/26 09:23:53.888     0.003  Data Error
  4 2003/05/26 09:23:53.882  2003/05/26 09:23:53.885     0.003  Dropout Error
  .
  .
  .
 27 2003/05/24 13:37:04.688  2003/05/24 13:37:04.689     0.001  Data Error
 28 2003/05/24 13:37:00.003  2003/05/24 13:37:04.688     4.685  Dropout Error
 29 2003/05/24 13:37:00.000  2003/05/24 13:37:00.003     0.003  Data Error

=>>
```

Figure 11 COMM Command Report

The communications monitor reports performance of the 87L channel. Review this report to optimize communications.

Automation

Control and Integration Features

The SEL-387L is fully compatible with the entire family of SEL communications processors. Use the SEL-2032, SEL-2030, and SEL-2020 Communications Processors to automatically retrieve, store, and parse reports from the SEL-387L. The communications processor also time synchronizes all of the connected relays and allows password protected engineering access to the relays from a dedicated or dial-up connection, or over the enterprise LAN via the SEL-2701 Ethernet Processor. All of these functions are supported simultaneously over a single connection to each relay (see *Figure 12*).

Serial Communications

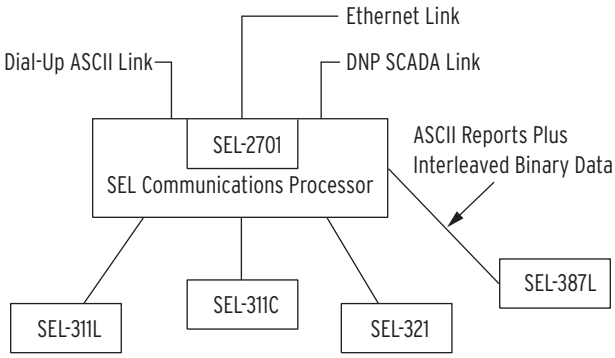


Figure 12 Example Communication System

SEL-387L integration capabilities include:

- Three EIA-232 serial ports and one isolated EIA-485 serial port.
- Full access to event history, relay status, and meter information from the serial ports.
- DNP3 Level 2 protocol with point mapping (optional).
- Open communications protocols including Simple ASCII, Compressed ASCII, Extended Fast Meter, Fast Operate, and Fast SER.

Monitoring, Metering, and Event Reporting

The relay provides accurate and extensive metering including:

- Local, remote, and difference currents: $I_{A, B, C}$, I_1, $3I_2$, $3I_0$
- Power system frequency
- DC battery voltage

Use the current differential meter to verify line charging current. Compare local and remote currents to detect CT connection errors at any terminal.

Forty event reports store 10 seconds of oscillographic data. Each event report contains 15 cycles (4-cycle prefault, 11-cycle postfault) of local, remote, and difference currents for all three phases, battery voltage, and system frequency at 16 samples per cycle, as well as every logic point in the relay (the entire Relay Word). A Sequential Events Recorder stores 512 of the most recent time-tagged transitions of over 30 key logic points. All 40 event records and 512 sequential events records are retained even if power is removed from the relay.

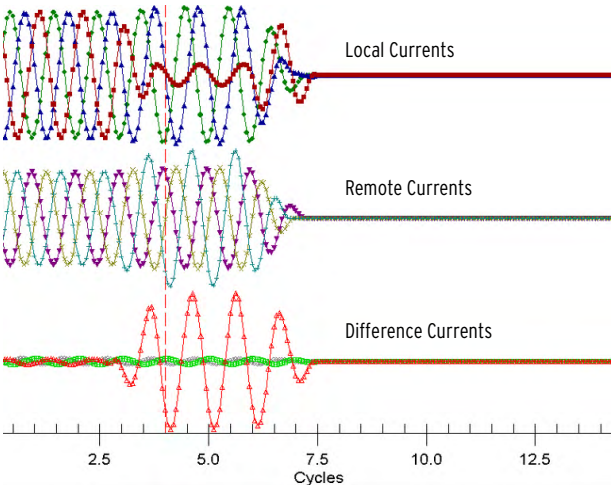


Figure 13 SEL-387L Oscillography via ACSELERATOR QuickSet

Oscillographic event records and sequential events records help you understand and reconstruct complex system disturbances. All of these advanced features are supported by ACSELERATOR QuickSet® SEL-5030 Software (see *Figure 13*). The features and the software are included with the SEL-387L at no additional cost.

