SEL-311A Protection and Automation System

Powerful Solutions for Transmission Line Protection

Major Features and Benefits

The SEL-311A Protection and Automation System is a basic, three-pole trip/reclose relay for transmission protection applications. The phase and ground protection elements provide 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 lines using two 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.
- **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

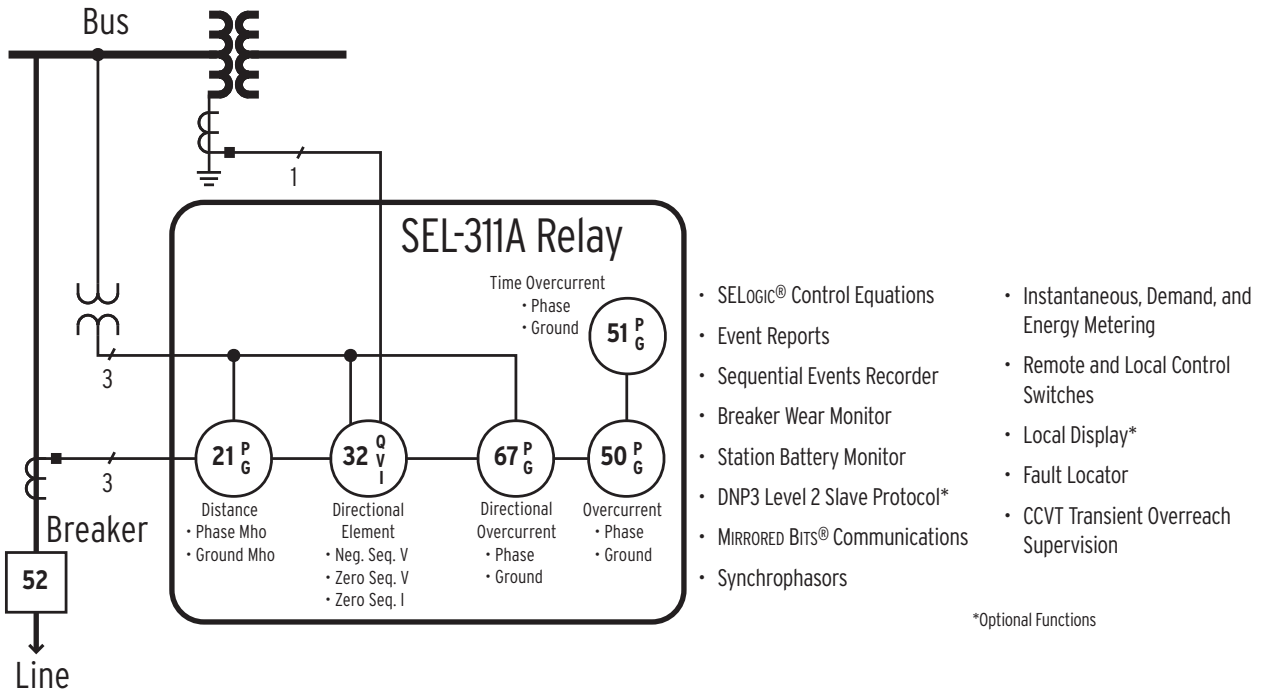


Figure 1 Functional Diagram

Protection Features

The SEL-311A Relay contains protective elements and control logic to protect overhead transmission lines and underground cables. It includes two 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.

An Application Template for the popular SEL-2PG10 Relay is included in addition to the setting groups. This template selection will limit the number and type of available settings to those similar to the SEL-2PG10. Terminal numbers are identical, simplifying migration to the SEL-311A.

Mho Distance Elements

The SEL-311A 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.

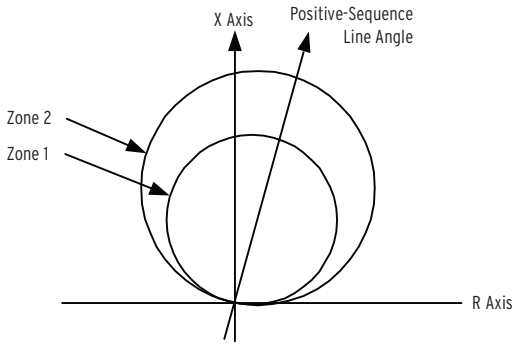


Figure 2 Phase and Ground Mho Distance Characteristics

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

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 exceeds the set relay reach, ZR.

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

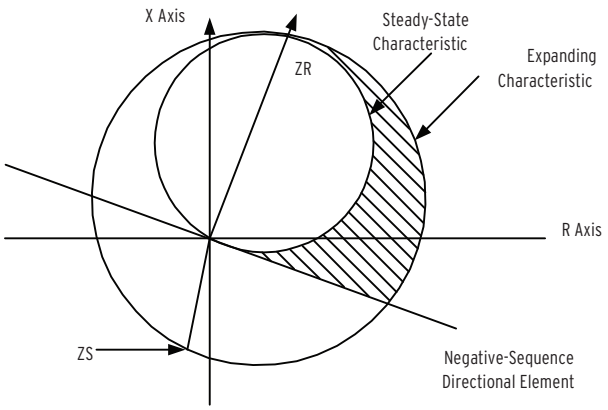


Figure 3 Phase-to-Phase Element Response for a Forward Phase-to-Phase Fault

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.

