SEL-311B Protection and Automation System

Powerful Solutions for Transmission Line Protection

Major Features and Benefits

The SEL-311B Protection and Automation System is a full-featured, three-pole trip/reclose relay for transmission protection applications. A powerful suite of phase and ground protection elements coupled with a four-shot recloser provides the user with step-distance tripping schemes. Event reports, Sequential Events Recorder, circuit breaker contact wear monitor, and substation battery monitor are all standard features. Communications ports include three EIA-232 serial ports (one front and two rear) and one rear EIA-485 serial port. MIRRORED BITS® communications and extensive automation features are also standard. A local display panel and Distributed Network Protocol (DNP3 Level 2 Slave) are available as optional functions.

- **Synchrophasors.** Improve operator awareness of system conditions. Use real-time data to view load angles, improve event analysis, and provide state measurements.
- **Protection.** Protect transmission lines using a combination of three zones of phase- and ground-distance elements in stepped distance schemes with directional overcurrent element backup protection. Select either positive-sequence polarized or compensator distance elements for phase protection. Patented Coupling Capacitor Voltage Transformer (CCVT) transient overreach logic enhances security of Zone 1 distance elements. Best Choice Ground Directional Element™ logic optimizes directional element performance and requires no directional settings.
- **Monitoring.** Schedule breaker maintenance when breaker monitor indicates. Notify personnel of substation battery voltage problems.
- **Reclosing Control.** Selectively reclose with synchronism and voltage checks using the built-in, programmable, four-shot recloser.
- **Fault Locator.** Efficiently dispatch line crews to quickly isolate line problems and restore service faster.
- **Automation.** Take advantage of enhanced automation features that include 16 elements for each of the following: local control and local indication with optional front-panel LCD and pushbuttons, remote control, and latch control. Use the three rear serial ports for efficient transmission of key information including metering data, protection elements and contact I/O status, Sequential Events Recorder (SER) reports, breaker monitor, relay summary event reports, and time synchronization. Optional DNP3 Level 2 Slave with point mapping is also available.

Functional Overview

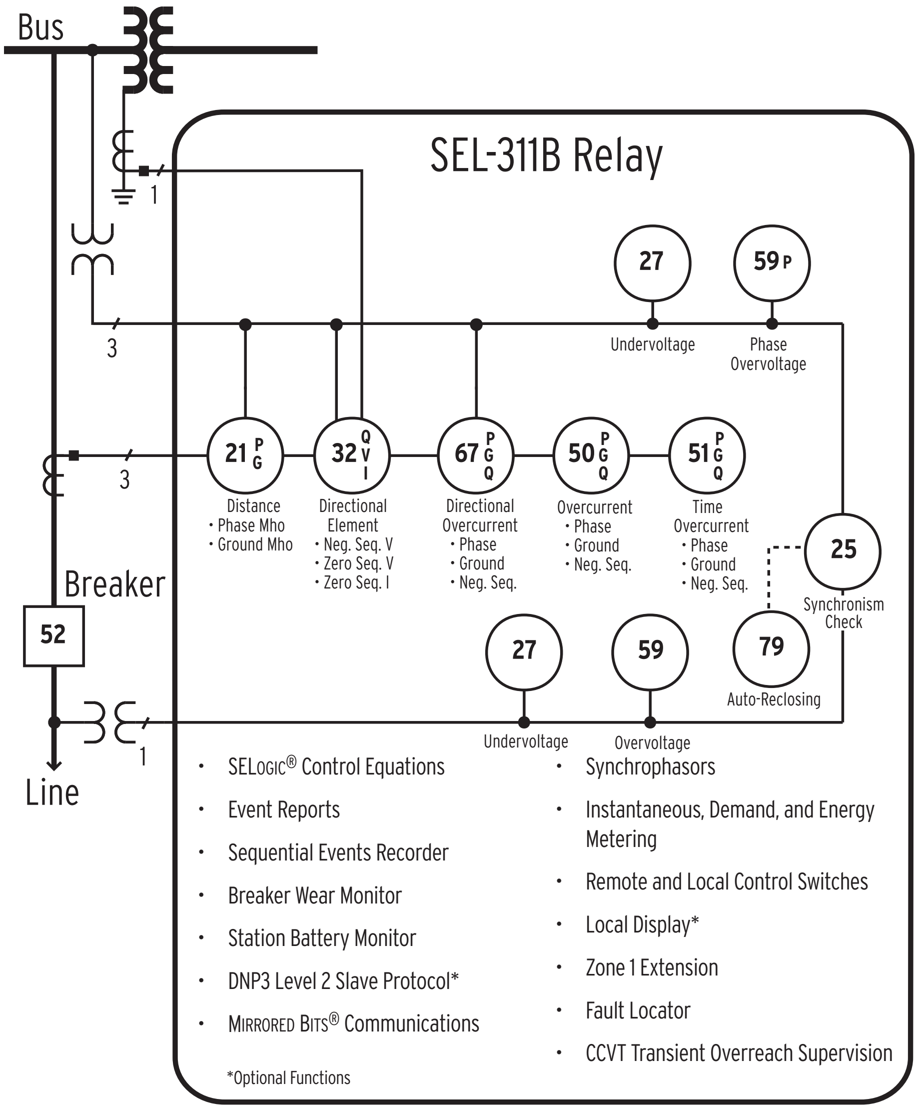


Figure 1 Functional Diagram

Protection Features

The SEL-311B Relay contains protective elements and control logic to protect overhead transmission lines and underground cables. It includes three zones of phase and ground mho distance elements. These distance elements, together with overcurrent functions, are applied in stepped-distance protection schemes. You can further tailor the relay to your particular application using advanced SELOGIC control equations.

The relay has six independent setting groups. With this flexibility, the relay may be automatically configured for many operating conditions: substitute line relay, line configuration changes, source changes, etc.

"Application Templates" for popular SEL-221 series relays are included in addition to the setting groups. These templates allow selection of a specific relay type, for example, "SEL-221F." This template selection will limit the number and type of available settings to those similar to the selected relay type. Terminal block numbers are identical to SEL-221 series relays, simplifying migration to the SEL-311B.

Mho Distance Elements

The SEL-311B uses mho characteristics for phase- and ground-distance protection. Two zones are fixed in the forward direction, and the remaining zone can be set for either forward or reverse. *Figure 2* illustrates an example of three forward zones, or two forward and one reverse zone.

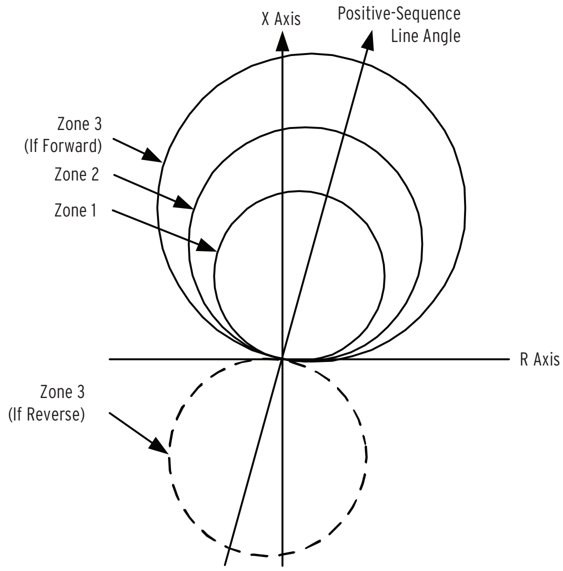


Figure 2 Phase and Ground Mho Distance Characteristics

All mho elements use positive-sequence memory polarization that expands the operating characteristic in proportion to the source impedance. This provides dependable, secure operation for close-in faults.

Figure 3 shows the forward-reaching mho characteristic for a forward phase-to-phase fault. The mho circle expands to the source impedance ZS, but never more than the set relay reach, ZR.

Depending on the application, the user can select from zero to four zones of distance protection.

Optionally, select compensator distance elements for distance protection through a delta-wye transformer or to provide a different operating principle for backup protection.

Each of the three ground-distance elements has an individual reach setting. The ground-distance elements include two zero-sequence compensation factor settings (k01, k0) to accurately calculate ground fault impedance. Setting k01 compensates for phase-to-phase zero-sequence mutual coupling of the protected circuit, and k0 compensates for zero-sequence mutual coupling between parallel lines.

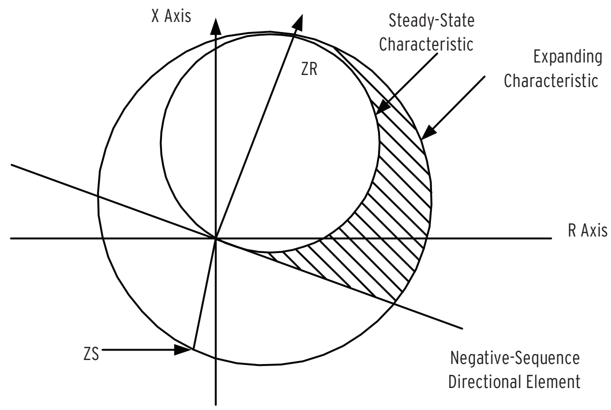


Figure 3 Phase-to-Phase Element Response for a Forward Phase-to-Phase Fault

Load Encroachment

Load-encroachment logic prevents operation of the phase-distance elements under high load conditions. This unique and easy to set feature permits load to enter a predefined area of the phase-distance characteristic without causing a trip. *Figure 4* shows the load-encroachment characteristic.