Front-Panel User Interface

Figure 15 shows a close-up view of the user interface portion of the SEL-387L front panel. It includes a two-line, 16-character LCD, 16 LED status and target indicators, and eight pushbuttons for local access. *Table 1* explains the front-panel LEDs.

The LCD shows event, metering, and relay self-test status information. The LCD is controlled by the pushbuttons and automatic messages the relay generates. The default display scrolls through key system parameters including local and remote A-, B-, and C-phase currents, breaker status, and 87 communications channel status. The relay displays two lines of text every five seconds as shown in *Figure 14*.

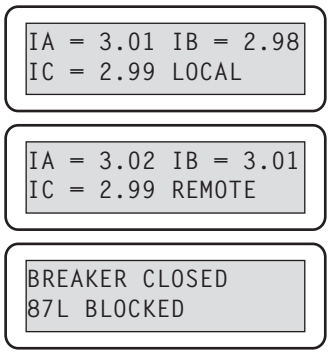


Figure 14 SEL-387L Default Front-Panel Display

Table 1 Description of Target LEDs

Target LED	Function
EN	Relay powered properly and self-tests okay
TRIP	Indication that a trip occurred
52 OPEN	
LOC	Local breaker open
REM	Remote breaker open
T1, T2	Transfer contact inputs T1 or T2 are energized
ADDR ERR	Current differential receive address error
TEST	Current differential test mode enabled
FAULT TYPE	
A, B, C	Phase(s) involved in fault
G	Ground involved in fault
R1, R2	Transfer contact outputs R1 or R2 are energized
87DIS	Current differential protection disabled
87CH FAIL	Current differential channel problem

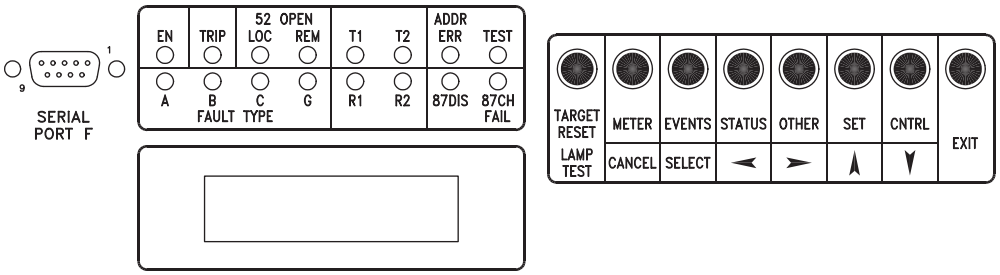


Figure 15 Status and Trip Target LEDs, Front-Panel Display, and Pushbuttons

Wiring Diagram

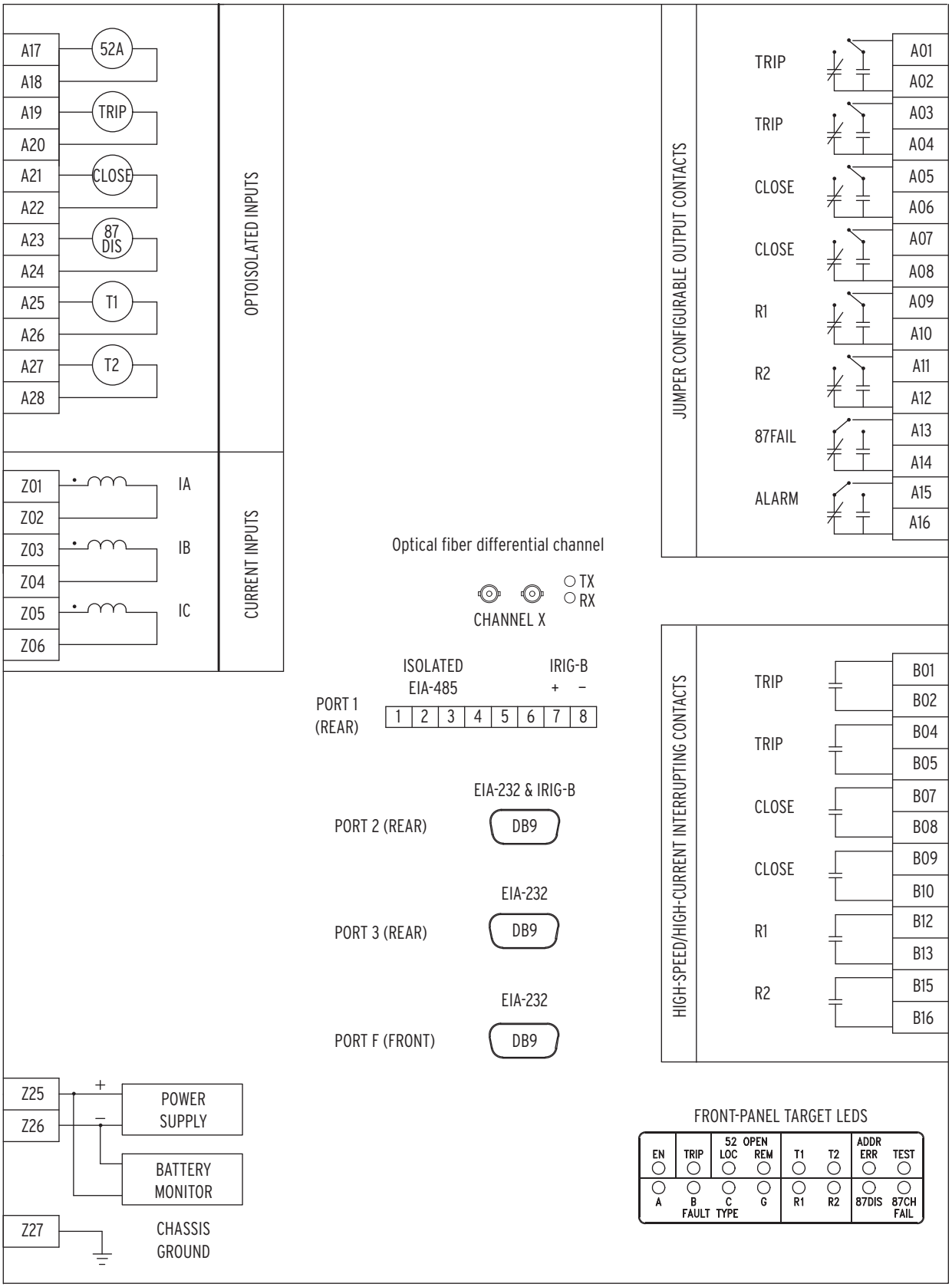
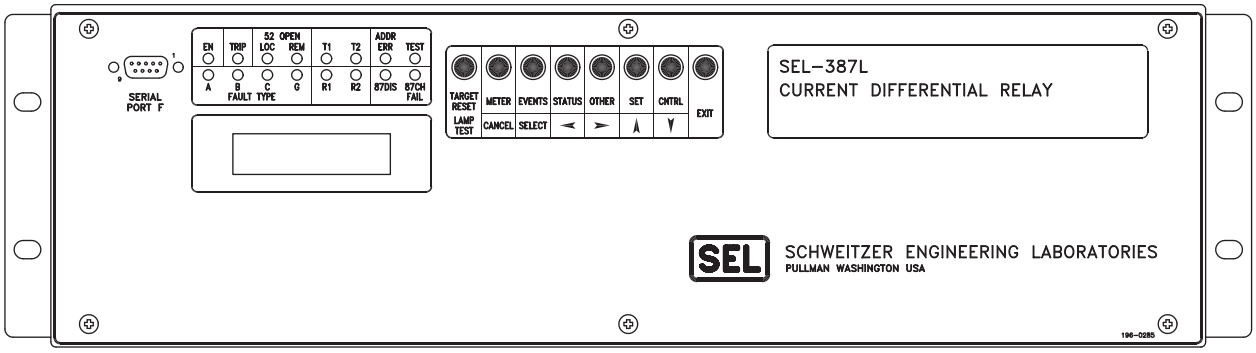


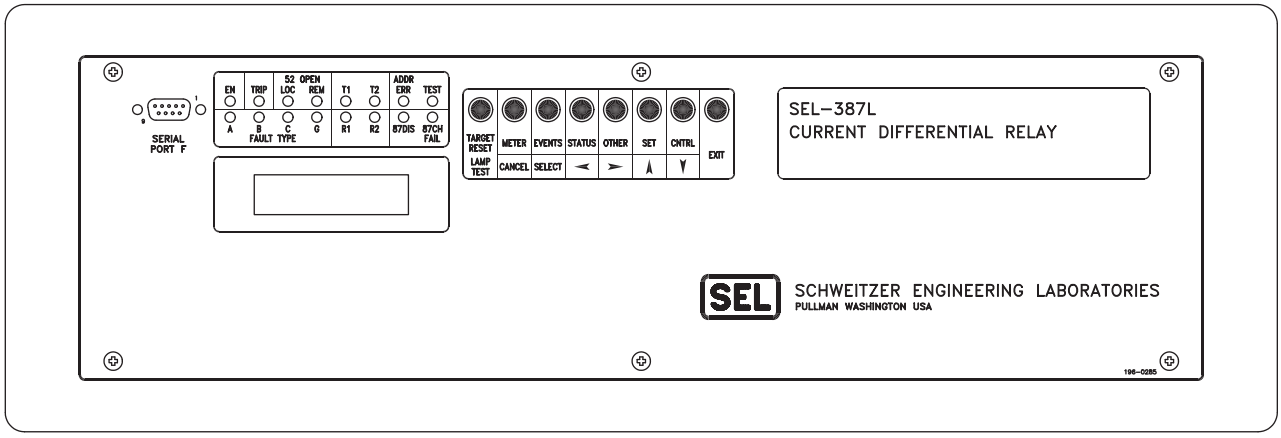
Figure 16 SEL-387L Inputs, Outputs, and Communications Ports

Mechanical Diagrams



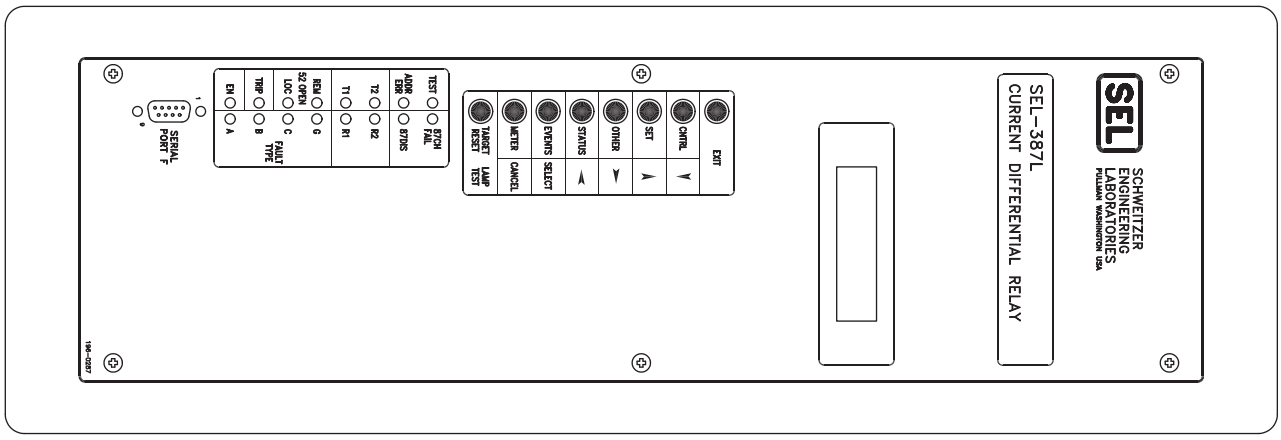
I3668d

Rack-Mount Front Panel



I3686d

Panel-Mount Front Panel



I3687d

Panel-Mount Vertical Front Panel

Figure 17 SEL-387L Front-Panel Diagrams

