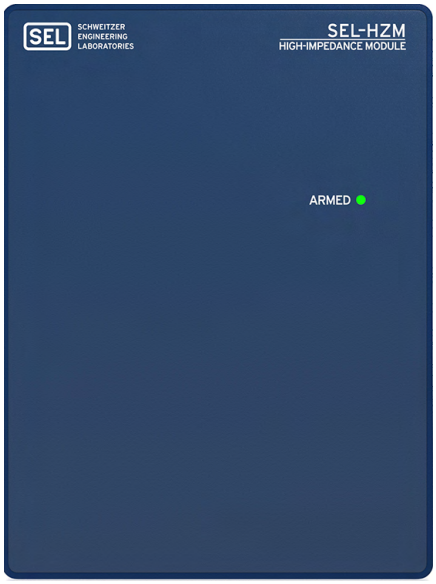
SEL-787Z High-Impedance Differential Relay

Comprehensive Protection and Monitoring for High-Impedance Differential Applications

Five-Inch, Color Touchscreen Display, Panel-Mount SEL-787Z Relay Model



Panel Mount SEL-HZM High-Impedance Module

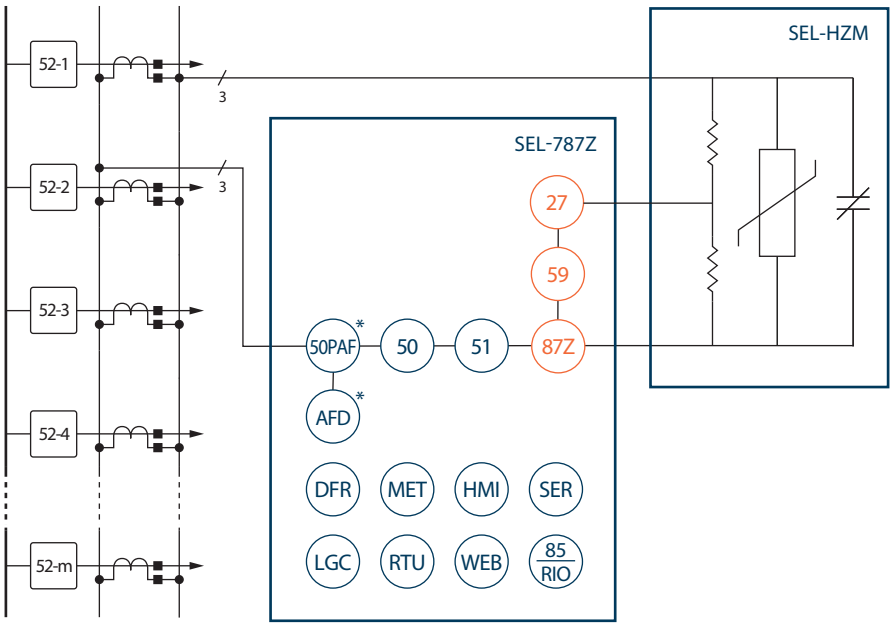
Major Features and Benefits

The SEL-787Z relay is a flexible high-impedance differential relay designed primarily for high-impedance bus protection. The relay is also suitable for restricted earth fault (REF) applications on transformers with grounded-wye windings. Use the independent overcurrent elements to complement the high-impedance differential elements.

- **Protection.** Use the high-impedance differential elements for fast tripping for in-zone faults while providing security during heavy through faults and CT saturation. Use high-impedance equations to calculate the voltage-based differential element settings.
- **Optional SEL-HZM.** The SEL-HZM includes the stabilizing resistors, the metal-oxide varistors (MOVs), and the optional 86 bypass relay to simplify the high-impedance differential protection scheme. The SEL-HZM may be ordered prewired to the SEL-787Z or as a standalone unit to be integrated into existing installations.
- **Reporting, Monitoring, and Metering.** Simplify fault analysis with event reports and the Sequential Events Recorder (SER). Use a low-set voltage differential element as a CT open-circuit detection function. Validate CT connections using the metered differential quantities.

- **Automation, Integration, and Communications.** Use the front- and rear-panel communication ports for system integration, relay settings, and event report retrieval. Modbus RTU, SEL ASCII, and SEL Fast Message protocols are included as standard features of the relay. Use front-panel pushbuttons to save the expense of separately mounted control switches. Use serial port communications for remote control of the circuit breaker or other programmable functions.
- **Relay and Logic Settings Software.** ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. The built-in HMI and control applications provide intuitive displays that support commissioning and troubleshooting.
- **Additional Standard Features.** Improve your bus protection with these additional standard features in every SEL-787Z: Modbus RTU, Event Messenger support, MIRRORED BITS® communications, IRIG-B input, and advanced SELOGIC equations.
- **Optional Communications Protocols.** Optional communications protocols include IEC 61850 Edition 2, Modbus TCP/IP, Simple Network Time Protocol (SNTP), IEEE 1588-2008 firmware-based Precision Time Protocol (PTP), EtherNet/IP, DNP3 LAN/WAN, DNP3 serial, IEC 60870-5-103, Rapid Spanning Tree Protocol (RSTP), and Parallel Redundancy Protocol (PRP).
- **Integrated Web Server.** With an Ethernet equipped relay, use the integrated web server to view settings and metering and monitoring data, download reports, and upgrade firmware.
- **Optional Communications Ports.** Elective communications ports include EIA-232 or EIA-485 multimode fiber-optic serial port and single or dual, copper or fiber-optic Ethernet ports.
- **Optional I/O Cards.** Digital and analog I/O options include 4 AI/4 AO, 4 DI/4 DO, 8 DI, 8 DO, 8 AI, 3 DI/4 DO/1 AO, 4 DI/3 DO, and 14 DI.
- **Supported Languages.** Choose English or Spanish for your serial ports, including the front-panel serial port. The standard relay front-panel overlay is in English. A Spanish overlay is available as an ordering option.
- **Mounting Options.** The SEL-787Z and SEL-HZM can be ordered with a panel, rack, or surface mounting option. For the panel-mount option, the two units are shipped separately without the wiring harness. The rack-mount option provides a complete assembly of two units together with the wiring harness installed. The surface-mount option offers the flexibility to mount the SEL-HZM inside a panel.

Functional Overview



ANSI Functions	
27	Definite-time undervoltage
50	Overcurrent
50PAF	Arc-flash overcurrent*
51	Time-overcurrent
59	Definite-time overvoltage
87Z	High-impedance differential

* Optional feature

Additional Functions	
85RIO	SEL MIRRORED BITS communications
AFD	Arc-flash detection*
DFR	Event reports
HMI	Human-machine interface
LGC	SELOGIC control equations
MET	High-accuracy metering
RTU	Remote terminal unit
SER	Sequential Events Recorder
WEB	Web server

* Optional feature

Figure 1 Functional Diagram

Protection Features

Differential Protection

Differential protection is one of the most economical and reliable protection principles available for buses, transformers, and reactors. CT saturation is the most critical design consideration.

Figure 2 shows a through fault with the direction of current flow in Feeders 1–4 towards the busbar. The sum of the fault current from Feeders 1–4 flows through the CT on Feeder 5, which can result in CT5 saturating.

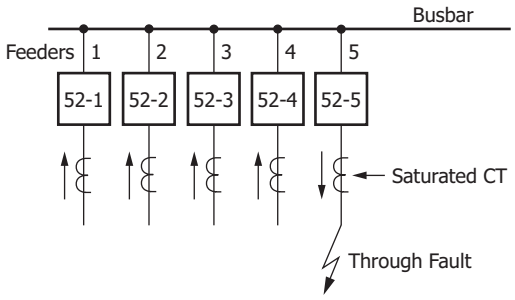


Figure 2 CT Saturation Resulting From a Through Fault

High-impedance differential protection offers immunity against relay misoperation that is the result of CT saturation, provided the stabilizing resistor has a sufficiently high value. To comply with this requirement, the SEL-787Z uses 2000-Ω resistors that are large enough to provide security against CT saturation for through faults. Use the optional 500- and 1000-Ω stabilizing resistor variants to provide high-impedance differential protection using other relays such as the SEL-751A or SEL-751.

Under fault conditions, large currents generate large voltages across stabilizing resistors, and this is detrimental to the insulation and extremely hazardous to personnel. The MOV connected in parallel with the stabilizing resistors clamps the voltage to less than 850 V. *Figure 3* shows the resultant voltage across the MOV during a bus fault.

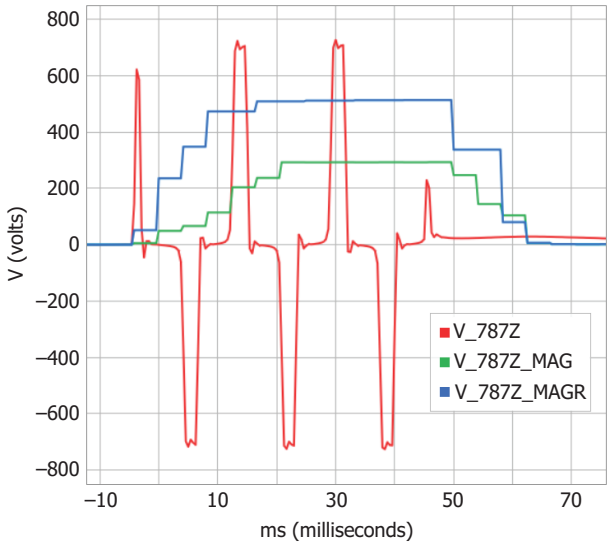


Figure 3 Voltage With MOV Clamping

The stabilizing resistors, combined with MOVs and the optional bypass relay, form the high-impedance input circuit of each phase. For the best performance, select current transformers with fully distributed windings and identical ratio and saturation characteristics.

Bus Protection

Bus protection requires a balance between security and dependability. In a single-zone application, the busbar is the common connection point of all the feeders in the substation. An incorrect bus protection operation affects all the feeders connected to that zone that, at smaller substations, affects each and every customer. The failure of bus protection to operate affects even more customers because remote protection at adjacent stations must clear the fault. In addition, high-impedance transformer grounding practices limit the ground fault current, necessitating sensitive, phase-segregated protection elements.

However, while the ground-fault current is limited, the phase-to-phase current can still be very high, which can result in CT saturation for through faults.

The SEL-787Z provides high-impedance differential elements that work on different operating quantities. For each phase, there are two elements operating on fundamental voltages, two elements operating on raw voltages, two elements operating on fundamental currents, and two elements operating on raw currents. For each operating quantity, there are two levels of protection. Level 1 differential elements can be used for bus protection, and Level 2 elements can be used for alarms.

Transformer Protection

The high-impedance elements are ideal for sensitive REF protection on transformers with grounded-wye windings. If both the HV and LV windings are wye-connected and grounded, use two high-impedance elements, one on each side of the transformer. REF protection is not affected by unbalanced load and very seldom by CT saturation for through faults. REF protection guards against only phase-to-ground faults. To protect against phase-to-phase faults and external phase-to-ground bushing faults, combine the high-impedance elements with instantaneous and time-overcurrent elements. For complete transformer protection that includes percentage differential elements, use the SEL-787-2, -3, -4 or SEL-387 relay with the SEL-787Z.

Backup Overcurrent Protection

The SEL-787Z includes phase and neutral overcurrent elements. Each element type has four levels of instantaneous protection with individual torque control and definite-time delay settings. Each element can operate on fundamental or raw magnitudes of current. The SEL-787Z features one level of inverse-time element for individual phase overcurrent protection and two levels of inverse-time elements for maximum phase and neutral overcurrent protection.