This advancement provides better protection for long lines without increasing operate times or unnecessarily limiting fault resistance coverage.

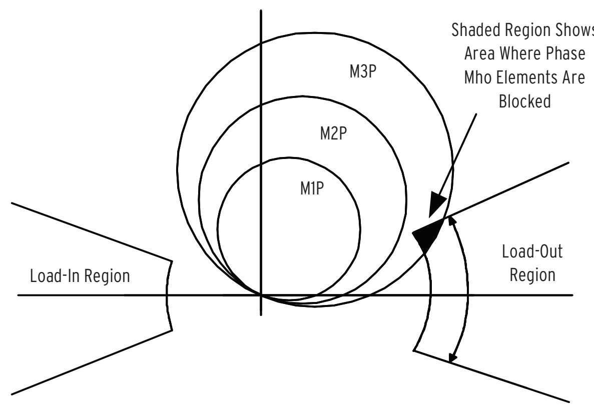


Figure 4 Load-Encroachment Characteristic

Overcurrent Elements

The SEL-311B includes three phase, three negative-sequence, and three ground instantaneous overcurrent elements with torque control and definite-time functions. The SEL-311B also includes one phase, one negative-sequence, and one ground inverse time-overcurrent element, each with torque control.

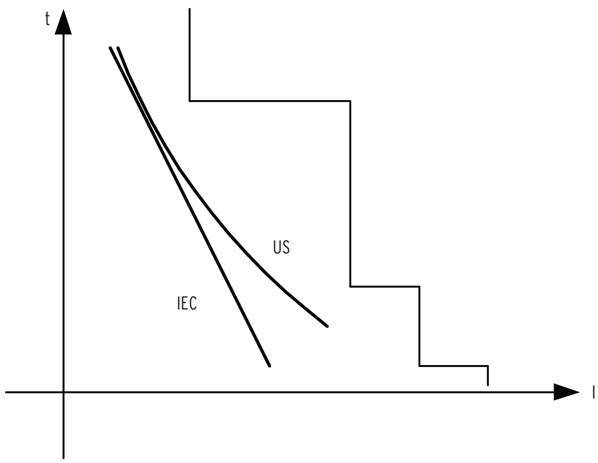


Figure 5 Instantaneous, Definite-Time, and Inverse Time-Overcurrent Characteristics

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

Table 1 Time-Overcurrent Curves

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

Directional Elements Increase Sensitivity and Security

Distance elements provide well-controlled reach. Directional overcurrent elements provide increased sensitivity. Use ground and negative-sequence directional overcurrent elements to detect high-resistance faults when using communications-assisted tripping schemes.

The SEL-311B includes a number of directional elements that are used to supervise overcurrent elements and distance elements. The negative-sequence directional element uses the same patented principle proven in our SEL-321 Relay. This directional element can be applied in virtually any application regardless of the amount of negative-sequence voltage available at the relay location.

Ground overcurrent elements are directionally controlled by three directional elements working together:

- Negative-sequence voltage-polarized directional element
- Zero-sequence voltage-polarized directional element
- Zero-sequence current-polarized directional element

Our patented Best Choice Ground Directional logic selects the best ground directional element for the system conditions and simplifies directional element settings. (You may override this automatic setting feature for special applications.)

Extra Protection and Control Using Under- and Overvoltage Elements

Phase undervoltage and overvoltage help you create protection and control schemes, such as:

- Hot-bus, dead-line, or hot-line, dead-bus recloser control.
- Blown transformer high-side fuse detection logic.
- Undervoltage load shedding.

Synchrophasors

The SEL-311B now includes phasor measurement technology that provides synchrophasor measurements throughout a power system. This technology in a protective relay reduces or eliminates incremental installation and maintenance costs while leaving system reliability unaffected. Incorporate present and future synchrophasor technology control applications without much effort into the same devices that protect and control the power system.

Metering and Monitoring

Complete Metering Capabilities

Extensive metering capabilities are provided by the SEL-311B, as shown in *Table 2*. Metering accuracies are provided in the *Specifications on page 19*.

Table 2 Metering Capabilities

Quantities	Description
Currents $I_{A,B,C,P}$, I_G	Input currents and Residual ground current ($I_G = 3I_0 = I_A + I_B + I_C$)
Voltages $V_{A,B,C}$, V_S	Wye-connected and Synchronism-check voltage inputs
Power $MW_{A,B,C,3P}$, $MVAR_{A,B,C,3P}$	Single-phase and three-phase megawatts and megavars
Energy $MWh_{A,B,C,3P}$, $MVARh_{A,B,C,3P}$	Single-phase and three-phase megawatt and megavar hours, in and out
Power Factor $PF_{A,B,C,3P}$	Single-phase and three-phase power factor
Sequence I_1, $3I_2$, $3I_0$, V_1, V_2, $3V_0$	Positive-, negative-, and zero-sequence currents and voltages
Frequency FREQ (Hz)	Instantaneous power system frequency (monitored on channel V_A)
Power Supply Vdc	Battery voltage
Demand and Peak Currents $I_{A,B,C,G}$, $3I_2$	Phase, ground, and negative-sequence currents
Demand and Peak Power $MW_{A,B,C,3P}$, $MVAR_{A,B,C,3P}$	Single- and three-phase megawatts and megavars, in and out

Event Reporting and Sequential Events Recorder (SER)

Event Reports and Sequential Events Recorder features simplify post-fault analysis and help you improve your understanding of simple and complex protective scheme operations. They also aid in testing and troubleshooting relay settings and protection schemes.

Event Reports

In response to a user-selected trigger, the voltage, current, 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: 1/4-cycle or 1/16-cycle resolution, filtered, or raw analog data. For each report the relay stores the most recent 15, 30, 60, or 180 cycles of data in nonvolatile memory. The relay stores a total of 11 seconds of event report data. Relay settings are appended to the bottom of each event report.

Event report information can be used in conjunction with the SEL-5601-2 SYNCHROWAVE® Event Software to produce oscillographic type reports suitable for inclusion in analysis documents and reports.

Event Summary

Each time the relay generates a standard event report, it also generates a corresponding Event Summary. This is a concise description of an event that includes the following information:

- Relay identification
- Event date and time
- Event type
- Fault location
- Recloser shot count at time of trigger
- System frequency at time of trigger
- Fault type at time of trip
- Pre-fault and fault phase and polarizing current levels
- Pre-fault and fault calculated zero- and negative-sequence currents
- Phase voltages
- ALARM status
- Status of all MIRRORED BITS channels
- Trip and close times of day
- Breaker status (open/close)

With an appropriate setting, the relay will automatically send an Event Summary in ASCII text to one or more serial ports each time an event report is triggered.

Sequential Events Recorder (SER)

The relay SER stores the latest 512 entries. Use this feature to gain a broad perspective of relay element operation. Items for triggering an SER entry include: input/output change of state, element pickup/dropout, recloser state changes, etc.

The IRIG-B time-code input synchronizes the SEL-311B Relay SER time stamps to within ±5 ms of the time-source input. A convenient source for this time code is the SEL-2032 or SEL-2030 Communications Processor (via Serial Port 2 on the SEL-311B).

Synchrophasor Measurements

Upgrade System Models

Send synchrophasor data using SEL Fast Message protocol to SEL communications processors, or to SEL-5077 SYNCHROWAVE Server phasor data concentration software, or to an 24-3306 Synchrophasor Processor. Data rates of as much as one message per second with an accuracy of ±1 electrical degree provide for real-time visualization.

The SEL-5077 SYNCHROWAVE Server software and the 24-3306 Synchrophasor Processor time correlate data from multiple SEL-311 relays and other phasor measurement and control units (PMCUs). Then, the SEL-5077 sends the concentrated data to visualization tools, such as the SEL-5078-2 SYNCHROWAVE Central Visualization and Analysis Software, for use by utility operations.

Use SEL-2032 or SEL-2030 Communications Processors to collect synchrophasor data from multiple SEL-311 relays and incorporate the data into traditional SCADA and EMS systems. Traditional power system models are created based on measurements of voltages and power flows at different points on the system. The system state is then estimated based on a scan of these values and an iterative calculation. The state estimation includes an inherent error caused by measurement inaccuracies, time delays between measurements, and model simplifications. Synchrophasor measurements reduce error and change state estimation into state measurement. The time required for iterative calculation is minimized, and system state values can be directly displayed to system operators and engineers.