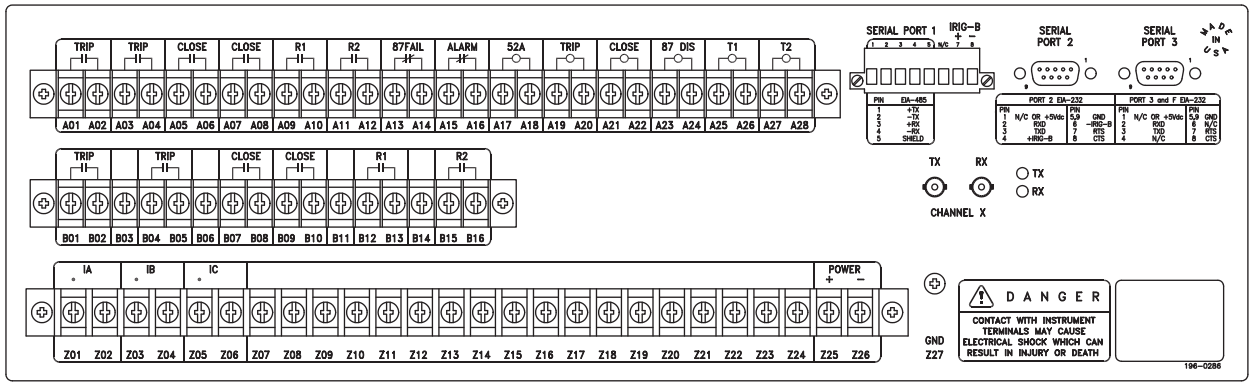


Figure 18 SEL-387L Rear-Panel Diagram

Relay Dimensions

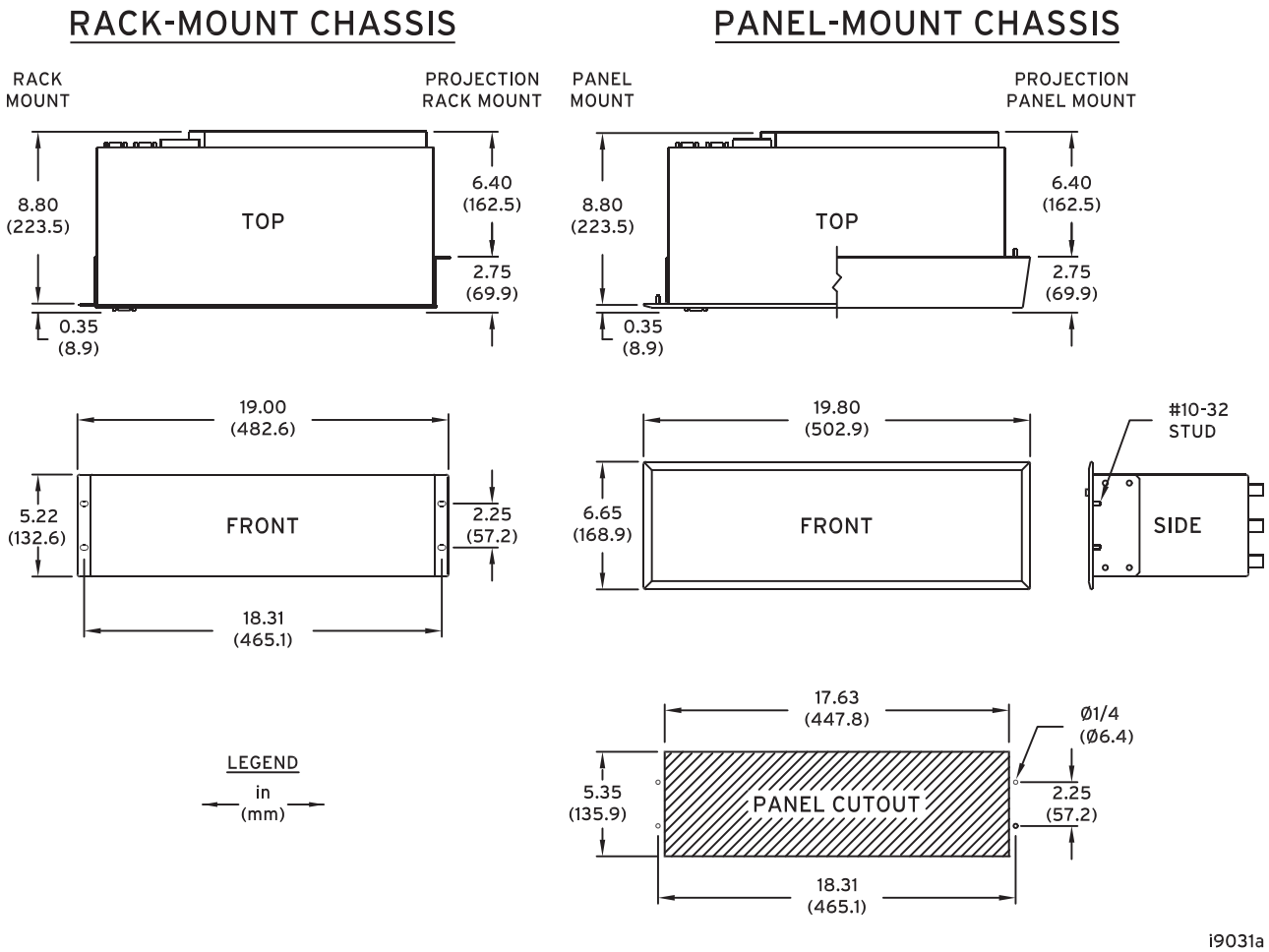


Figure 19 SEL-387L Dimensions for Rack- and Panel-Mount Models
(Horizontal mounting shown; dimensions also apply to vertical mounting.)

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
Class 1 Laser Product

General

AC Current Inputs

5 A nominal:	15 A continuous; linear to 100 A symmetrical
	500 A for 1 second
	1250 A for 1 cycle
Burden:	0.27 VA @ 5 A
	2.51 VA @ 15 A
1 A nominal:	3 A continuous; linear to 20 A symmetrical
	100 A for 1 second
	250 A for 1 cycle
Burden:	0.13 VA @ 1 A
	1.31 VA @ 3 A

Power Supply

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Rated:	48/125 Vdc or 125 Vac
Range:	38–140 Vdc or 85–140 Vac
Rated:	24/48 Vdc
Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Output Contacts

Standard

Make:	30 A
Carry:	6 A continuous @ 70°C; 4 A continuous @ 85°C