When you use the SEL-787Z for transformer protection, the instantaneous overcurrent elements provide phase and neutral overcurrent protection for bushing faults, while the time-overcurrent elements provide phase and neutral protection for coordination with other system protection.

Under- and Overvoltage Protection

The SEL-787Z provides two levels of undervoltage (27) and two levels of overvoltage (59) elements. The operating quantity of each element can be either fundamental phasor magnitude or raw magnitude.

Arc-Flash Protection

An arcing short circuit or a ground fault in low- or medium-voltage switchgear can cause serious equipment damage and personnel injury, which can result in prolonged and expensive downtime.

The best way to minimize the impact of an arc-flash event is to reduce the detection and circuit breaker tripping time. Conventional protection may need several cycles to detect the resulting overcurrent fault and trip the breaker. In some cases, there may not be sufficient current to detect an overcurrent fault. Tripping may be delayed by hundreds of milliseconds for sensitivity and selectivity reasons in some applications.

The arc-flash detection-based protection can act on the circuit breaker in a few milliseconds (2–5 ms). This fast response can limit the arc-flash energy, thus preventing injury to personnel and limiting or eliminating equipment damage.

The arc-flash protection option in the SEL-787Z adds eight fiber-optic AFD inputs and protection elements. Each channel has a fiber-optic receiver and an LED-sourced fiber-optic transmitter that continuously self-tests and monitors the optical circuit to detect and alarm for any malfunction. There are two types of applications supported by the SEL-787Z: point sensor applications and fiber sensor applications.

Point Sensor Application

The arc is detected by transmitting the arc-flash light captured by the optical diffuser (located appropriately in the switchgear) over a 1000 µm plastic fiber-optic cable to the optical detector in the relay. The relay performs sensor loopback tests on the optical system using an LED-based transmitter to transmit light pulses at regular intervals to the point-sensor assembly (through a second fiber-optic cable). If the relay optical receiver does not detect this light, the relay declares a malfunction and alarms. *Figure 4* (top) shows a diagram for the point sensor application.

Fiber Sensor Application

Fiber sensor AFD uses a clear-jacketed 1000-µm plastic fiber-optic cable located in the switchgear equipment. One end of the fiber is connected to the optical detector in the relay and the other end is connected to the LED transmitter in the relay. The LED transmitter injects periodic light pulses into the fiber as a sensor loopback test to verify the integrity of the loop. The relay detects and alarms for any malfunction. *Figure 4* (bottom) shows a diagram of the clear-jacketed fiber sensor application.

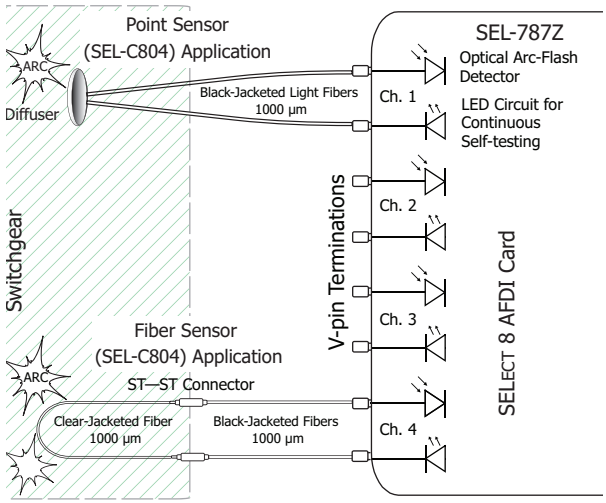


Figure 4 SEL-787Z Arc-Flash Detection System

The SEL-787Z AFD system provides eight channels per relay that can be configured for point sensor or fiber sensor applications. The optional fast hybrid outputs (high-speed and high-current) of the relay provide fast-acting trip outputs to the circuit breaker (less than 50 µs). The fast breaker tripping can prevent serious damage or personnel injury in case of an arc-flash event. The relay also provides light metering and light event capture to aid in setting the relay and capturing the arc-flash event for records and analysis.

Settable arc-flash phase and neutral overcurrent elements are combined with arc-flash light detection elements to provide secure, reliable, and fast acting arc-flash event protection.

Operator Controls

Operator controls eliminate traditional panel control switches. Eight conveniently sized operator controls, each with two programmable tricolor LEDs, are located on the relay front panel (see *Figure 5*). You can set the SER to track operator controls. Use SELOGIC control equations to change operator control functions. Use configurable labels to change all the text shown in *Figure 5*.

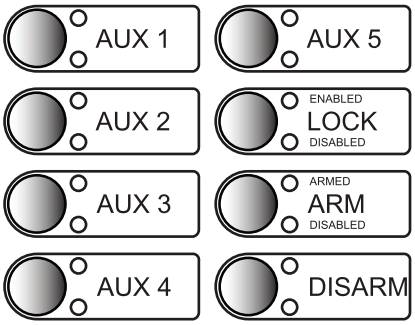


Figure 5 Operator Control Pushbuttons and LEDs

The following operator control descriptions are for the factory-set logic.

LOCK: The **LOCK** operator control blocks selected functions. Press it for at least three seconds to engage or disengage the lock function. When the **LOCK** pushbutton is engaged, the **ARM** and **DISARM** operators are blocked.

ARM and **DISARM**: Use the **ARM** and **DISARM** operator controls to close and open the 86 bypass relay contacts, if the SEL-HZM is equipped with a bypass relay.

AUX x: You can program the **AUX x** (x = 1, 2, 3, 4, or 5) pushbuttons for additional control of your specific application.

In the SEL-787Z with the touchscreen display, you can use the front-panel operator control pushbuttons to jump to a specific screen while also using them for LOCK/ARM/DISARM operations, etc. You can program the selectable operator pushbutton screen settings under the Touchscreen settings category in QuickSet to map the button to the specific screen.

Built-In Web Server

Every Ethernet-equipped SEL-787Z includes a built-in web server. Interface with the relay by using any standard web browser to perform the following actions:

- Log in with password protection.
- Safely read the relay settings.
- Verify the relay self-test status and view the relay configuration.
- Inspect meter reports.
- Download SER and event reports.
- Upload new firmware (firmware upgrade).

Figure 6 shows the fundamental metering screen that can be accessed by clicking **Meter > Fundamental**. Use the Meter menu to view all the available relay metering statistics.

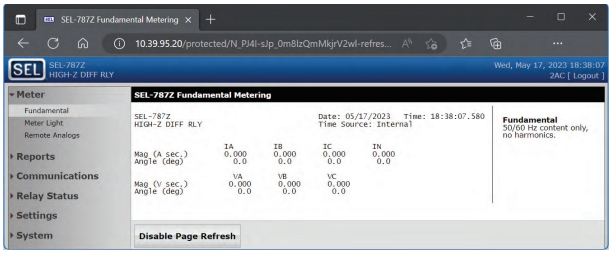


Figure 6 Fundamental Meter Report Webpage

Figure 7 shows the Group 1 settings webpage. You can view the settings of each relay settings class by selecting **Settings** and the respective relay settings class.

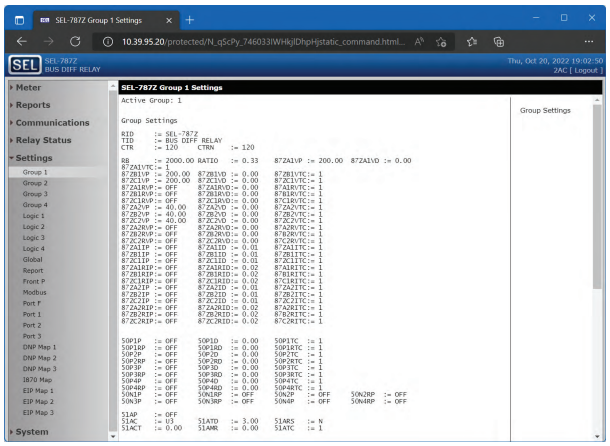


Figure 7 Group 1 Settings Webpage

You can upgrade the relay firmware through the relay web server by clicking **System > File Management** (available at Access Level 2) and selecting the firmware upgrade file. *Figure 8* shows the firmware upgrade webpage.

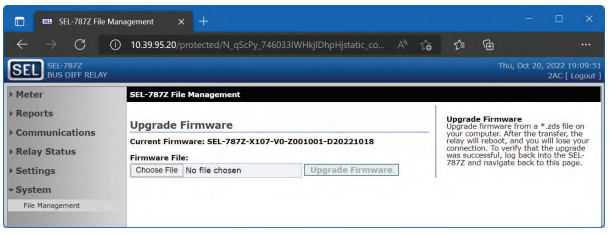


Figure 8 Upgrade the Relay Firmware From the File Management Webpage

Relay and Logic Settings Software

QuickSet simplifies settings and provides analytical support for the SEL-787Z. There are several ways to create and manage relay settings with QuickSet.

- Develop settings offline with an intelligent settings editor that only allows valid settings.
- Create SELOGIC control equations with a drag-and-drop text editor.
- Configure proper settings using online help.
- Organize settings with the relay database manager.
- Load and retrieve settings using a simple PC communications link.

With QuickSet, you can verify settings and analyze power system events with the integrated waveform and harmonic analysis tools.

Use the following features of QuickSet to monitor, commission, and test the SEL-787Z.

- Use the HMI to monitor meter data, Relay Word bits, and output contact statuses during testing.
- Use the PC interface to remotely retrieve power system data.
- Use the Event Report Analysis tool for easy retrieval and visualization of ac waveforms and digital inputs and outputs the relay processes.
- Use bay control to design new bay screens and edit existing bay screens by launching ACSELERATOR Bay Screen Builder SEL-5036 Software for SEL-787Z relays with the touchscreen display.

ACSELERATOR Bay Screen Builder SEL-5036 Software

The SEL-787Z with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. You can display the bay configuration as a single-line diagram (SLD) on the touchscreen. You can use ANSI and IEC symbols, along with analog and digital labels, for the SLD to indicate the status of the breaker and disconnects. In addition to SLDs, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. You can design these screens with the help of Bay Screen Builder in conjunction with QuickSet. Bay Screen Builder provides an intuitive and powerful interface to design bay screens to meet your application needs.