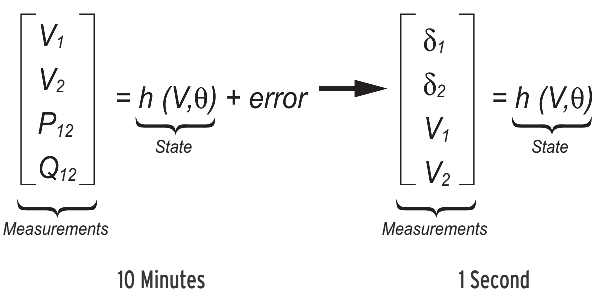


Figure 6 Synchrophasor Measurements Turn State Estimation Into State Measurement

Improve Situational Awareness

Provide improved information to system operators. Advanced synchrophasor-based tools provide a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

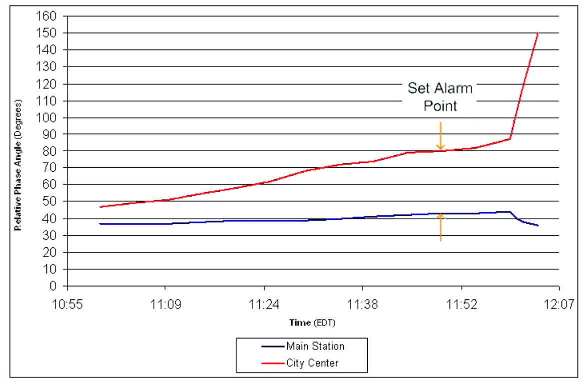


Figure 7 Visualization of Phase Angle Measurements Across a Power System

- ➤ Increase system loading while maintaining adequate stability margins.
- ➤ Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
- ➤ Advance system knowledge with correlated event reporting and real-time system visualization.
- ➤ Validate planning studies to improve system load balance and station optimization.

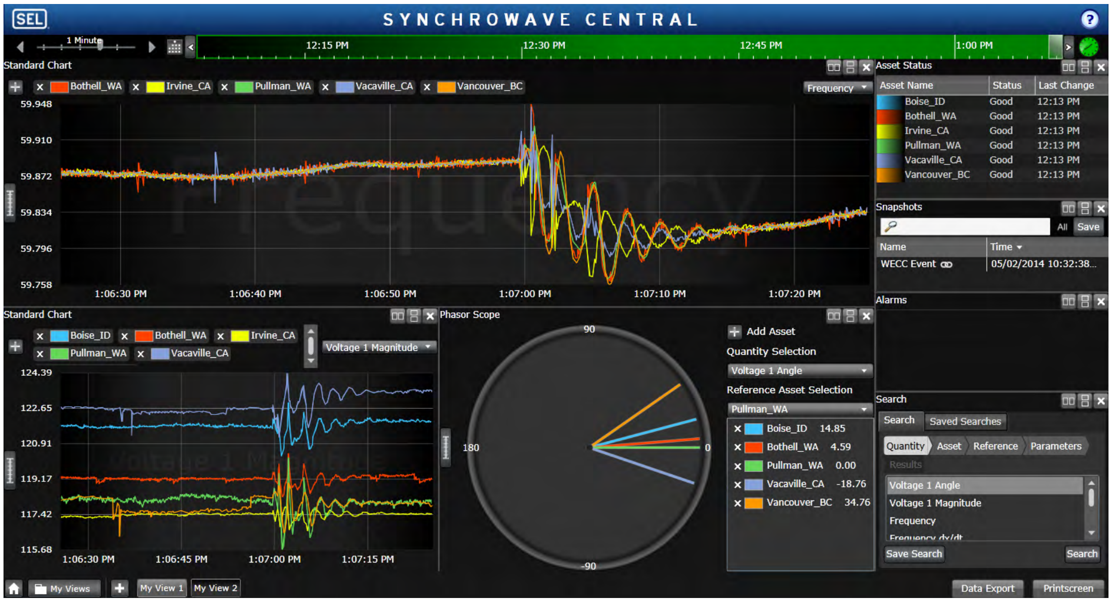


Figure 8 SYNCHROWAVE Central Real-Time Wide-Area Visualization Tool

Substation Battery Monitor for DC Quality Assurance

The SEL-311B measures and reports the substation battery voltage presented to its power supply terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails, the measured dc voltage falls below a programmable threshold and operations personnel are then notified before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with an SEL communications processor and trigger messages, telephone calls, or other actions.

The measured dc voltage is reported in the `METER` display via serial port communications, on the optional LCD, and in the event report. Use the event report data to see an oscillographic display of the battery voltage. You can see how much the substation battery voltage drops during trip, close, and other control operations.

Reclosing Relay

Four-Shot Recloser Handles Your Application Today and Tomorrow

Internal element status or external inputs can condition the recloser to match your practice:

- ➤ Reclose initiate (e.g., breaker status, fault type, trip).
- ➤ Drive-to-lockout or last shot (e.g., input from manual or SCADA open).
- ➤ Skip shot (use 27/59 elements, fault current magnitude).
- ➤ Stall open-interval timing.
- ➤ Separate times to reset from cycle or lockout.

The recloser shot counter can control which protective elements are involved in each reclose interval. Front-panel LEDs track the recloser state: Reset (**RS**) and Lockout (**LO**).

Fault Locator

The SEL-311B provides an accurate fault location calculation even during periods of substantial load flow. The fault locator uses fault type, replica line impedance settings, and fault conditions to calculate fault location without communications channels, special instrument transformers, or pre-fault information. This feature contributes to efficient dispatch of line crews and fast restoration of service.

The fault location information is provided in the event reports and event summaries.

Automation

Flexible Control Logic and Integration Features

Use the SEL-311B control logic to:

- ➤ Replace traditional panel control switches.
- ➤ Eliminate RTU-to-relay wiring.
- ➤ Replace traditional latching relays.
- ➤ Replace traditional indicating panel lights.

Use the SEL-311B relay control logic to:

- ➤ Replace traditional panel control switches.
- ➤ Eliminate RTU-to-relay wiring.
- ➤ Replace traditional latching relays.
- ➤ Replace traditional indicating panel lights.

Eliminate traditional panel control switches with 16 local control points. Set, clear, or pulse local control points with the optional front-panel pushbuttons and display. Program the local control points into your control scheme via SELOGIC control equations. Use the local control points to trip test, enable/disable reclosing, trip/close the breaker, and so on.

Control relay logic with 16 remote control points. Set, clear, or pulse remote control points via serial port commands. Program the remote control points into your control scheme via SELOGIC control equations. Use remote control points for SCADA-type control operations: trip, close, settings group selection, etc.

Replace traditional latching relays for such functions as "remote control enable" with 16 latching control points. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the latch control points via optoisolated inputs, remote control points, local control points, or any programmable logic condition. The latch control points retain their state when the relay loses power.

Replace traditional indicating panel lights with 16 programmable text displays. Define custom messages (e.g., `BREAKER OPEN`, `BREAKER CLOSED`, `RECLOSER ENABLED`) to report power system or relay conditions on the optional LCD. Control which messages are displayed via SELOGIC control equations; drive the LCD display via any logic point in the relay.

Serial Communications

- ➤ Three EIA-232 serial ports and one isolated EIA-485 serial port. Each serial port operates independently of the other serial ports.
- ➤ Full access to event history, relay status, and meter information from the serial ports.
- ➤ Settings and group switching have password control.
- ➤ DNP3 Level 2 Slave protocol with point mapping (optional).
- ➤ Open communications protocols (see *Table 3*).

The relay does not require special communications software. Dumb terminals, printing terminals, or a computer supplied with terminal emulation and a serial communications port is all that is required. Establish communication by connecting computers, modems, protocol converters, printers, an SEL communications processor, SCADA serial port, and/or RTU for local or remote communication.

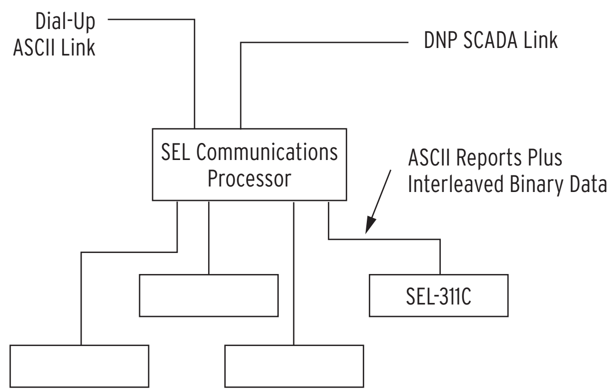


Figure 9 Example Communications System

The SEL communications processor is often applied as the hub of a star network, with point-to-point wire or fiber connection between the hub and the SEL-311B. Wire connections of up to 30 to 50 feet are made with EIA-232 cable connected directly into the 9-pin serial ports of the relay and the communications processor. For connections up to 500 meters, or where a conductive connection is not desirable, use the SEL-2800 or SEL-2810 Fiber-Optic Transceiver. Fiber-optic cable assemblies, built to your length specifications, are available from SEL. Or, you can build your own cable in minutes by installing ready-to-use terminations using simple hand tools; no epoxy or polishing is needed. These two transceivers are powered from the serial port so no external power supply connection is needed. The SEL-2810 provides the same reliable communications as the SEL-2800 with the added benefit of sending a demodulated IRIG-B time-code from the communications procedure. The communications processor supports external communications links including the public switched telephone network for engineering access to dial-out alerts and private line connections to your SCADA system.

Table 3 Open Communications Protocols

Type	Description
Simple ASCII	Plain-language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows an external device to obtain relay data in a format that directly imports into a spreadsheet or database program. Data are checksum protected.
Extended Fast Meter	Binary protocol for machine-to-machine communications. Quickly updates the SEL-2032, SEL-2030, or SEL-2020, an RTU, and other substation devices with metering information, relay element, input and output statuses, time-tags, open and close commands, sequence of events records, and summary event reports. Data are checksum protected. Binary and ASCII protocol operates simultaneously over the same communications lines such that control operator metering information is not lost while a technician is transferring an event report.
LMD	Enables multiple SEL devices to share a common communications bus (two character address setting range is 01 to 99). Use LMD for low-cost, port-switching applications.
DNP	Distributed Network Protocol (DNP3) Level 2 Slave.