1 s Rating:	50 A
MOV Protected:	270 Vac, 360 Vdc, 40 J
Pickup Time:	<5 ms

Breaking Capacity (10,000 operations):

48 V	0.5 A	L/R = 40 ms
125 V	0.3 A	L/R = 40 ms
250 V	0.2 A	L/R = 40 ms

Cyclic Capacity (2.5 cycles/second):

48 V	0.5 A	L/R = 40 ms
125 V	0.3 A	L/R = 40 ms
250 V	0.2 A	L/R = 40 ms

High-Speed High-Current Interruption

Make:	30 A
Carry:	6 A continuous @ 70°C; 4 A continuous @ 85°C
1 s Rating:	50 A
MOV Protected:	330 Vdc, 130 J
Pickup Time:	<10 µs
Dropout Time:	<8 ms, typical

Breaking Capacity (10,000 operations):

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 interruptions/second, followed by 2 minutes idle for thermal dissipation):

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

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Optoisolated Input Ratings

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 15–30 Vdc

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

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC (interchange two phases on both relays for ACB rotation)
Frequency Tracking Range:	40.1–65 Hz

Serial Communications Ports

Port 1:	EIA-485
Baud rate:	9600 without DNP3 300–19200 with DNP3
Port 2–3:	EIA-232
Baud rate:	19200 without DNP3 300–38400 with DNP3
Port 4 (Front Port):	EIA-232
Baud rate:	9600 without DNP3 300–38400 with DNP3

Differential Communications Ports

Fiber Optics—ST connector

1550 nm single mode direct fiber
1300 nm multimode or single mode

Tx Power:	–18 dBm
Rx Min. Sensitivity:	–58 dBm
System Gain:	40 dB

850 nm multimode, C37.94 (for connection to a digital multiplexer or for direct connection to an SEL-311L, but not for direct connection to another SEL-387L)

	50 µm	**62.5 µm**
Tx Power:	–23 dBm	–19 dBm
Rx Min. Sensitivity:	–32 dBm	–32 dBm
System Gain:	9 dB	13 dB

Electrical: Use the SEL-3094 for EIA-422 or CCITT G.703 synchronous interfaces to multiplexers.