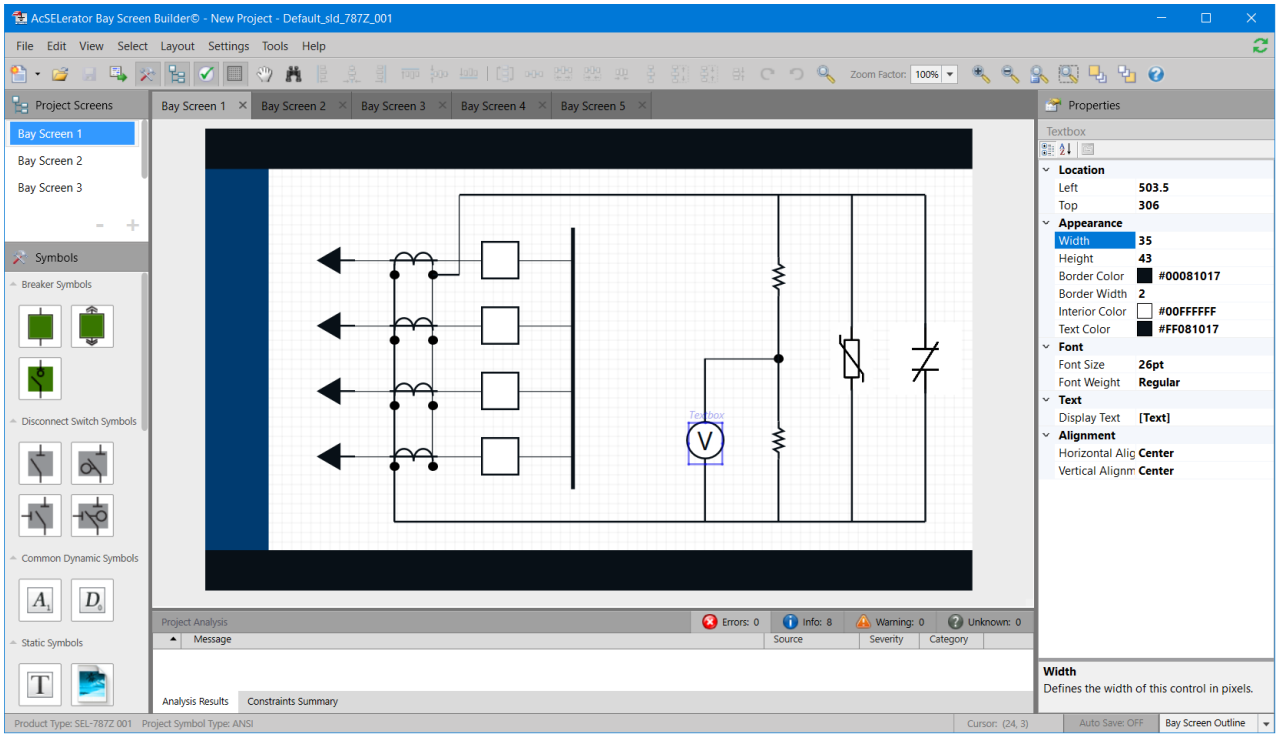


Figure 9 Bay Screen Builder

Monitoring and Metering

The SEL-787Z includes metering functions to display the present values of currents, voltages, and other analog inputs. As shown in *Table 1*, metered quantities include phase voltages and currents, light intensity, analog inputs, math variables, and remote analogs. The relay reports all metered quantities in secondary quantities (current in A secondary and voltage in V secondary).

Table 1 SEL-787Z Metered Values (Model Dependent)

Types of Metering		
Fundamental	Math variables	Analog transducer input
Light	Remote analog	

Quantities	Description
Currents IA, IB, IC	Phase current magnitude and angle, secondary A
IN	Neutral current magnitude and angle, secondary A
Voltages VA, VB, VC	Phase voltage and angles, secondary V
Light Intensity (%) LS1–LS8	Arc-flash light inputs in percentage of full scale
AI*x*01–AI*x*08 (*x* = 3, 4, or 5)	Analog inputs
MV01–MV32	Math variables
RA001–RA128	Remote analogs

Improve Situational Awareness

The SEL-787Z provides improved information to system operators. Use event reports and SERs to analyze the cause of relay operations and quickly restore the protected equipment to service. Synchronized measurement helps to time align systemic events and IEC 61850 Test mode allows you to test an in-service relay.

Event Reporting and SER

Event reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user-selected trigger, the voltage, current, frequency, and 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 (e.g., 1/4-, 1/40-, or 1/48-cycle resolution, filtered or unfiltered analog data, respectively).

The relay stores as many as 6 of the most recent 180-cycle event reports, 17 of the most recent 64-cycle event reports, or 39 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings to the bottom of each event report.

The following analog data formats are available:

- 1/4-, 1/40-, or 1/48-cycle resolution, filtered or unfiltered analog, ASCII or Compressed ASCII reports
- 1/40- or 1/48-cycle resolution COMTRADE reports

The relay SER feature stores the latest 1,024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences and element pickup/dropout.

Synchronized Measurements

The IRIG-B time-code input synchronizes the SEL-787Z internal clock time to within ±1 µs of the time-source input. Convenient sources for this time code are an SEL-2401 Satellite-Synchronized Clock, an SEL communications processor, or an SEL RTAC (via Serial Port 2 or 3 on the SEL-787Z). For time accuracy specifications for metering and events, see *Specifications*.

IEC 61850 Test Mode

Test Mode includes five different modes.

On: In On mode, the relay operates as normal; it reports IEC 61850 Mode/Behavior status as On and processes all inputs and outputs as normal. If the quality of the subscribed GOOSE messages satisfies the GOOSE processing, the relay processes the received GOOSE messages as valid.

Blocked: This mode is similar to On mode, except that the device does not trip any physical contact outputs.

Test: In Test mode, the relay processes valid incoming test signals and normal messages and operates physical contact outputs, if the outputs are triggered.

Test/Blocked: This is similar to Test mode, except that the device does not trip any physical contact outputs.

Off: The device does not process any incoming data or control commands (except commands to change the mode). All protection logic is disabled and all data quality is marked as invalid.

Simulation Mode

In this mode, the relay continues to process normal GOOSE messages until a simulated GOOSE message is received for a subscription. Once a simulated GOOSE message is received, only simulated GOOSE messages are processed for that subscription. The simulated mode only terminates when LPHDSIM is returned to FALSE. When the relay is not in simulation mode, only normal GOOSE messages are processed for all subscriptions.

Touchscreen Display

You can order the SEL-787Z with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-787Z features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

You can navigate the touchscreen by tapping the folders and applications. The folders and applications of the Home screen are shown in *Figure 10*. Folders and applications are labeled according to functionality. Additional folder and application screens for the SEL-787Z touchscreen display option can be seen in *Figure 11* through *Figure 18*.

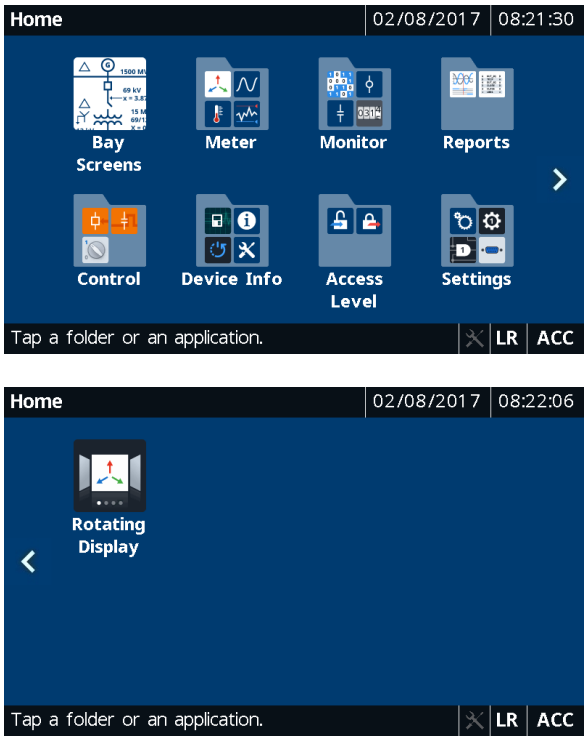


Figure 10 Home

Bay Screens Application

The SEL-787Z with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as an SLD on the touchscreen. You can create as many as five bay screens with one controllable breaker, eight controllable two-position disconnects, and two controllable three-position disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed SLDs of the bay to indicate the status of the breaker and disconnects. *Figure 11* shows the default SLD for the touchscreen display option.

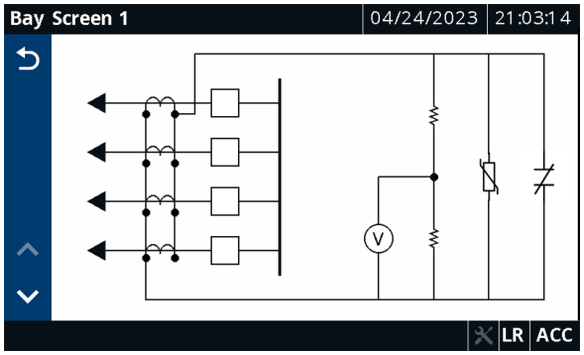


Figure 11 Default Bay Screen

Meter Folder Applications

The applications in the Meter folder are part-number dependent. Only those metering applications specific to your part number appear in the Meter folder. Tapping an application in the Meter folder shows you the report for that particular application. *Figure 12* shows a fundamental metering screen.

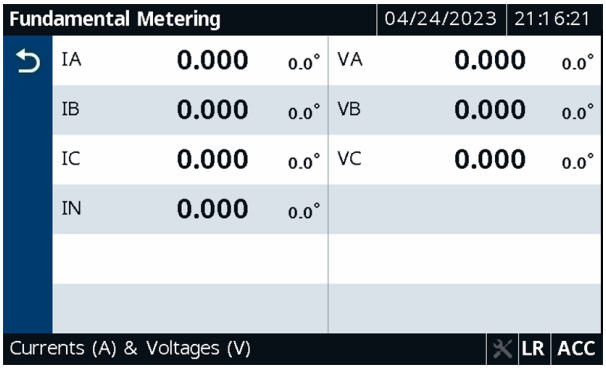


Figure 12 Fundamental Metering

Reports Folder Applications

Tapping the **Reports** folder navigates you to the screen where you can access the Events and SER applications. Use these applications to view events and SERs. To view the event summary (see *Figure 13*) of a particular event record, tap the event record on the Event History screen. You can also trigger an event report from the Event History screen.

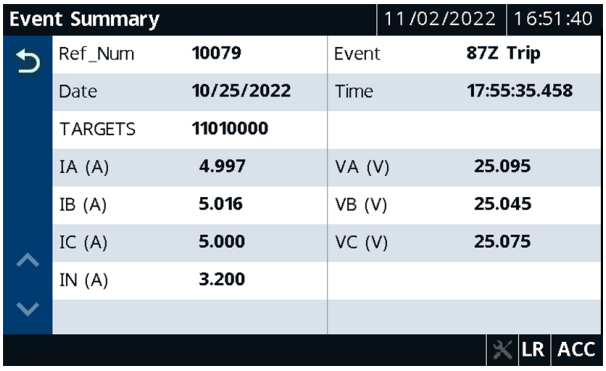


Figure 13 Event Summary

Tap the **Sequential Events Recorder** application to view a history of the SER reports (see *Figure 14*).

Figure 14 Sequential Events Recorder

Tapping the **Trash** button, shown in *Figure 14*, on the Event History and Sequential Events Recorder screens and confirming the delete action removes the records from the relay.

Control Folder Applications

Tapping the **Control** folder navigates you to the screen where you can access the Breaker Control, Output Pulsing, and Local Bits applications. Use the applications to perform breaker control operations, pulse output contacts (*Figure 15*), and control the local bits (*Figure 16*).