Load Encroachment

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

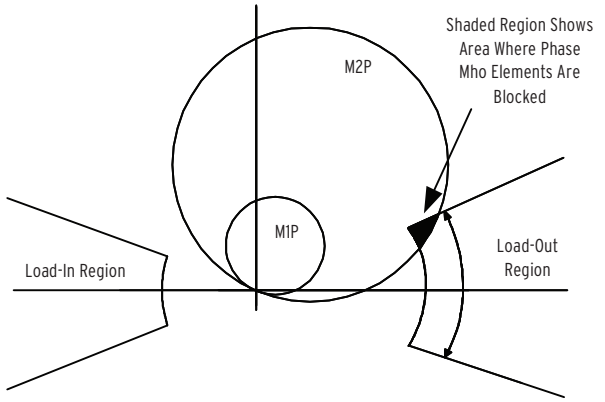


Figure 4 Load-Encroachment Characteristic

Overcurrent Elements

The SEL-311A includes one phase and one ground instantaneous overcurrent element with torque control and definite-time functions. The SEL-311A also includes one phase and one ground inverse time-overcurrent element, each with torque control.

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.

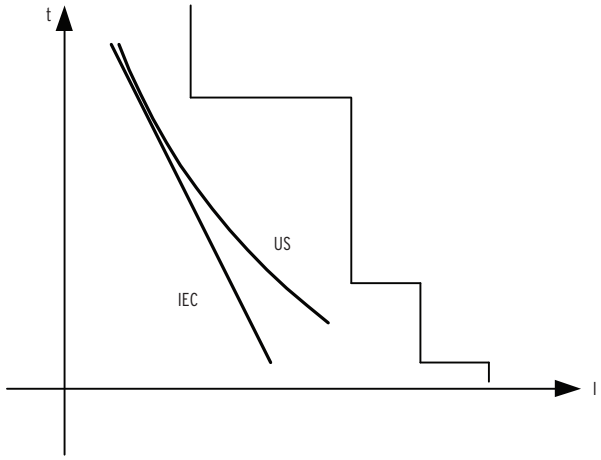


Figure 5 Instantaneous, Definite-Time, and Inverse Time-Overcurrent Characteristics

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.

The SEL-311A 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.)

Synchrophasors

The SEL-311A 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-311A, 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 $V_{A,B,C}$	Wye-connected 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. In addition to triggering an event report for relay trips, any element of the relay can trigger an event report. This includes the starting of overreaching zones of protection, external contact inputs to the relay, or relay monitors such as loss-of-potential. A complete list of possible internal triggers is found in the Relay Word table in *Section 9* of the *SEL-311A Instruction Manual*.

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

- 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 and tags with time and date the latest 512 entries. Use this feature to gain a broad perspective of relay element operation. Up to 72 elements can be included as SER triggers with all change of state recorded. Items for triggering an SER entry include: input/output change of state, element pickup/dropout, recloser state changes, etc. Other uses can be recording station access (through a contact input) or receipt of other station alarms. All relay power-ups and setting changes are also recorded.

The IRIG-B time-code input synchronizes the SEL-311A 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-311A).

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 SEL-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 SEL-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.

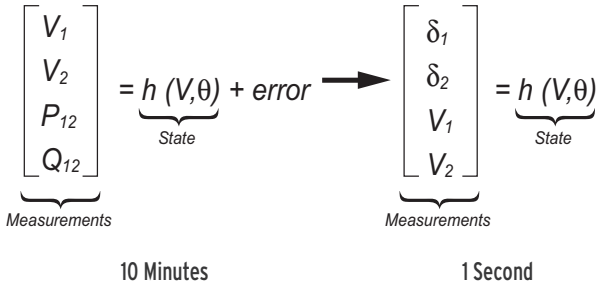


Figure 6 Synchrophasor Measurements Turn State Estimation Into State Measurement

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.

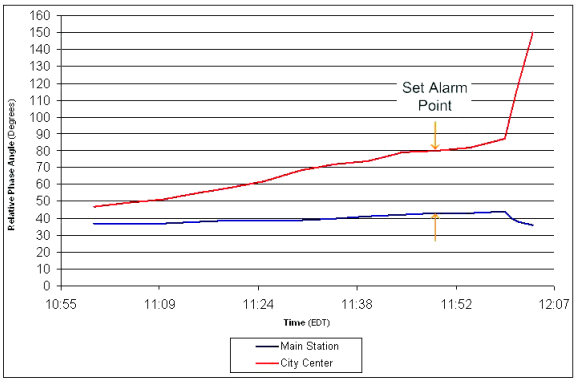


Figure 7 Visualization of Phase Angle Measurements Across a Power System

- 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.