Effective Breaker Maintenance Scheduling

Circuit breakers experience mechanical and electrical wear every time they operate. Effective scheduling of breaker maintenance takes into account the manufacturer's published data of contact wear, interruption levels, and operation count. The SEL-311B breaker monitor feature compares the breaker manufacturer's published data to the interrupted current.

Each time a monitored breaker trips, the relay integrates the interrupted current with previously stored current values. When the results exceed the threshold set by the breaker wear curve (*Figure 10*), the relay initiates an alarm via an output contact or the front-panel display. The typical settings shown in *Figure 10* are as follows:

- ➤ Set Point 1 approximates the continuous load current rating of the breaker
- ➤ Set Point 3 is the maximum rated interrupting current for the particular breaker
- ➤ Set Point 2 is some intermediate current value that provides the closest visual "fit" to the manufacturer's curve

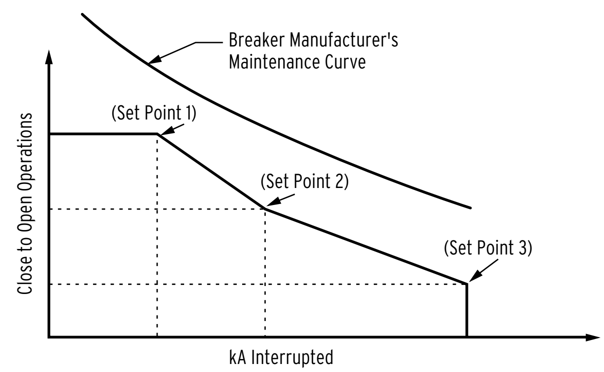


Figure 10 Breaker Contact Wear Curve and Settings

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

Unique Capabilities

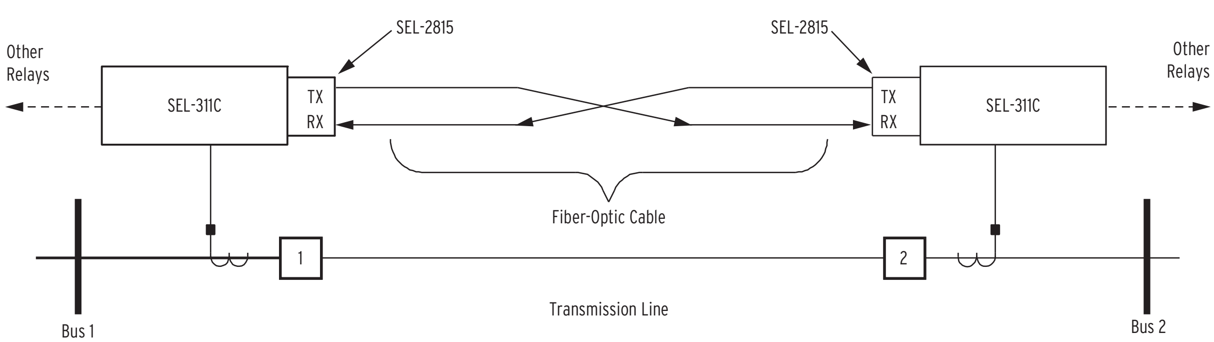


Figure 11 Integral Communications Provide Secure Protection, Monitoring, and Control

Relay-to-Relay Digital Communications (Mirrored Bits)

The SEL patented Mirrored Bits technology provides bidirectional relay-to-relay digital communications. In the SEL-311B, Mirrored Bits can operate simultaneously on any two serial ports, for three-terminal operation.

This bidirectional digital communication creates eight additional outputs (transmitted Mirrored Bits) and eight additional inputs (received Mirrored Bits) for each serial port operating in the Mirrored Bits mode. These Mirrored Bits can be used to transfer information between line terminals to enhance coordination and achieve faster tripping. Mirrored Bits also help reduce total scheme operating time by eliminating the need to close output contacts and debounce contact inputs. Use the dual-port Mirrored Bits capabilities for high-speed direct transfer trip schemes, breaker failure schemes, and transformer-terminated lines.

Advanced SELogic Control Equations

Advanced SELogic control equations put relay logic in the hands of the protection engineer. Assign the relay inputs to suit your application, logically combine selected relay elements for various control functions, and assign outputs to your logic functions.

Programming SELogic control equations consists of combining relay elements, inputs, and outputs with SELogic control equation operators. Any element in the Relay Word can be used in these equations.

The SELogic control equation operators include the following: OR, AND, invert, parentheses, and rising and falling edges of element state changes.

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

Six Independent Setting Groups Increase Operation Flexibility

The relay stores six setting groups. Select the active setting group by contact input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies. Selectable setting groups make the SEL-311B ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

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

Loss-of-Potential (LOP) Logic Supervises Directional Elements

The SEL-311B includes logic that detects blown potential fuses. Loss-of-potential affects distance and directional element performance. Simple user settings configure LOP logic to either block or enable-forward ground and phase directional elements and disable distance elements.

The LOP logic is based upon measuring a degree in the magnitude of positive-sequence voltage without a simultaneous change (magnitude or angle) in either the positive-sequence or zero-sequence currents. The system is faster than the Zone 1 distance units, so the overcurrent supervision elements can be set below minimum fault current (or even to minimum setting) without concern of being above maximum load. No voltage or current settings are made by the user and no system knowledge is required.

Additional Features

Front-Panel User Interface

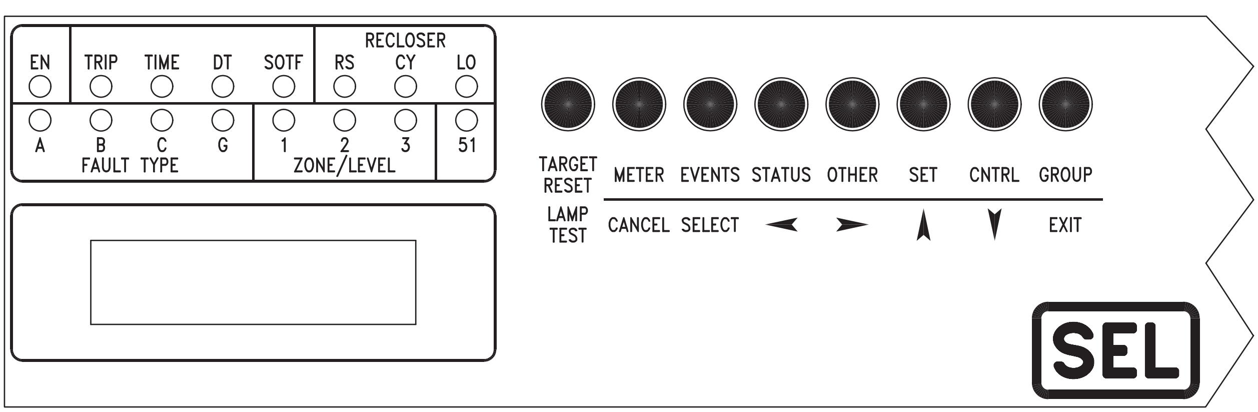


Figure 12 Status and Trip Target LEDs, Front-Panel Display and Pushbuttons

A close-up view of the user interface portion of the SEL-311B front panel is shown in *Figure 12*. It includes an optional two-line, 16-character LCD, 16 LED target indicators, and 8 pushbuttons for local communication.

Front-Panel Display

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

The LCD is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed Display Points. The default display scrolls through any active, nonblank Display Points. If none are active, the relay displays the A-, B-, and C-phase currents in primary quantities. Each display remains for five seconds, before scrolling continues. Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The {EXIT} pushbutton returns the display to the default display.

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

During power up the current will be displayed until the relay is enabled. When the EN LED indicates the relay is enabled, the active Display Points will be scrolled.

Contact Inputs and Outputs

The model SEL-311B includes eight output contacts and six optoisolated inputs. Assign the contact inputs for control functions, monitoring logic, and general indication. Except for a dedicated alarm output, each contact output is programmable using SELOGIC control equations. All output contacts are rated for 30 A trip duty.

Status and Trip Target LEDs

The SEL-311B includes 16 status and trip target LEDs on the front panel. These targets are shown in *Figure 13* and explained in *Table 4*.

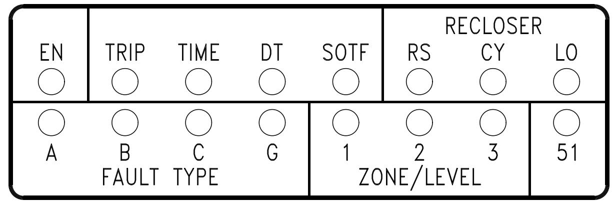


Figure 13 Status and Trip Target LEDs

Table 4 Description of LEDs

Target LED	Function
EN	Relay powered properly and self-tests okay
TRIP	Indication that a trip occurred
TIME	Time-delayed trip
COMM	Communications-assisted trip
SOTF	Switch-onto-fault trip
RECLOSER	
RS	Ready for reclose cycle
LO	Control in lockout state
51	Time-overcurrent element trip
FAULT TYPE	
A, B, C	Phases involved in fault
G	Ground involved in fault
ZONE/LEVEL	
1–4	Trip by Zone 1–4 distance elements and/or Level 1–4 overcurrent elements

Wiring Diagram With Dual Terminal Labels

For installation in systems with drawings designed for SEL-221 relays, use the numeric terminal labels provided.