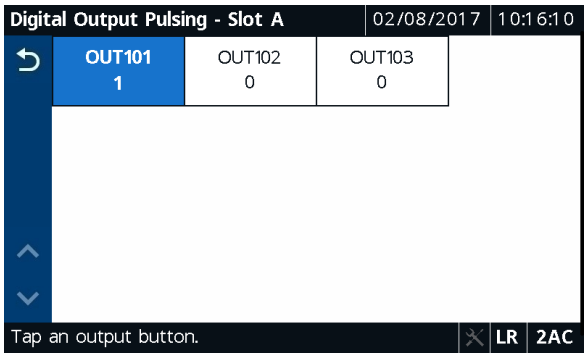


Figure 15 Digital Output Pulsing-Slot A

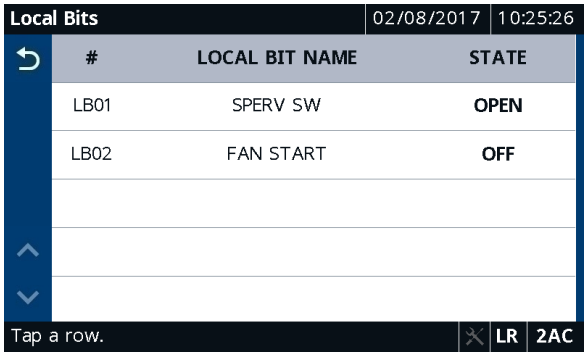


Figure 16 Local Bits

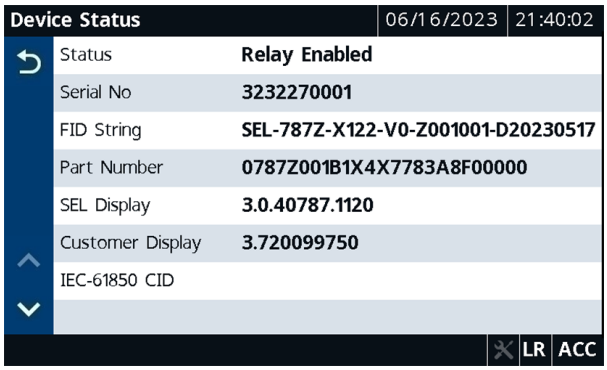


Figure 17 Device Status

Device Info Folder Applications

Tapping the **Device Info** folder navigates you to the screen where you can access specific device information applications (Status, Configuration, Arc-Flash Diagnostics, and Trip & Diag. Messages) and the Reboot application. Tap the **Status** application to view the relay status, firmware version, part number, etc. (see *Figure 17*).

To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application (see *Figure 18*). When a diagnostic failure, trip, or warning occurs, the relay displays the diagnostic message on the screen until it is either overridden by the restart of the rotating display or the inactivity timer expires.

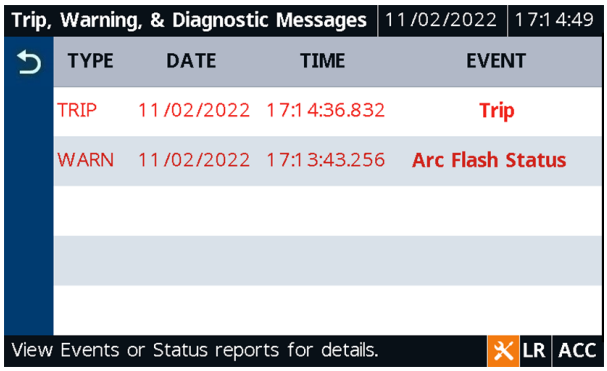


Figure 18 Trip and Diagnostics

Automation

Flexible Control Logic and Integration Features

The SEL-787Z can be ordered with as many as four independently operated serial ports:

- EIA-232 port on the front panel
- EIA-232 or EIA-485 port on the Slot B card in the rear
- EIA-232 fiber-optic port on the Slot B card in the rear
- EIA-232 or EIA-485 port on the optional communications card in Slot C in the rear

Optionally, the relay supports single or dual, copper or fiber-optic Ethernet ports. The relay does not require special communications software. You can use any system that emulates a standard terminal system for engineering access to the relay. Establish local or remote communication by connecting computers, modems, protocol converters, printers, an SEL RTAC, SEL communications processor, SEL computing platform, SCADA serial port, or RTUs. Refer to *Table 2* for a list of communications protocols available in the SEL-787Z.

Table 2 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 communications processors, RTUs, and other substation devices with metering information, relay elements, 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.
Fast SER Protocol	Provides SER events to an automated data collection system.
DNP3	Serial or Ethernet-based DNP3 protocols. Provides default and mappable DNP3 objects that include access to metering data, protection elements, Relay Word bits, contact I/O, targets, SER, relay summary event reports, and setting group selection.
Modbus	Serial- or Ethernet-based Modbus protocol with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
IEC 61850 Edition 2	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities.
Event Messenger	The use of SEL-3010 Event Messenger allows you to receive alerts directly on your cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.
IEEE 1588-2008 firmware-based PTP	Ethernet-based protocol that provides time synchronization of the relay.
PRP	Provides seamless recovery from any single Ethernet network failure in a dual redundant Ethernet network, in accordance with IEC 62439-3.
RSTP	Provides faster recovery in response to changes and failures in switched mode dual redundant Ethernet networks, in accordance with IEEE 802.1Q-2014.
IEC 60870-5-103	Serial communications protocol—international standard for interoperability between intelligent devices in a substation.
EtherNet/IP	Ethernet-based protocol that provides access to metering data, protection elements, targets, and contact I/O.

Apply an SEL communications processor as the hub of a star network with a point-to-point fiber or copper connection between the hub and the SEL-787Z (see *Figure 19*).

The communications processor supports external communications links, including the public switched telephone network, for engineering access to dial-out alerts and private line connections of the SCADA system.

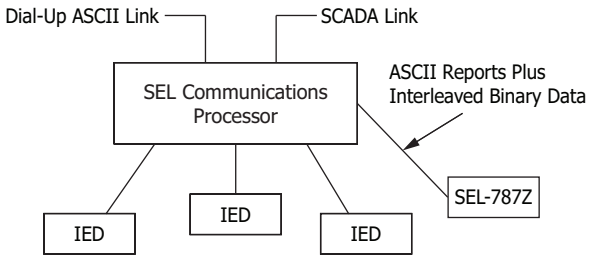


Figure 19 Example Communications System

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.

The SEL-787Z control logic improves integration in the following ways.

- **Replaces traditional panel control switches.** Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.
- **Eliminates RTU-to-relay wiring with 32 remote bits.** Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.

- **Replaces traditional latching relays.** Replace as many as 32 traditional latching relays for such functions as remote control enable with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.
- **Replaces traditional indicating panel lights.** Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., `Breaker Open`, `Breaker Closed`) to report power system or relay conditions on the front-panel display. Use advanced SELOGIC control equations to control which messages the relay displays.
- **Eliminates external timers.** Eliminate external timers for custom protection or control schemes with 32 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with the element you want (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.
- **Eliminates setting changes.** Selectable setting groups make the SEL-787Z ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions. The relay stores four setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies. Switching setting groups switches logic and relay element settings. Program groups for different operating conditions.

Fast SER Protocol

SEL Fast SER provides SER events to an automated data collection system. SEL Fast SER protocol is available on any rear serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-787Z relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Ethernet Network Architectures

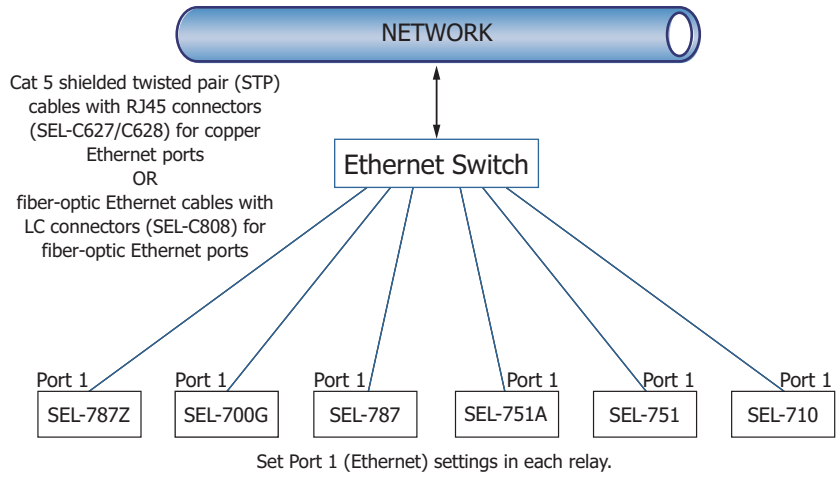


Figure 20 Simple Ethernet Network Configuration

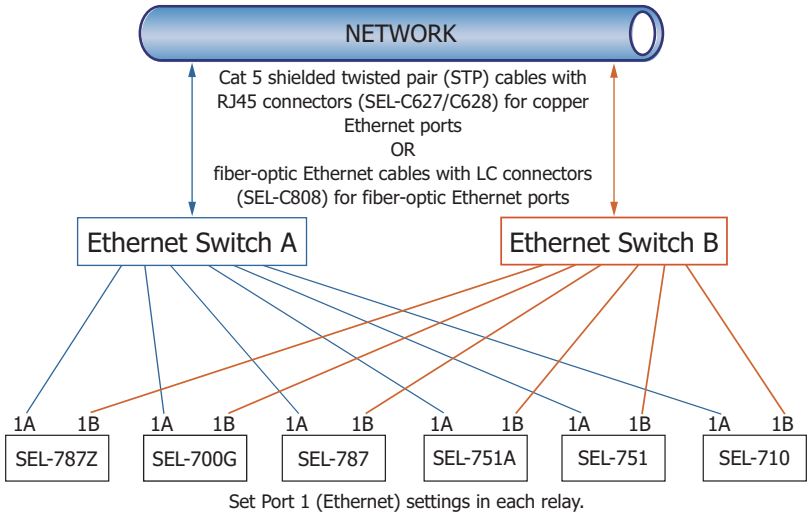


Figure 21 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

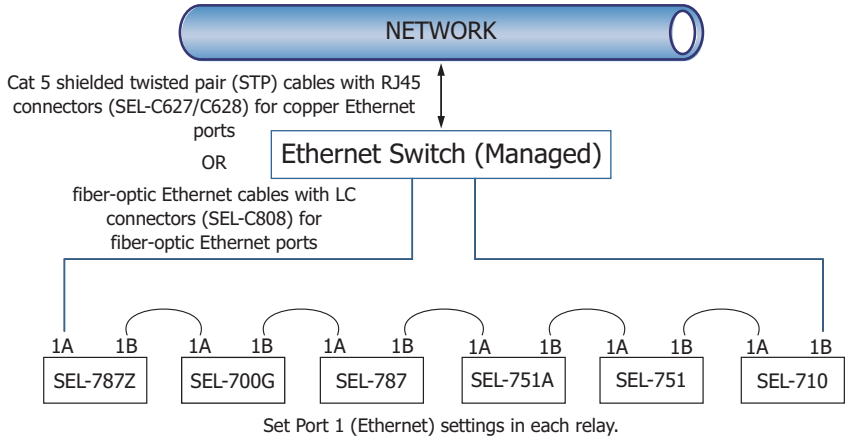


Figure 22 Ethernet Network Configuration With Ring Structure (Switched Mode)

Additional Features

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS communications can operate independently on as many as two EIA-232 rear serial ports and one fiber-optic rear serial port on a single SEL-787Z.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 23*). Use these MIRRORED BITS to transmit/receive information between upstream relays and a downstream recloser control (e.g., SEL-351R) to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

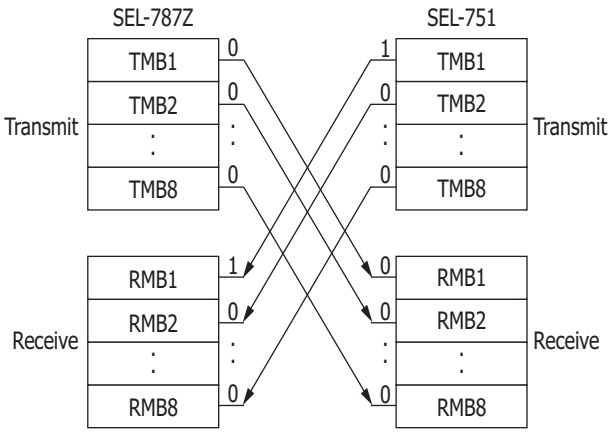


Figure 23 MIRRORED BITS Transmit and Receive Bits

Status and Trip Target LEDs

The SEL-787Z includes 24 status and trip target tricolor LEDs on the front panel. When shipped from the factory, all LEDs are predefined and fixed in settings. You can reprogram these LEDs for specific applications. This combination of targets is explained and shown in *Figure 29*. Some front-panel relabeling of the LEDs may be needed if you reprogram them for unique or specific applications—see *Configurable Labels*.