Metering Accuracy

Currents I_A, I_B, I_C

Local

5 A nominal: ±0.05 A secondary

1 A nominal: ±0.01 A secondary

Remote: ±3%

Total: ±3%

Currents 3I2, 3I0, I1

Local and Remote

5 A nominal: ±0.05 A secondary and ±5%

1 A nominal: ±0.01 A secondary and ±5%

Total: ±3%

Substation Battery Voltage Monitor

Range: 20–300 Vdc

Accuracy: ±2%, ±2 Vdc

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1 or 2.

Relay time is synchronized to within ±5 ms of time source input.

Current differential protection does not require external time source.

Terminal Connections

Rear Screw-Terminal Tightening Torque:

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.

Operating Temperature Range

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20°C.

Relay Weight

7.24 kg (16 lbs)

Type Tests

Electromagnetic Compatibility Immunity

Electrostatic Discharge: IEC 60255-22-2:1996, IEC 61000-4-2, IEEE C37.90.3 Severity Level 4 (8000 V contact, 15,000 V air)

Fast Transient Disturbance: IEC 60255-22-4:1992; IEC 61000-4-4:1995, 4 kV @ 2.5 kHz (4000 V on power supply, 2000 V on inputs and outputs)

Radiated Radio Frequency: IEC 60255-22-3:1989, 10 V/m; IEEE C37.90.2, 35 V/m; IEC 61000-4-3, 10 V/m

Surge Withstand: IEEE C37.90.1-1989, 3000 V oscillatory, 5000 V transient
IEEE C37.90.1-2002, 2500 V oscillatory, 4000 V fast transient

1 MHz Burst Disturbance: IEC 60255-22-1:1988, Severity Level 3 (2500 V common and 1000 V differential mode)

Environmental

Cold: IEC 60068-2-1:1990, Test Ad; 16 hr. @ –40°C

Dry Heat: IEC 60068-2-2:1974, Test Bd; 16 hr. @ +85°C

Damp Heat, Cyclic: IEC 60068-2-30:1980, Test Db; 55°C, 6 cycles, 95% humidity

Object Penetration: IEC 60529:1989, IP30

Sinusoidal Vibration: IEC 60255-21-1:1988 Vibration Endurance, Class 1 Vibration Response, Class 2

Shock and Bump: IEC 60255-21-2:1988 Bump Test, Class 1 Shock Withstand, Class 1 Shock Response, Class 2

Seismic: IEC 60255-21-3:1993, Class 2

Safety

Dielectric Strength: IEC 60255-5:1977; IEEE C37.90-1989 2500 Vac (rms) for 1 minute on analog inputs, optoisolated inputs, and output contacts; 3100 Vdc for 1 minute on power supply.

Impulse: IEC 60255-5:1977, 0.5 J, 5000 V

Laser Safety: IEC 60825-1:1993; 21 CFR 1040.10; ANSI Z136.1-1993; ANSI Z136.2-1988, eye-safe Class 1 laser product

Relay Element Accuracies

Line Current Differential (87L) Elements

Phase, Negative-Sequence, and Zero-Sequence Accuracy: ±3% ±0.01 I_{NOM}

Restraint Characteristic Accuracy: ±5% of 6
±3° of 195°

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