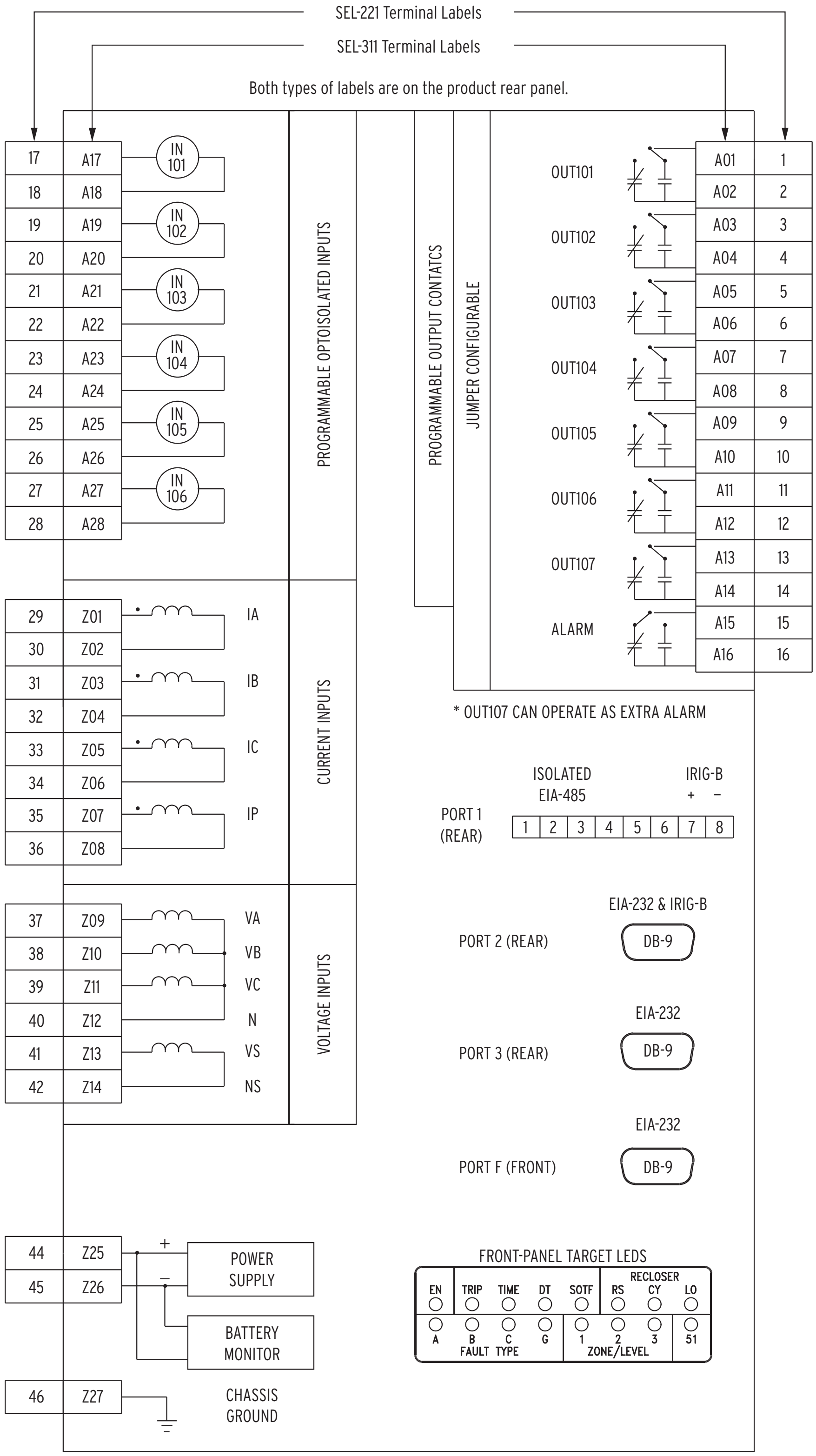


Figure 14 SEL-311B Inputs, Outputs, and Communications Ports

Front- and Rear-Panel Diagrams

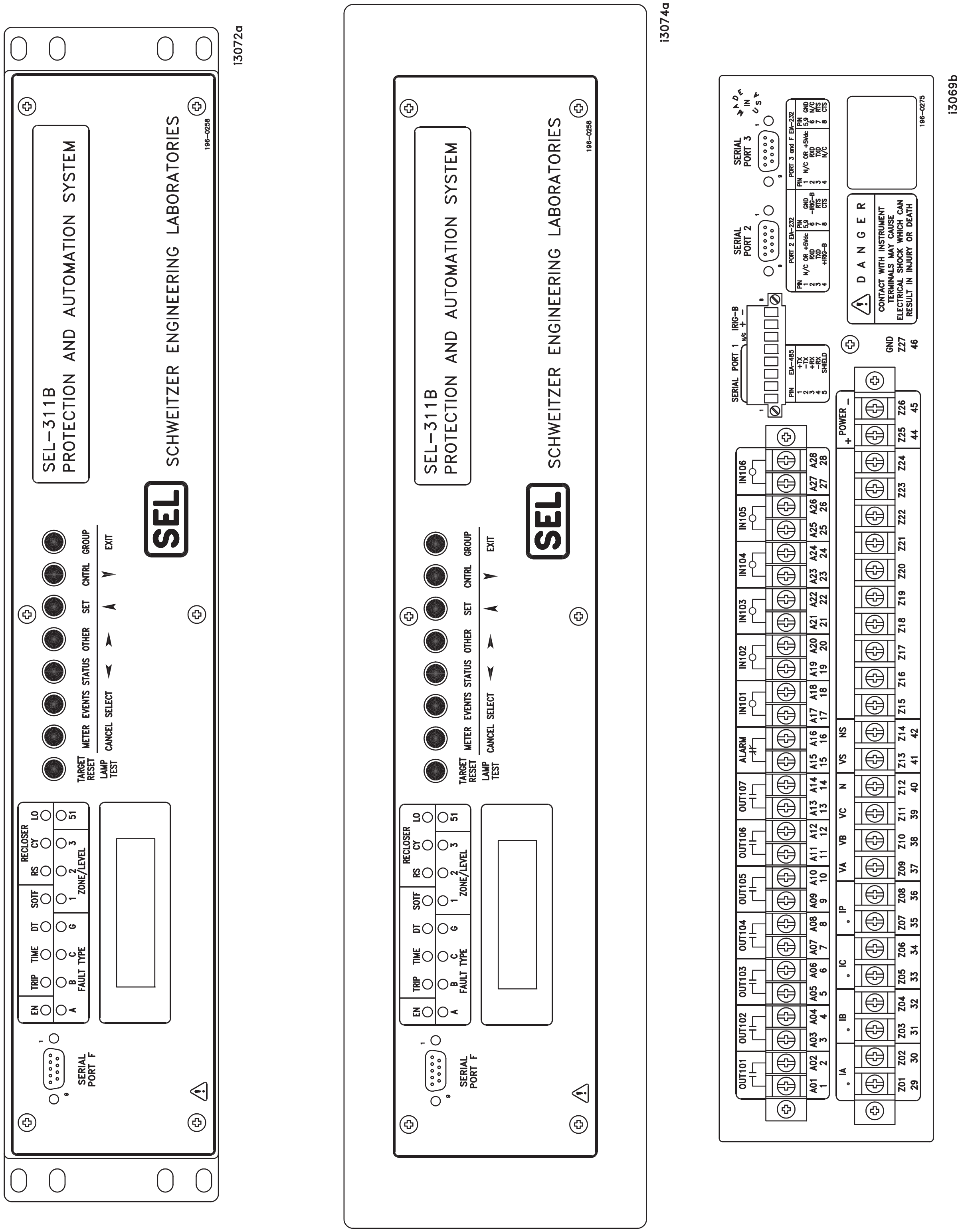


Figure 15 SEL-311B Front- and Rear-Panel Drawings—Models 0311B00H2 (Rack) and 0311B0032 (Panel)