Configurable Labels

Use the configurable labels to relabel the operator controls and LEDs (shown in *Figure 29*) to suit your installation requirements. This feature includes preprinted labels (with factory-default text), blank label media, and a Microsoft Word template. The Microsoft Word template is available at selinc.com. This allows you to create quick, professional-looking labels for the SEL-787Z. Labels may also be customized without the use of a PC by writing the new label on the blank stock provided. The ability to customize the control and indication features allows specific utility or industry procedures to be implemented without the need for adhesive labels.

Web Server

The web server allows you to communicate with the relay via the Ethernet port without the need for additional communication software (web browser required). The web server allows you to access metering and monitoring data and to perform firmware upgrades.

Firmware Download Via Ethernet Ports

Relay firmware can be securely downloaded to your relay via the Ethernet port. The firmware is digitally signed to prevent malicious modification. Additionally, the Ethernet firmware download allows you to access and update all your network relays simultaneously.

Relay Dimensions

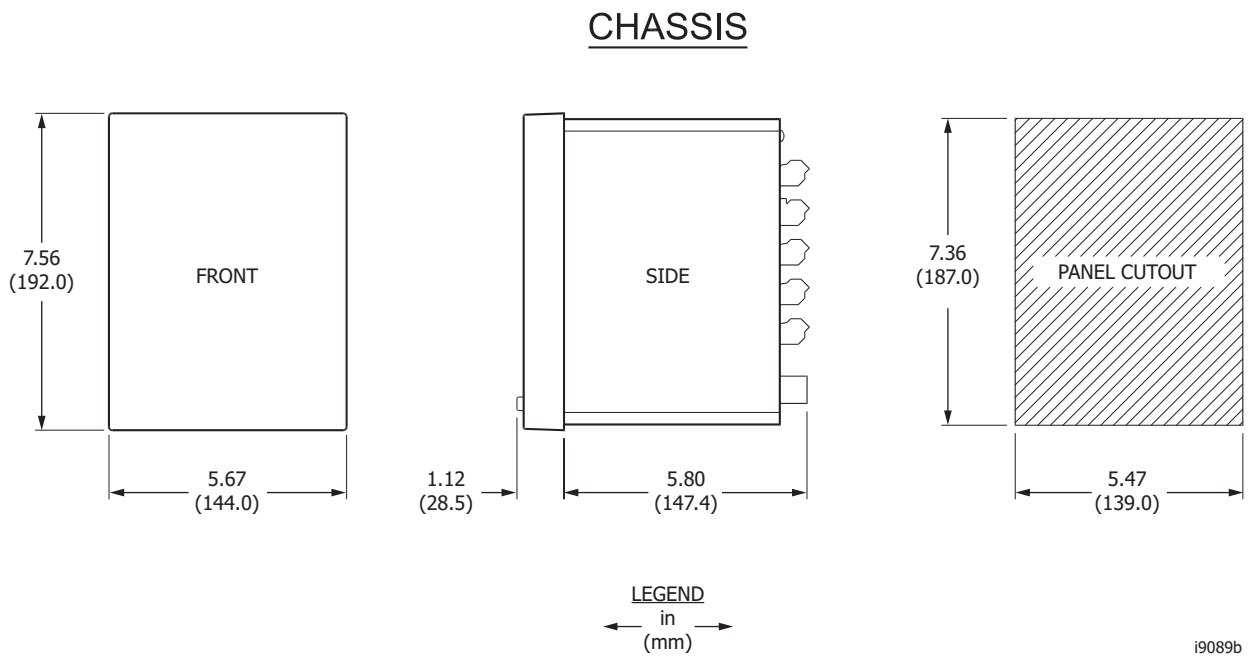


Figure 24 SEL-787Z Dimensions

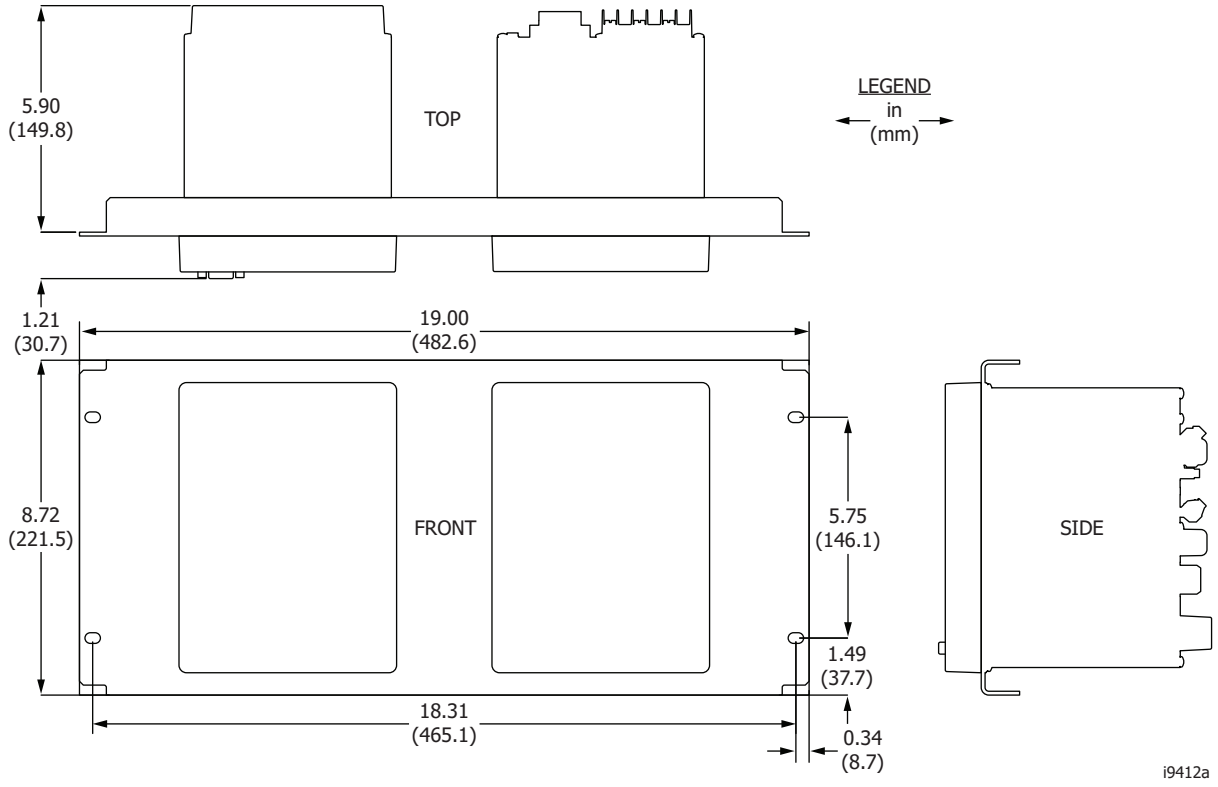


Figure 25 SEL-787Z Rack-Mount Dimensions

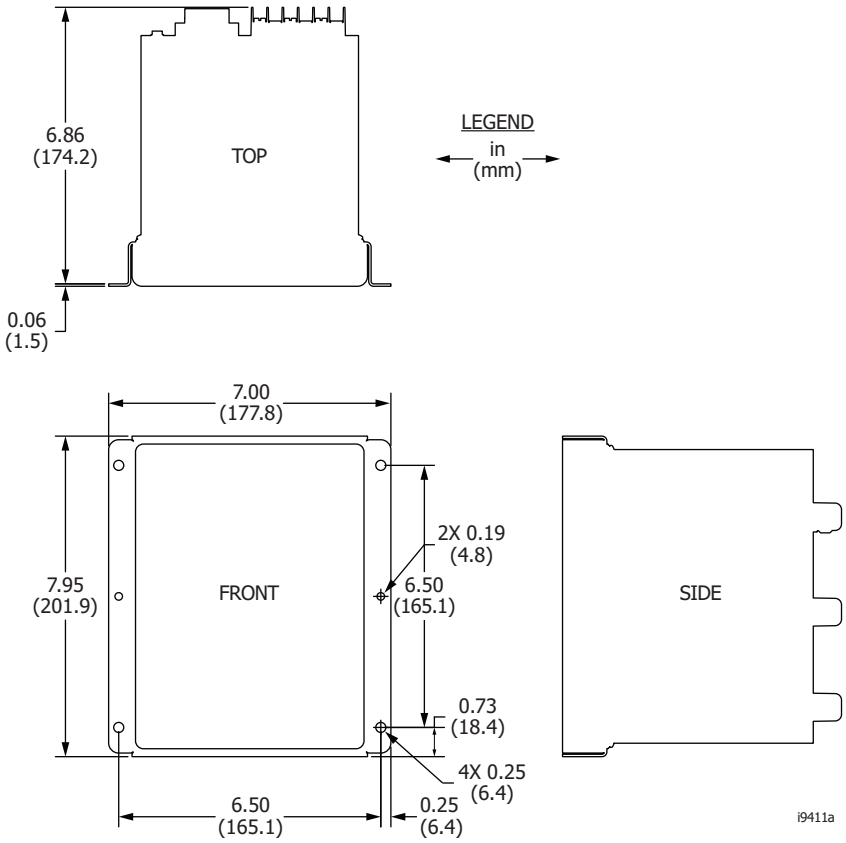


Figure 26 SEL-HZM Surface-Mount Dimensions

Hardware Overview

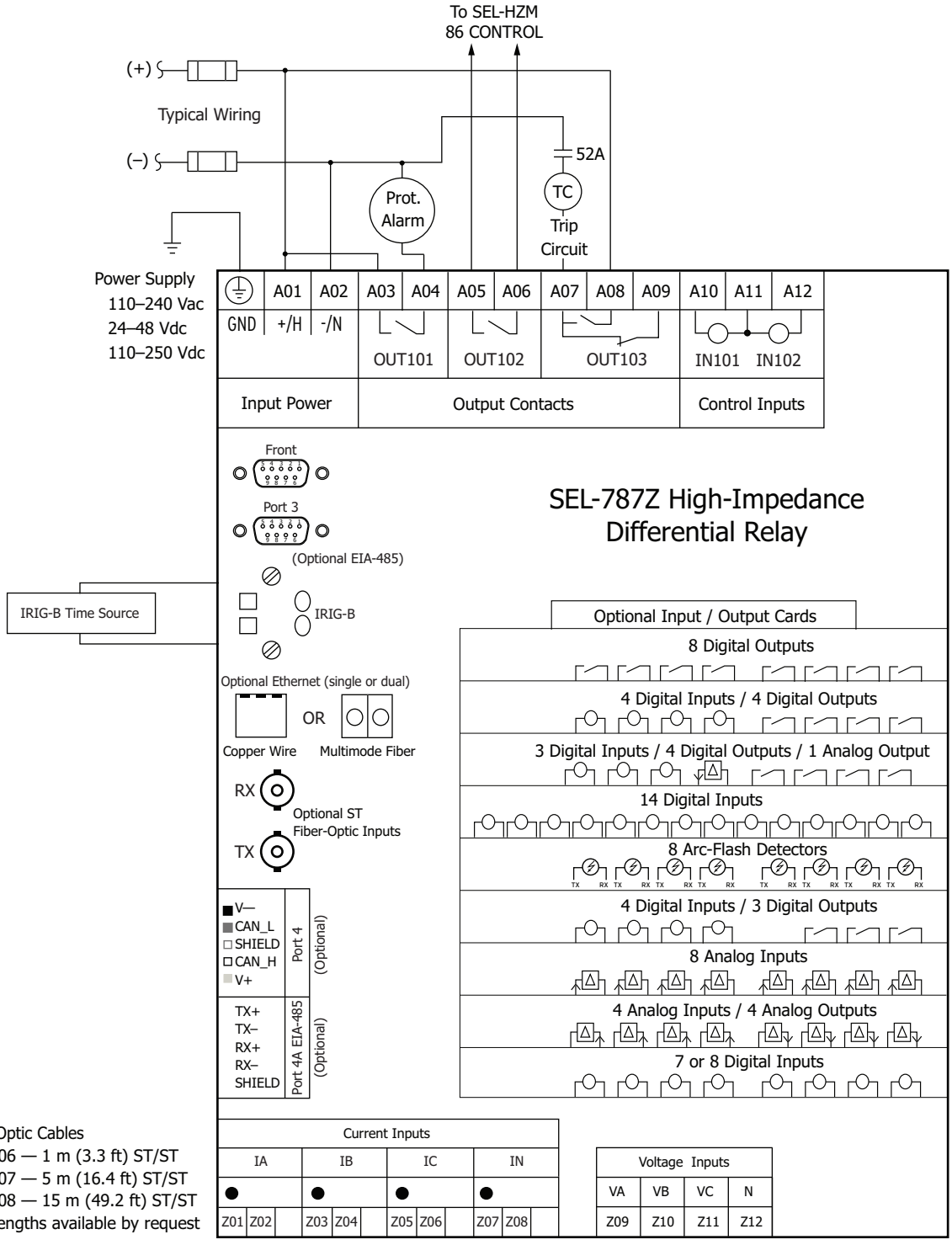


Figure 27 SEL-787Z Wiring Diagram

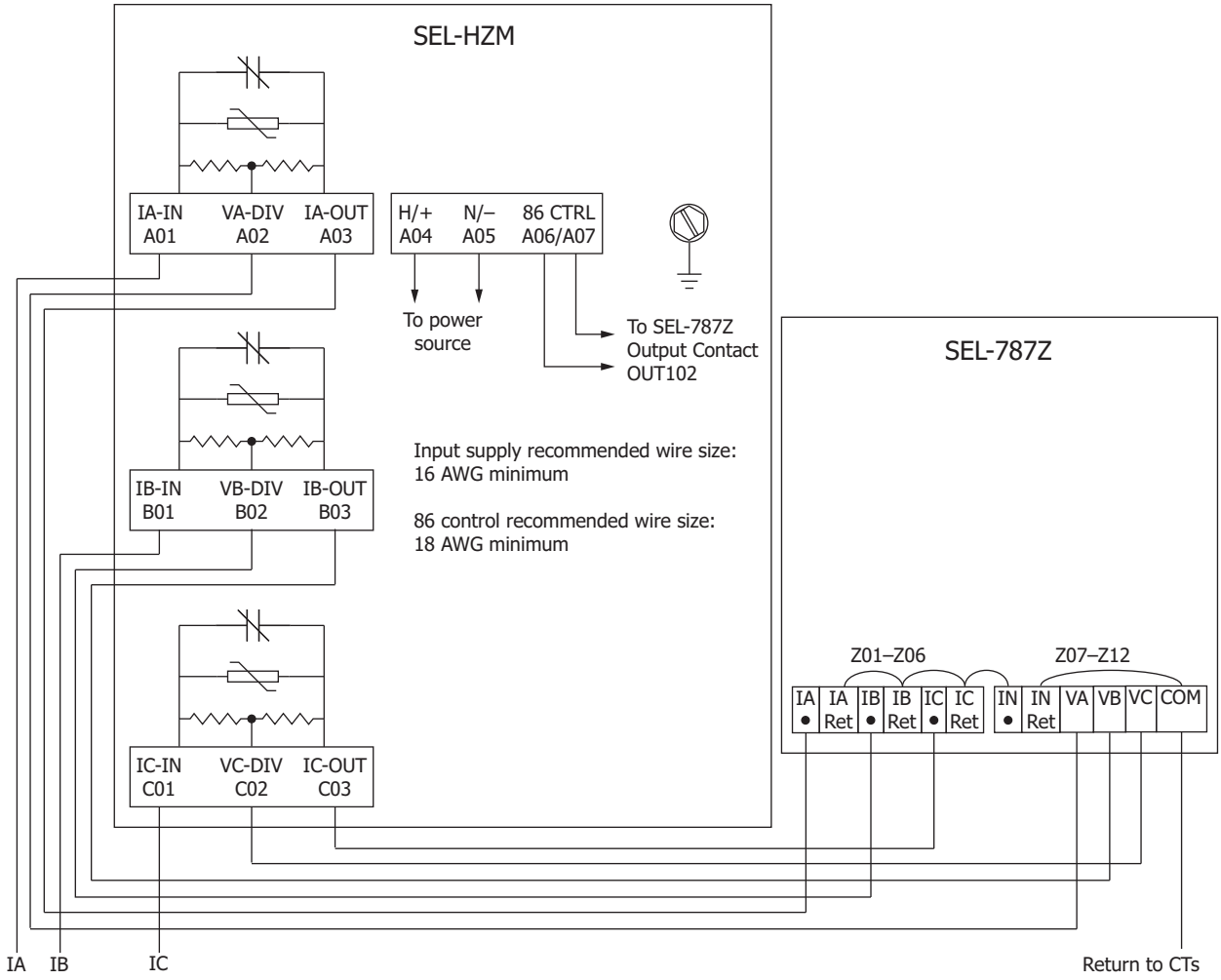


Figure 28 SEL-787Z and SEL-HZM Wiring Diagram

Relay Panel Diagrams

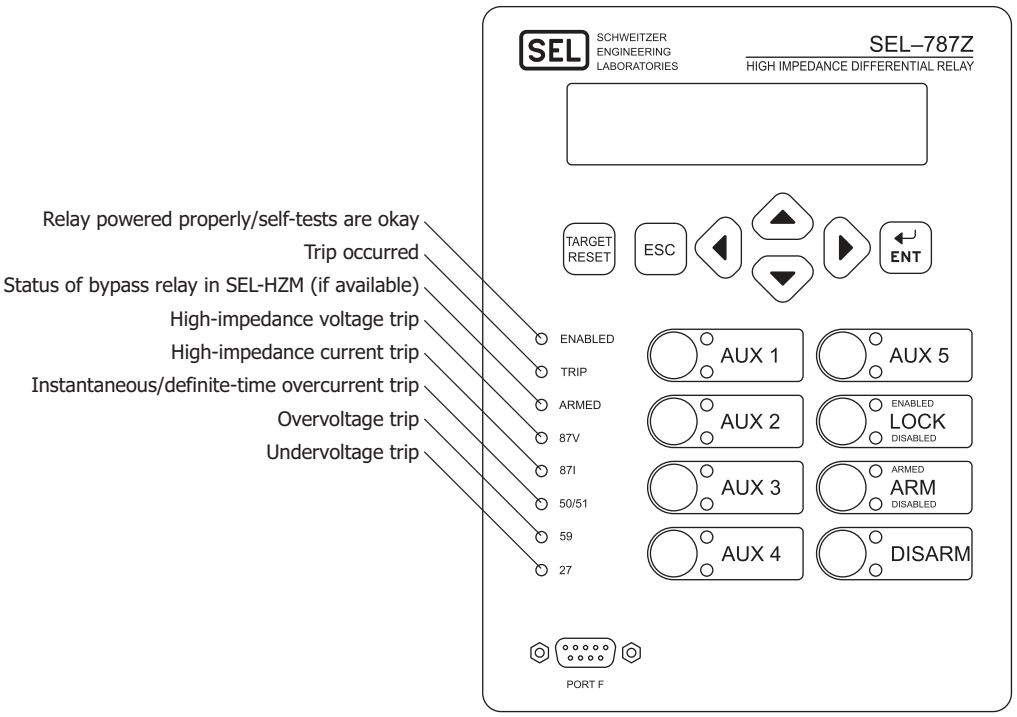
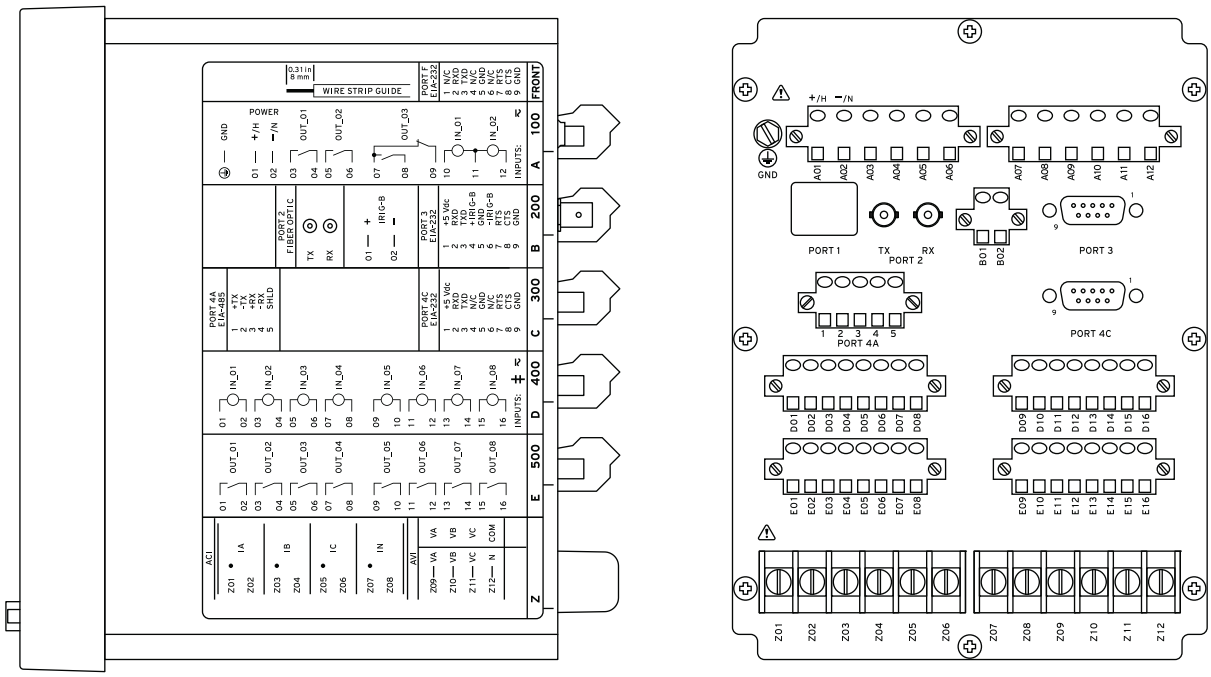