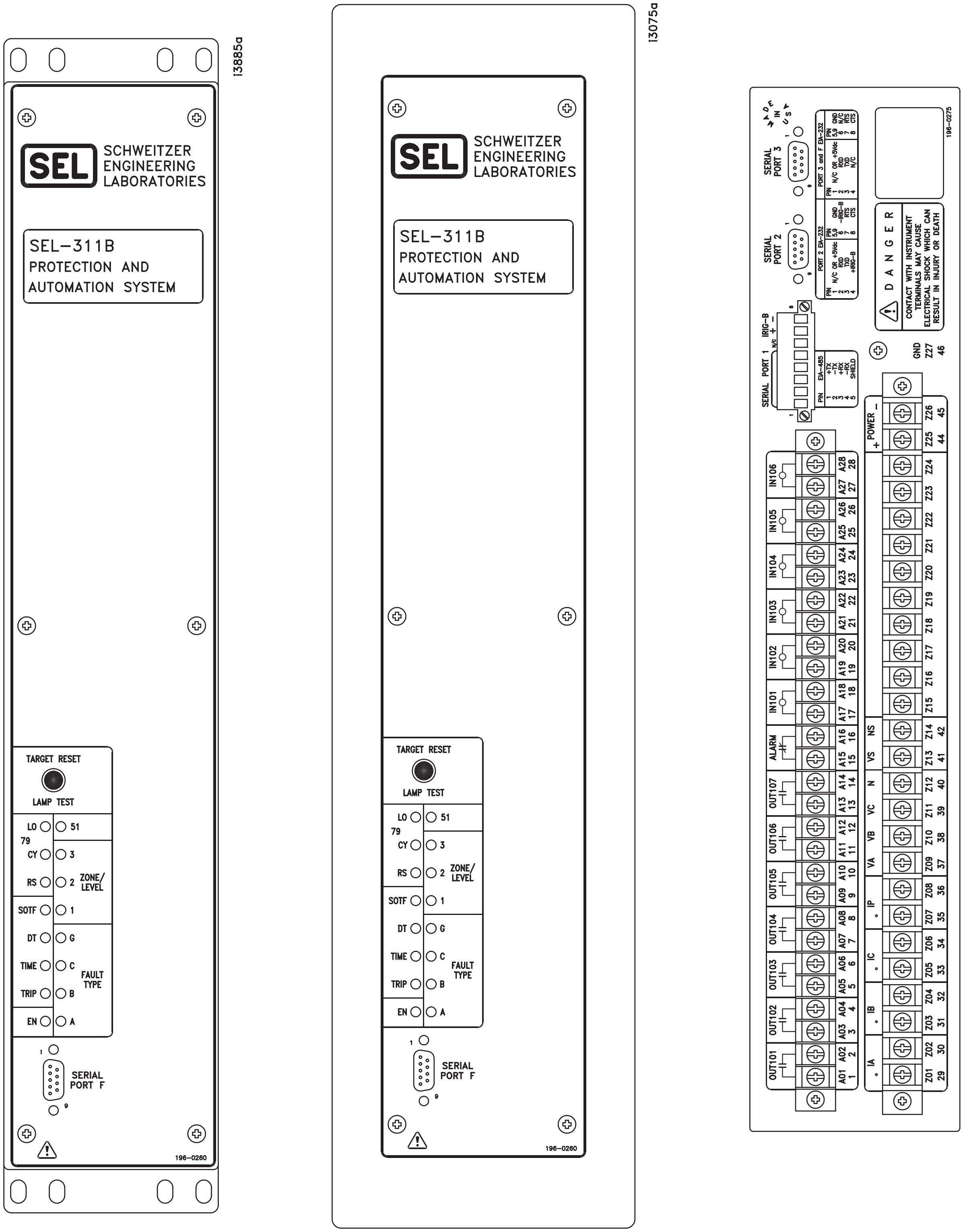


Figure 16 SEL-311B Front- and Rear-Panel Drawings—Models 0311B00V1 (Rack) and 0311B0041 (Panel)

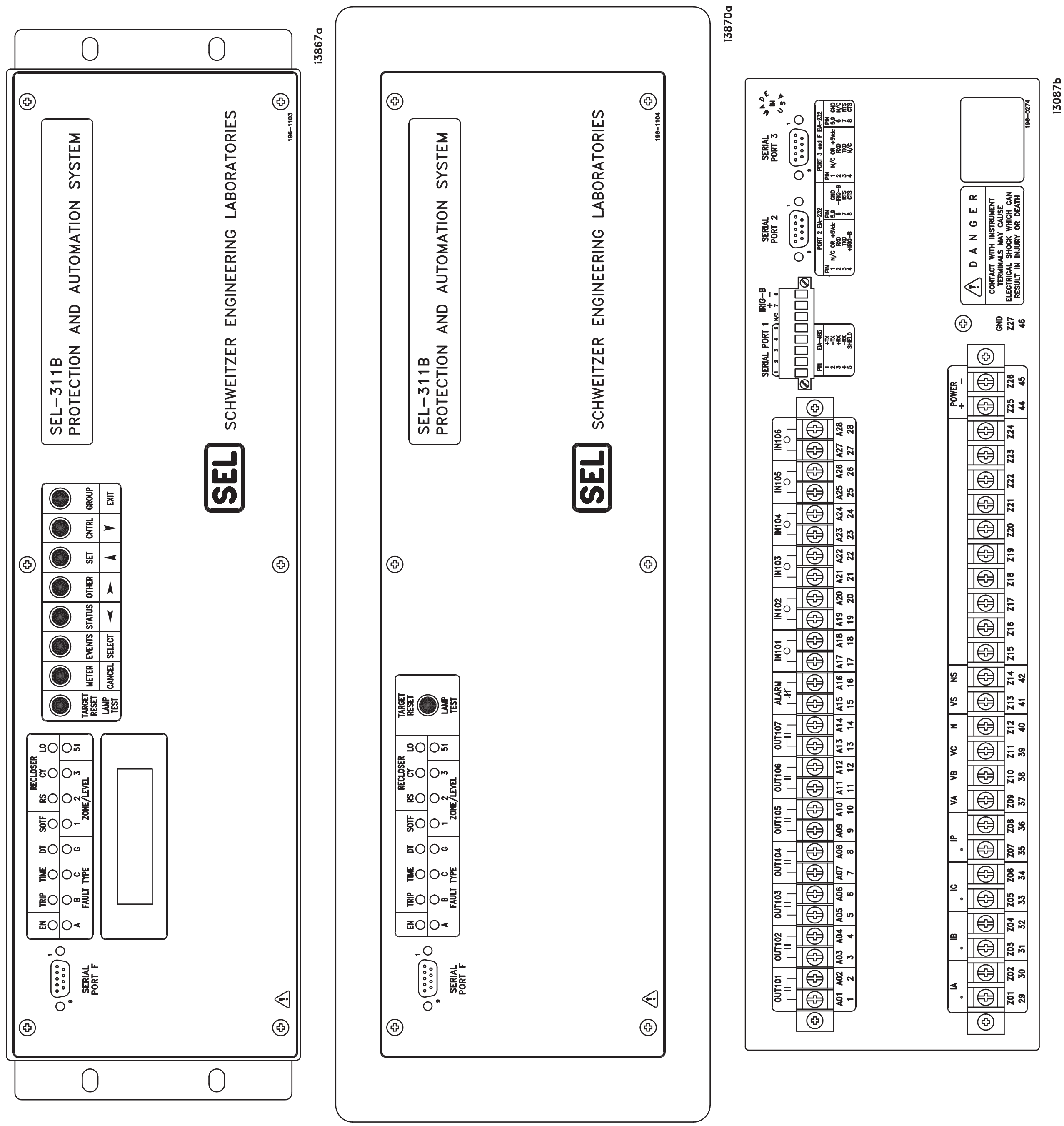


Figure 17 SEL-311B Front- and Rear- Panel Drawings—Models 0311B01H2 (Rack) and 0311B0131 (Panel)