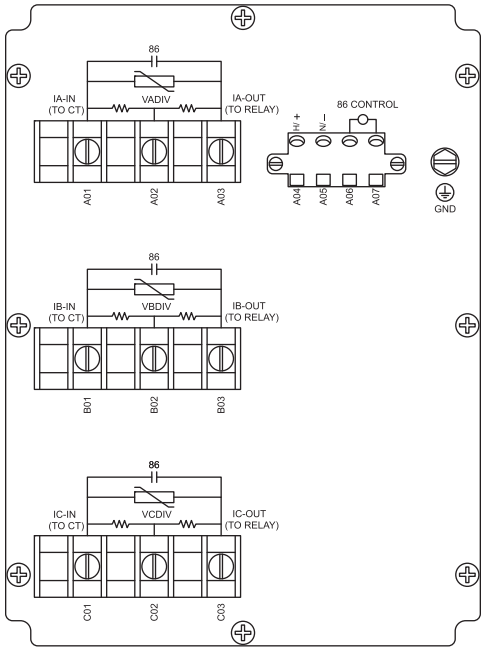
Figure 29 Front-Panel Overview



(A) SEL-787Z Side-Panel Input and Output Designations

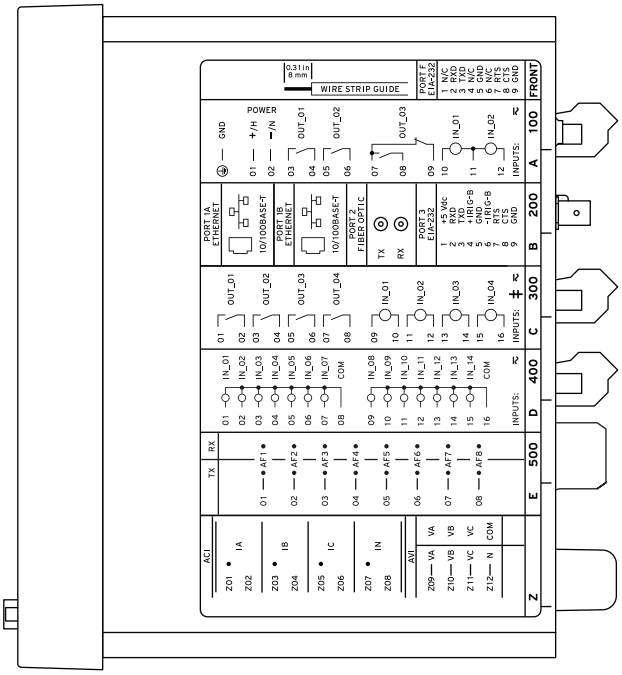
(B) SEL-787Z Rear-Panel Layout

Figure 30 No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 0787Z001AA03A2A8500010111)



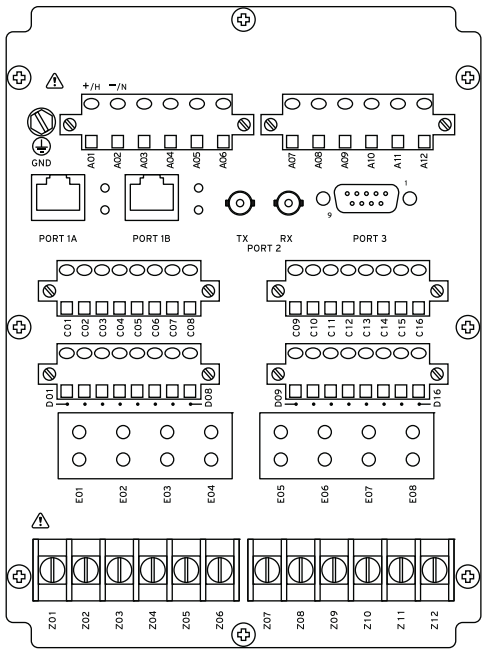
(C) SEL-HZM Rear-Panel Layout

Figure 30 No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 0787Z001AA03A2A8500010111) (Continued)



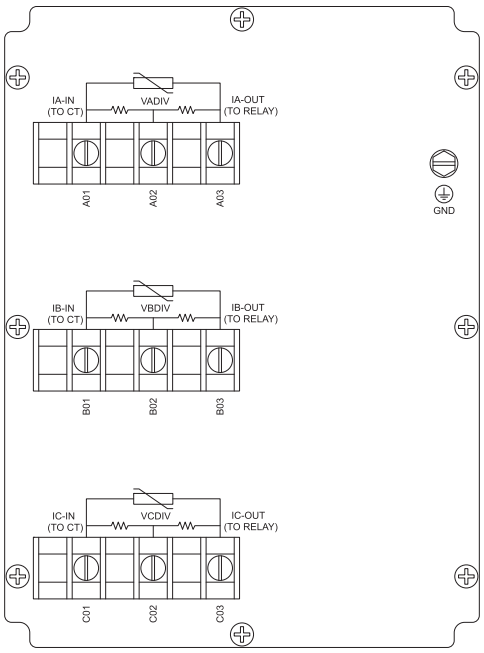
‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) SEL-787Z Side-Panel Input and Output Designations



(B) SEL-787Z Rear-Panel Layout

Figure 31 Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 1 A Neutral, and Three-Phase AC Voltage Inputs (300 Vac) (Relay MOT 0787Z001A1A4A7781A6310010)



(C) SEL-HZM Rear-Panel Layout

Figure 31 Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 1 A Neutral, and Three-Phase AC Voltage Inputs (300 Vac) (Relay MOT 0787Z001A1A4A7781A6310010) (Continued)

Applications

Bus Protection

Figure 32 illustrates a typical single-zone, high-impedance bus protection installation. The CTs must have identical ratios and saturation characteristics (C-ratings).

Configure the second level of the high-impedance element to an alarm function with a low setting to report on CT open-circuit conditions. Advance warning of an open-circuit CT gives maintenance personnel time to take corrective action that may prevent severe damage to the CT and nearby primary equipment.

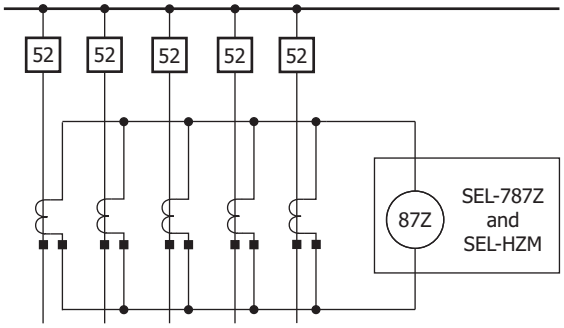


Figure 32 Example Bus Protection (One Phase Shown Connected)

Transformer Protection

Combine the overcurrent elements with the high-impedance differential elements to provide protection for smaller, wye-connected and grounded transformers; see *Figure 33*. The REF CTs must have identical ratios and saturation characteristics. When you use the SEL-787Z for transformer protection, use the overcurrent elements to provide backup instantaneous phase and ground overcurrent protection for bushing faults. These elements provide phase and neutral time-overcurrent protection for coordination with other system protection.

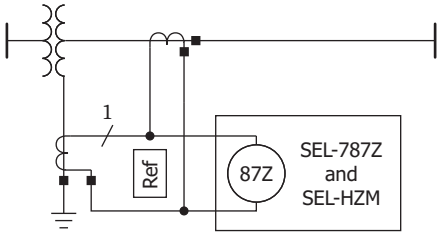


Figure 33 Transformer With Grounded-Wye Connected Winding

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

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.

Normal Locations

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

Note: UL has not yet developed requirements for products intended to detect and mitigate an arc flash; consequently, UL has not evaluated the performance of this feature. While UL is developing these requirements, it will place no restriction on the use of this product for arc-flash detection and mitigation. For test results performed by an independent laboratory and other information on the performance and verification of this feature, please contact SEL customer service.

CE Mark in accordance with the requirements of the European Union

Ambient air temperature shall not exceed –20°C ≤ Ta ≤ +50°C

RCM Mark in accordance with the requirements of Australia

General

AC Current Input

I_{NOM} = 200 mA, 1 A, or 5 A secondary, depending on the model.

Measurement Category: II

Phase and Neutral Currents

I_{NOM} = 5 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 217 A peak (154 Arms symmetrical)

Saturation Current Rating: Linear to 96 A symmetrical

1-Second Thermal: 500 A

Burden (Per Phase): <0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating: 3 • I_{NOM} @ 85°C
4 • I_{NOM} @ 55°C

A/D Measurement Limit: 43 A peak (31 Arms symmetrical)

Saturation Current Rating: Linear to 19.2 A symmetrical

1-Second Thermal: 100 A

Burden (Per Phase): <0.01 VA @ 1 A

I_{NOM} = 200 mA

Continuous Rating: 4 A

A/D Measurement Limit: 8.4 A peak (6 Arms symmetrical)

Saturation Current Rating: Linear to 4 A symmetrical

1-Second Thermal: 500 A

Burden (Per Phase): <0.01 VA @ 0.2 A

AC Voltage Input

300 Vac Voltage Inputs

Rated Continuous Voltage: 300 Vac (phase-to-neutral)

10-Second Thermal: 600 Vac (phase-to-neutral)

	Burden	Input Impedance (Per Phase)	Input Impedance (Phase-to-Phase)
Vphase	0.008 VA @ 120 Vac	2 MΩ	4 MΩ

Power Supply

Relay Start-Up Time: Approximately 5–10 seconds (after power is applied until the **ENABLED** LED turns on)

High-Voltage Supply

Rated Supply Voltage: 110–240 Vac, 50/60 Hz
110–250 Vdc

Input Voltage Range (Design Range): 85–264 Vac
85–300 Vdc

Power Consumption: <55 VA (ac)
<25 W (dc)

Interruptions: 50 ms @ 125 Vac/Vdc
100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage: 24–48 Vdc

Input Voltage Range (Design Range): 19.2–60.0 Vdc

Power Consumption: <25 W (dc)

Interruptions: 10 ms @ 24 Vdc
50 ms @ 48 Vdc

Fuse Ratings

Low-Voltage Power Supply Fuse

Rating: 3.15 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

High-Voltage Power Supply Fuse

Rating: 3.15 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

Output Contacts

General

The relay supports Form A, B, and C outputs.

Dielectric Test Voltage: 2500 Vac

Impulse Withstand Voltage (U_{IMP}): 5000 V

Mechanical Durability: 100,000 no-load operations

Standard Contacts

Pickup/Dropout Time: ≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Continuous Carry: 6 A @ 70°C
4 A @ 85°C

1-Second Thermal: 50 A

Contact Protection: 360 Vdc, 115 J MOV protection across open contacts

Note: Continuous current through the output contacts will be restricted when over nine control inputs are energized with a voltage of 100 V or above. De-rate by 3 A per additional control input energized with a voltage of 100 V or above. If energizing voltages are below 100 V, twice the number of control inputs may be used.

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

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

Cyclic (2.5 Cycles/Second) per IEC 60255-0-20:1974:

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

AC Output Ratings

Maximum Operational Voltage (U_e) Rating: 240 Vac

Insulation Voltage (U_i) Rating (excluding EN 61010-1): 300 Vac

1-Second Thermal: 50 A

Contact Rating Designation: B300

B300 (5 A Thermal Current, 300 Vac Max)			
	Maximum Current		Max VA
Voltage	120 Vac	240 Vac	—
Make	30 A	15 A	3600
Break	3 A	1.5 A	360
PF < 0.35, 50–60 Hz			

Utilization Category: AC-15

AC-15		
Operational Voltage (Ue)	120 Vac	240 Vac
Operational Current (Ie)	3 A	1.5 A
Make Current	30 A	15 A
Break Current	3 A	1.5 A
Electromagnetic loads > 72 VA, PF < 0.3, 50–60 Hz		

Voltage Protection Across Open Contacts: 270 Vac, 40 J

Fast Hybrid (High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage: 250 Vdc

Rated Voltage Range: 19.2–275 Vdc

Rated Insulation Voltage: 300 Vdc

Make: 30 A @ 250 Vdc per IEEE C37.90

Carry: 6 A @ 70°C
4 A @ 85°C

1-Second Thermal: 50 A

Open State Leakage Current: <500 µA

MOV Protection (Maximum Voltage): 250 Vac/330 Vdc

Pickup Time: <50 µs, resistive load

Dropout Time: <8 ms, resistive load

Breaking Capacity (10,000 Operations):

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

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation):

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

AC Output Ratings

See *AC Output Ratings* for *Standard Contacts*.