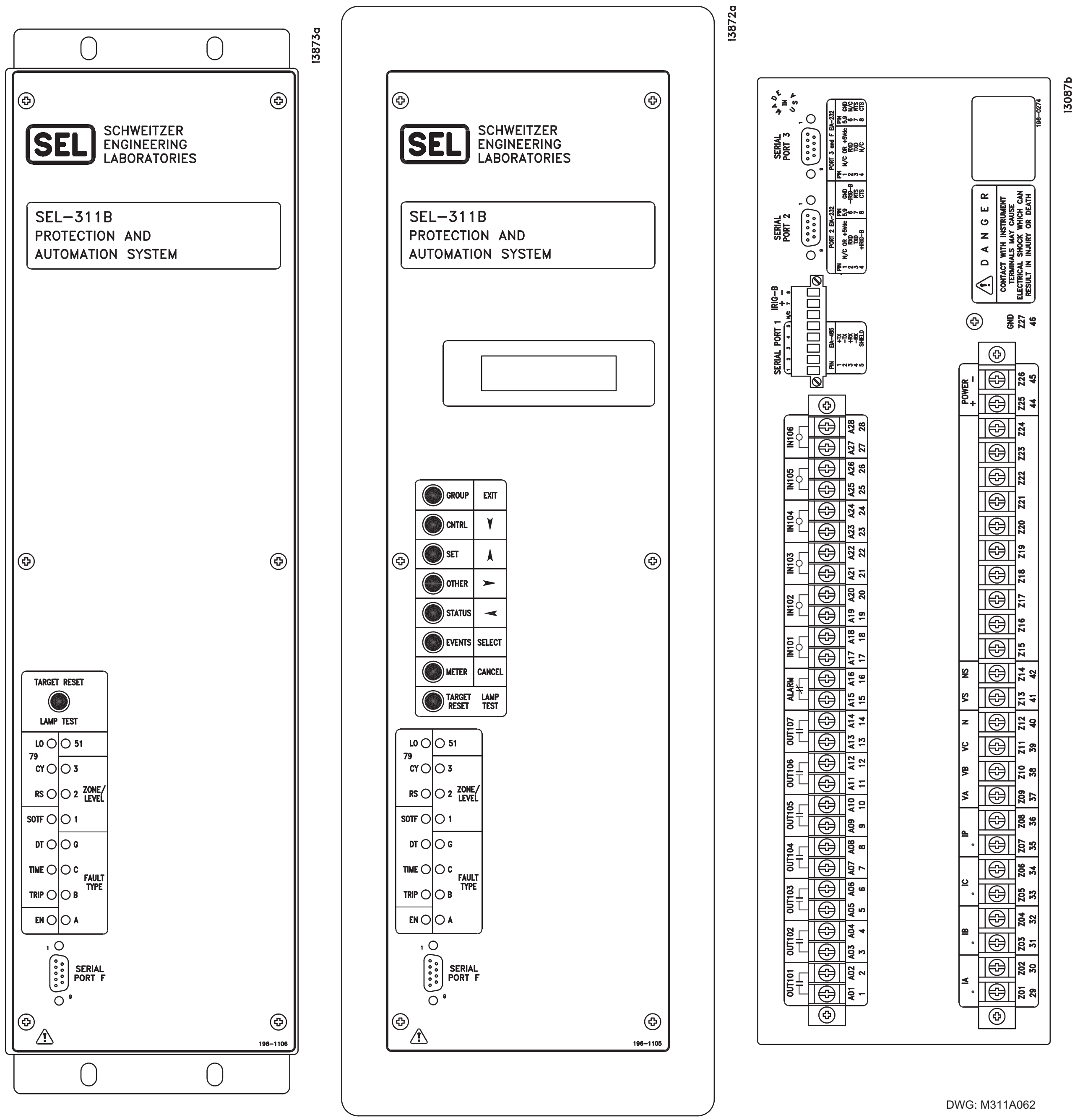


Figure 18 SEL-311B Front- and Rear-Panel Drawings—Models 0311B01V1 (Rack) and 0311B0142 (Panel)

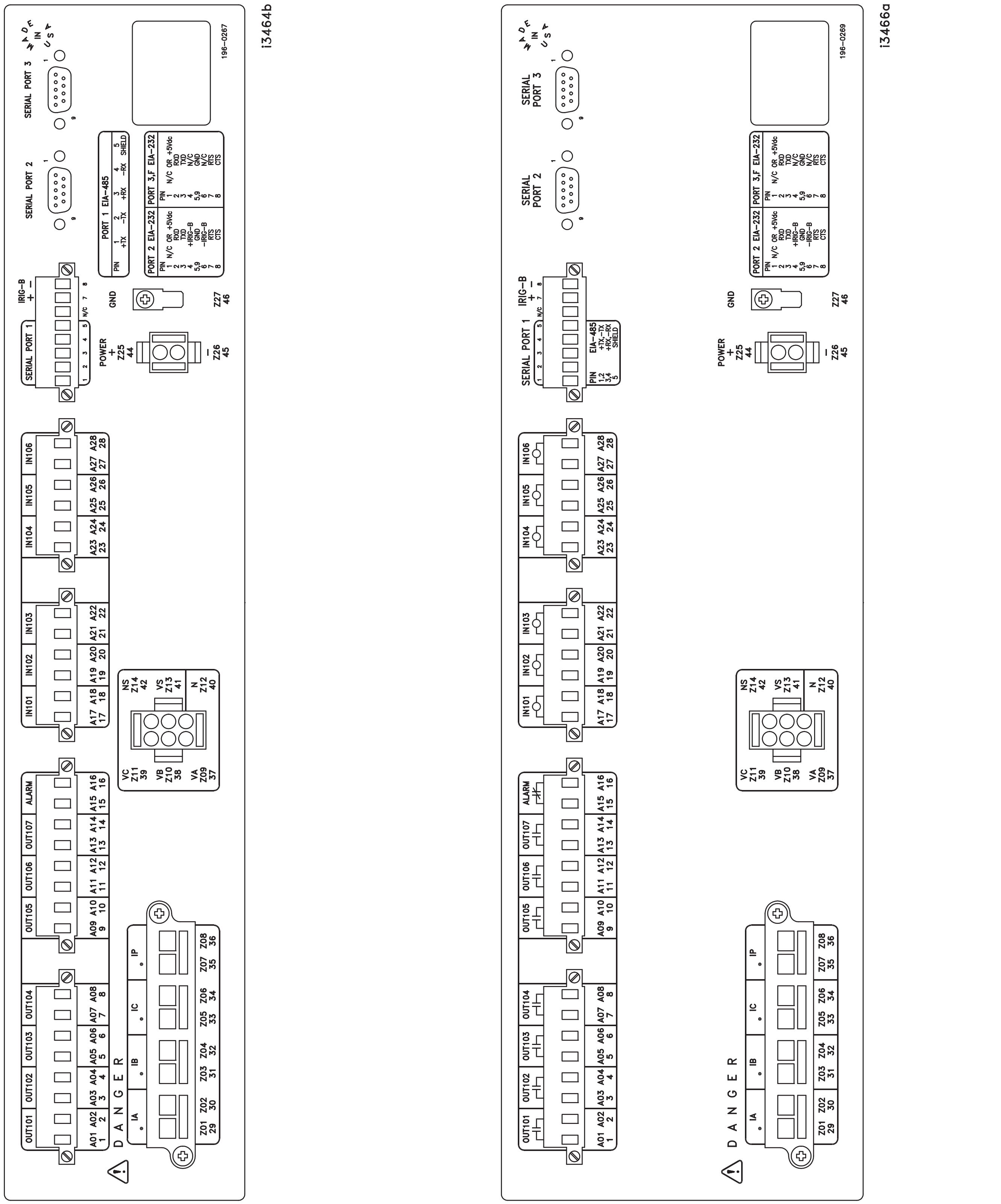
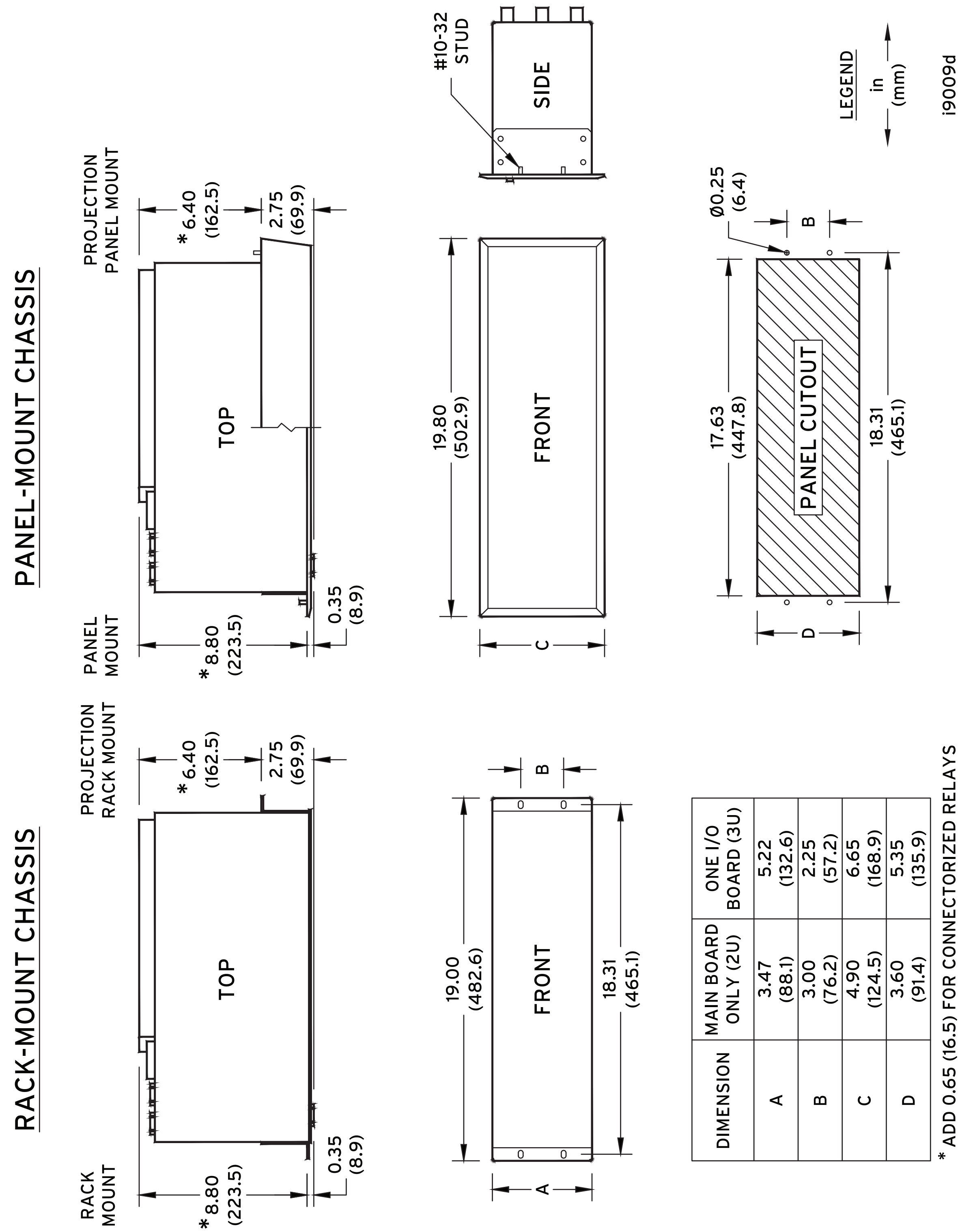


Figure 19 SEL-311B Connectorized® 2U and 3U Rear-Panel Drawing

Relay Dimensions



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

* ADD 0.65 (16.5) FOR CONNECTORIZED RELAYS

For projection rack mounting, brackets must be reversed.

Figure 20 SEL-311B Dimensions for Rack- and Panel-Mount Models

Specifications

Important: Do not use the following specification information to order an SEL-311B. Refer to the actual ordering information sheets.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
CE Mark

General

AC Current Inputs

Nominal:	5 A
Continuous:	15 A, 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
Nominal:	1 A
Continuous:	3 A, 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

AC Voltage Inputs

Nominal:	67 V_{L-N}, three-phase four-wire connection
Continuous:	150 V_{L-N} (connect any voltage up to 150 Vac) 365 Vac for 10 seconds
Burden:	0.13 VA @ 67 V 0.45 VA @ 120 V

Power Supply

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Rated:	48/125 Vdc or 125 Vac
Range:	38–200 Vdc or 85–140 Vac
Burden	<25 W
Rated:	24/48 Vdc
Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Output Contacts

Standard

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	270 Vac, 360 Vdc, 130 J
Pickup Time:	<5 ms

Breaking Capacity (10000 operations):

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 Capacity (2.5 cycles/second):

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

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.
Note: 220 Vdc optoisolated inputs are not available in the Connectorized® version of the relay.

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC or ACB
Frequency Tracking Range:	40.1–65 Hz

Note: V_A required for frequency tracking.

Communications Ports

EIA-232:	1 Front and 2 Rear
EIA-485:	1 Rear, 2100 Vdc isolation
Baud Rate:	300–38400 (Port 1 Baud Rate 300–19200)

Terminal Connections

Rear Screw-Terminal Tightening Torque:

Terminal Block	
Minimum:	9-in-lb (1.1 Nm)
Maximum:	12-in-lb (1.3 Nm)
Connectorized	
Minimum:	5-in-lb (0.6 Nm)
Maximum:	7-in-lb (0.8 Nm)

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

Routine Dielectric Test

Voltage/Current inputs:	2500 Vac for 10 s
Power supply, optoisolated inputs, and output contacts:	3000 Vdc for 10 s

The following IEC 60255-5 Dielectric Tests–1977 are performed on all units with the CE mark:
2500 Vac for 10 s on analog inputs
3100 Vdc for 10 s on power supply, optoisolated inputs, and output contacts.

Time-Code Input

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

Synchronization (specification is with respect to the accuracy of the time source)

Synchrophasor:	±10 µs
Other:	±5 ms

Operating Temperature

–40° to +85°C (–40° to +185°F)

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

Weight

2U rack unit:	13 lb (5.92 kg)
3U rack unit:	16 lb (7.24 kg)

Type Tests

Environmental Tests

Cold:	IEC 60068-2-1:2007, Test Ad; 16 hr. @–40°C
Damp Heat Cyclic:	IEC 60068-2-30:2005, Test Db; 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:2007, Test Bd; 16 hr. @ +85°C
Object Penetration:	IEC 60529:201, IP30

Emissions Tests

Emissions:	IEC 60255-25:2000

EMC Immunity Tests

ESD:	IEC 60255-22-2:2008, Severity Level 4 (8 kV contact, 15 kV air) IEC 61000-4-2:2008
Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 61000-4-4:1995, Severity Level 4 (4 kV on power supply, 2 kV on inputs and outputs)
Radiated Radio Frequency:	IEC 60255-22-3:2007 IEEE C37.90.2-2004, 35 V/m
Surge Withstand:	IEEE C37.90.1-2002 2.5 kV oscillatory; 4.0 kV transient IEC 60255-22-1:2007, Severity Level 3 (2.5 kV common and 1 kV differential mode)
Conducted RF Immunity:	IEC 60255-22-6:2001 IEC 61000-4-6:2008
Digital Radio Telephone:	ENV 50204:1995
Surge Immunity:	IEC 60255-22-5:2008
Power Supply Immunity:	IEC 60255-11:1979 IEC 61000-4-11:2004

Vibration and Shock Tests

Vibration:	IEC 60255-21-1:1988, Class 1 IEC 60255-21-2:1988, Class 1 IEC 60255-21-3:1993, Class 2

Insulation Tests

Dielectric Strength and Impulse:	IEC 60255-5:2000 IEEE C37.90:2005

Processing Specifications

AC Voltage and Current Inputs

16 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 560 Hz.

Digital Filtering

One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing

4 times per power system cycle

Relay Element Settings Ranges and Accuracies

Metering Accuracy

Voltages

V_A, V_B, V_C, V_S, V_1, V_2, $3V_0$:	±2% (33.5–150 V)

Currents

I_A, I_B, I_C, I_P:	±1% (0.5 to 100.0 A) (5 A nominal) ±1% (0.1 to 20.0 A) (1 A nominal)
I_1, $3I_0$, $3I_2$:	±3% (0.25 to 100.0 A)(5 A nominal) ±3% (0.05 to 20.0 A) (1 A nominal)

Phase Angle Accuracy:	±1°
MW/MVAR:	±3%

Synchrophasor Accuracy

(Specification is with respect to **MET PM** command and SEL Fast Message Synchrophasor Protocol.)

Voltages	(33.5–150 V; 45–65 Hz)
Magnitudes:	±2%
Angles:	±1°
Currents	(0.50–1.25 A; 45–65 Hz) (5 A nominal) (0.10–0.25 A; 45–65 Hz) (1 A nominal)
Magnitudes:	±4%
Angles:	±1.5° @ 25°C ±2.0° over the full temperature range
Currents	(1.25–7.50 A; 45–65 Hz) (5 A nominal) (0.25–2.50 A; 45–65 Hz) (1 A nominal)
Magnitudes:	±2%
Angles:	±1.0° @ 25°C ±1.5° over the full temperature range

Substation Battery Voltage Monitor Specifications

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

Timer Specifications

Reclosing Relay Pickup:	0.00–999,999.00 cycles, 0.25-cycle steps
Other Timers:	0.00–16,000.00 cycles, 0.25-cycle steps
Pickup/Dropout Accuracy for All Timers:	±0.25 cycle and ±0.1% of setting

Mho Phase Distance Elements

Zones 1–3 Impedance Reach

Setting Range:	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal) Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone.
Accuracy:	±5% of setting at line angle for $30 \leq SIR \leq 60$ ±3% of setting at line angle for $SIR < 30$
Transient Overreach:	< 5% of setting plus steady-state accuracy

Zones 1–3 Phase-to-Phase Current Fault Detectors (FD)

Setting Range:	0.5–170.00 A_{P-P} secondary, 0.01 A steps (5 A nominal) 0.1–34.00 A_{P-P} secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	< 5% of pickup
Maximum Operating Time:	See pickup and reset time curves in *Figure 3.14* and *Figure 3.15* in the instruction manual.

Mho and Quadrilateral Ground Distance Elements

Zones 1–3 Impedance Reach

Mho Element Reach:	OFF, 0.05 to 64 Ω sec, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320 Ω sec, 0.01 Ω steps (1 A nominal)
Accuracy:	±5% of setting at line angle for $30 \leq SIR \leq 60$ ±3% of setting at line angle for $SIR < 30$
Transient Overreach:	<5% of setting plus steady-state accuracy

Zones 1–3 Phase and Residual Current Fault Detectors (FD)

Setting Range:	0.5–100.00 A secondary, 0.01 A steps (5 A nominal) 0.1–20.00 A secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Maximum Operating Time:	See pickup and reset time curves in *Figure 3.14* and *Figure 3.15* in the instruction manual.

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range:	OFF, 0.25–100.00 A, 0.01 A steps (5 A nominal) OFF, 0.05–20.00 A, 0.01 A steps (1 A nominal)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25-cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting
Maximum Operating Time:	See pickup and reset time curves in *Figure 3.14* and *Figure 3.15* in the instruction manual.

Time-Overcurrent Elements

Pickup Range:	0.25–16.00 A, 0.01 A steps (5 A nominal) 0.05–3.20 A, 0.01 A steps (1 A nominal)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Time Dial Range:	0.50–15.00, 0.01 steps (U.S.) 0.05–1.00, 0.01 steps (IEC)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup

Under- and Overvoltage Elements

Pickup Range:	OFF, 0.00–150.00 V, 0.01 V steps (phase elements) OFF, 0.00–260.00 V, 0.01 V steps (phase-to-phase elements)
Steady-State Pickup Accuracy:	±1 V and ±5% of setting
Transient Overreach:	<5% of pickup

Synchronism-Check Elements

Slip Frequency Pickup Range:	0.005–0.500 Hz, 0.001 Hz steps
Slip Frequency Pickup Accuracy:	±0.003 Hz
Phase Angle Range:	0–80°, 1° steps
Phase Angle Accuracy:	±4°

Notes

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