Optoisolated Control Inputs

When Used With DC Control Signals

Pickup/Dropout Time: Depends on the input debounce settings

250 V: ON for 200.0–312.5 Vdc
OFF below 150 Vdc

220 V: ON for 176–275 Vdc
OFF below 132 Vdc

125 V: ON for 100.0–156.2 Vdc
OFF below 75 Vdc

110 V: ON for 88.0–137.5 Vdc
OFF below 66 Vdc

48 V: ON for 38.4–60.0 Vdc
OFF below 28.8 Vdc

24 V: ON for 15–30 Vdc
OFF below 5 Vdc

When Used With AC Control Signals

Pickup Time: 2 ms

Dropout Time: 16 ms

250 V: ON for 170.6–312.5 Vac
OFF below 106 Vac

220 V: ON for 150.2–275.0 Vac
OFF below 93.3 Vac

125 V: ON for 85.0–156.2 Vac
OFF below 53 Vac

110 V: ON for 75.1–137.5 Vac
OFF below 46.6 Vac

48 V: ON for 32.8–60.0 Vac
OFF below 20.3 Vac

24 V: ON for 14–30 Vac
OFF below 5 Vac

Current Draw at Nominal DC Voltage: 2 mA (at 220–250 V)
4 mA (at 48–125 V)
10 mA (at 24 V)

Rated Impulse Withstand Voltage (U_{imp}): 4000 V

Analog Output (Optional)

	1 A0	4 A0
Current:	4–20 mA	±20 mA
Voltage:	—	±10 V
Load at 1 mA:	—	0–15 kΩ
Load at 20 mA:	0–300 Ω	0–750 Ω
Load at 10 V:	—	>2000 Ω
Refresh Rate:	100 ms	100 ms
% Error, Full Scale, at 25°C:	<±1%	<±0.55%
Select From:	Analog quantities available in the relay	

Analog Inputs (Optional)

Maximum Input Range: ±20 mA
±10 V
Operational range set by user

Input Impedance: 200 Ω (current mode)
>10 kΩ (voltage mode)

Accuracy at 25°C

With User Calibration:	0.05% of full scale (current mode) 0.025% of full scale (voltage mode)
Without User Calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full-scale (±20 mA or ±10 V)

Arc-Flash Detectors (Optional)

Multimode Fiber-Optic Receiver/Transmitter Pair

Fiber Type:	1000 µm diameter, 640 nm wavelength, plastic, clear-jacketed, or black-jacketed
Connector Type:	V-pin

Frequency

System Frequency:	50, 60 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
All Other Reports:	±5 ms
SNTP Accuracy:	±1 ms (in an ideal network)
PTP Accuracy:	±1 ms
Unsynchronized Clock Drift Relay Powered:	2 minutes per year typical

Communications Ports

Standard EIA-232 (2 Ports)

Location:	Front panel Rear panel
Data Speed:	300–38400 bps

EIA-485 Port (Optional)

Location:	Rear panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

Single/Dual 10/100BASE-T copper (RJ45 connector)
Single/Dual 100BASE-FX (LC connector)

EIA-232 Multimode Fiber-Optic Port (Optional)

Location:	Rear panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
RX Min. Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~6.4 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Port 2 Serial

Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	8 dB
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~1 km
Data Rate:	5 Mbps
Typical Fiber Attenuation:	–4 dB/km

Channels 1–8 Arc-Flash Detectors (AFDI)

Diagnostic Wavelength:	640 nm
Optical Connector Type:	V-pin
Fiber Type:	Multimode
Typical TX Power:	–12 dBm

Point Sensor

Minimum Receive Sensitivity:	–52.23 dB
Point Sensor Diagnostic Worst Case Loss:	–28 dB
Link Budget:	12.23 dB
Black-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Black-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 35 m

Fiber Sensor

Minimum Receive Sensitivity:	–29.23 dB
Link Budget:	17.23 dB
Clear-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Clear-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 70 m

Optional Communications Cards

EIA-232 or EIA-485 communications card

Communications Protocols

SEL, Modbus RTU and TCP/IP, DNP3 serial and LAN/WAN, FTP, Telnet, SNTP, IEEE 1588-2008 firmware-based PTP, IEC 61850 Edition 2, IEC 60870-5-103, EtherNet/IP, PRP, MIRRORED BITS, Event Messenger, and IEEE 802.1Q-2014 RSTP

Operating Temperature

IEC Performance Rating:	–40° to +85°C (–40° to +185°F) (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)

Note: Not applicable to UL applications.
Note: The front-panel display is impaired for temperatures below –20°C and above +70°C.

Optoisolated Control Inputs:	As many as 26 inputs are allowed in ambient temperatures of 85°C or less As many as 34 inputs are allowed in ambient temperatures of 75°C or less As many as 44 inputs are allowed in ambient temperatures of 65°C or less

Operating Environment

Insulation Class:	1
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa

Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 155.0 mm (6.10 in)

Weight

2.04 kg (4.50 lb)

Relay Mounting Screw (#8-32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Note: The connections to the terminal blocks must be made with UL-certified fork or ring terminals.

Screw Size:	#6
Ring Terminal Width:	0.310-inch maximum

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

High-Impedance Module (SEL-HZM)

Burden:	500, 1000, 2000 Ω stabilizing resistors

MOV

Maximum Transient Energy Rating:	7800 J
Maximum Continuous AC Voltage Rating:	320 V
MOV Clamping Voltage Rating:	800 V

86 (Bypass) Relay

Current Rating:	200 A for 1 s
Make (Contact Current):	100 A, 2000 operations @ 500 Vdc
Operating Time:	22 ms

Dimensions

144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 155.0 mm (6.10 in)

Weight

2.04 kg (4.5 lb)

Relay Mounting Screw (#8-32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Screw Size:	#6
Ring Terminal Width:	0.310-inch maximum (without terminal block cover) 0.265-inch maximum (with terminal block cover)

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013
Safety Standards:	IEC 60255-27:2013 UL 508 CSA C22.2 No. 14-05

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel (2-line display models) IP54 enclosed in panel (touchscreen models) IP50 for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C temperature derating applies to the temperature specifications of the relay. IP10 for terminals and the relay rear panel IP20 for terminals and the relay rear panel with optional terminal block cover
Vibration Resistance:	IEC 60255-21-1:1988 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 (panel and surface mount) Class 1 (rack mount) Response: Class 2
Shock Resistance:	IEC 60255-21-2:1988 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25° to 55°C, 95% relative humidity, 6 cycles
Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (Hi-Pot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG 2.5 kVac on contact I/O 3.6 kVdc on power supply, IN and VN terminals
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 530 V on analog outputs IEEE C37.90:2005 0.5 J, 5 kV 0.5 J, 530 V on analog outputs

RFI and Interference Tests

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013; Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013; Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity:	IEC 61000-4-4:2011 IEC 60255-26:2013; Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-26:2013; Section 7.2.7 2 kV line-to-line 4 kV line-to-earth LEA ports compliant with IEC 61869-13 tested to 1 kV, 1 MHz line-to-earth only
Surge Withstand Capability Immunity:	EN 61000-4-18:2010 IEC 60255-26:2013; Section 7.2.6 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013; Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9: 2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

Conducted Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.107 Class A CAN ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A
Radiated Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.109 Class A CAN ICES-001 (A) / NMB-001 (A) EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	40 samples per power system cycle for 60 Hz nominal frequency 48 samples per power system cycle for 50 Hz nominal frequency
Digital Filtering:	One-cycle adaptive Fourier filter after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 24 ms).
Arc-Flash Processing:	Arc-flash light is sampled 40 or 48 times per cycle for 60 Hz or 50 Hz nominal frequency, respectively Arc-flash current, light, and 2 fast hybrid outputs are processed 20 or 24 times per cycle for 60 Hz or 50 Hz nominal frequency, respectively

Oscillography

Length:	15, 64, or 180 cycles
Sampling Rate:	40 samples per cycle unfiltered for 60 Hz nominal frequency 48 samples per cycle unfiltered for 50 Hz nominal frequency 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (40 samples per cycle unfiltered for 60 Hz nominal frequency, 48 samples per cycle unfiltered for 50 Hz nominal frequency)

Note: Binary COMTRADE format as per IEEE C37.11-1999, IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems.

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (With Respect to Time Source) for all Relay Word bits except those corresponding to digital inputs (IN*xxx*) and arc-flash elements (TOL*x*/50*x*AF/OUT*xxx*):	±5 ms

Time-Stamp Accuracy (With Respect to Time Source) for Relay Word bits corresponding to digital inputs (IN*xxx*) and arc-flash elements (TOL*x*/50*x*AF/OUT*xxx*):	1 ms

Relay Elements

Accuracies are specified for sinusoidal ac currents and voltages at nominal frequency.

High-Impedance Differential (87Z)

Voltage Divider Setting Range:

R_STBLZ:	10.00–10000.00 Ω
RATIO:	0.10–1.00
Pickup Setting Range:	OFF, 20.00–800.00 V, 0.01 V steps
Accuracy:	±3% of setting plus ±0.4 V
Time Delay:	0.00–400.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1 cycle

Instantaneous/Definite-Time Overcurrent (50P, 50N)

Pickup Setting Range, A Secondary:

5 A Models:	0.25–100.00 A, 0.01 A steps
1 A Models:	0.05–20.00 A, 0.01 A steps
200 mA Models:	0.010–4.000 A, 0.001 A steps (50N)
Accuracy:	±3% of setting plus ±0.02 • I_{NOM} A secondary (steady state) ±5% of setting plus ±0.02 • I_{NOM} A secondary (transient)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps
Pickup/Dropout Time:	<1.5 cycles

Arc-Flash Instantaneous Overcurrent (50PAF, 50NAF)

Pickup Setting Range, A Secondary:

5 A Models:	0.50–100.00 A, 0.01 A steps
1 A Models:	0.10–20.00 A, 0.01 A steps
Accuracy:	0 to +10% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)
Pickup/Dropout Time:	2–5 ms/1 cycle

Arc-Flash Time-Overlight (TOL1–TOL8)

Pickup Setting Range, % of Full Scale:	3.0–80.0% (point sensor) 0.6–80.0% (fiber sensor)
Pickup/Dropout Time:	2–5 ms/1 cycle

Inverse-Time Overcurrent (51P, 51N)

Pickup Setting Range, A Secondary:

5 A Models:	0.25–24.00 A, 0.01 A steps
1 A Models:	0.05–4.80 A, 0.01 A steps
200 mA Models:	10.00–960.00 mA, 0.01 mA steps (51N)
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)

Time Dial

U.S.:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy:	±1.5 cycles, plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27P)

Setting Range:	OFF, 2.00–300.00 V (phase elements)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

Overvoltage (59P)

Setting Range:	OFF, 2.00–300.00 V (phase elements)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

Metering

Accuracies are specified at 20°C, nominal frequency, filtered ac currents within (0.2–20.0) • I_{NOM} A secondary, and filtered ac voltages within 50–250 V secondary, unless otherwise noted.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A) ±1.6 mA and ±1% (0.04–4.0 A) (0.2 A nominal channel IN current input)
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V

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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Notes

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