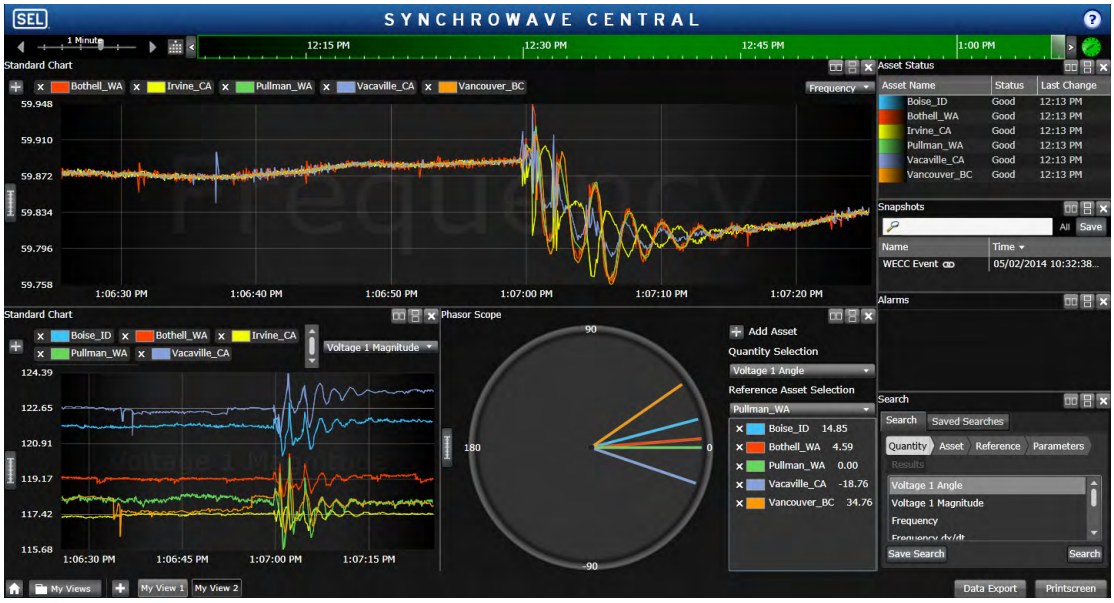


Figure 8 SYNCHROWAVE Central Real-Time Wide-Area Visualization Tool

Substation Battery Monitor for DC Quality Assurance

The SEL-311A 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.

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-311A breaker monitor feature compares the breaker manufacturer's published data to the interrupted current. Breaker wear data are stored on a per-pole basis to best represent the state of each breaker contact.

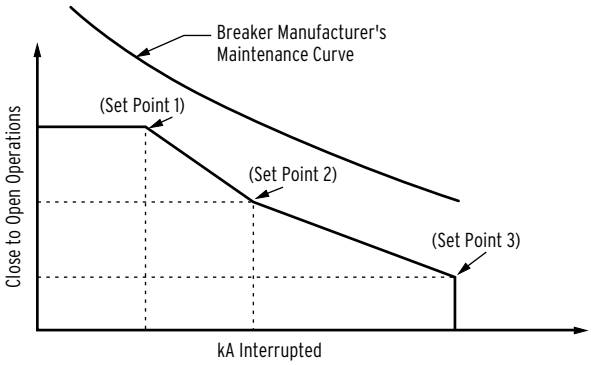


Figure 9 Breaker Contact Wear Curve and Settings

Every time the breaker trips, the interrupted current is integrated. When the result of this integration exceeds the threshold set by the breaker wear curve (*Figure 9*), the relay can alarm via the output contact or the optional front-panel display. With this information, breaker maintenance is scheduled in a timely, economical fashion.

Fault Locator

The SEL-311A 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. It can also be displayed on the optional LCD screen.

Automation

Flexible Control Logic and Integration Features

Use the SEL-311A 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 bits. Set, clear, or pulse local control bits with the optional front-panel pushbuttons and display. Program the local control bits into your control scheme via SELOGIC control equations. Use the local bits to trip test, enable/disable reclosing, trip/close the breaker, etc.

Eliminate RTU-to-relay wiring with 16 remote control bits. Set, clear, or pulse remote control bits via serial port commands. Program the remote bits into your control scheme via SELOGIC control equations. Use remote bits 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 bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the latch bits via optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.

Replace traditional indicating panel lights with 16 programmable 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.
- ➤ Open communications protocols (see *Table 3*).
- ➤ Settings and group switching have password control (Access Levels shown in *Table 4*).
- ➤ Full access to event history, relay status, and meter information from the serial ports.
- ➤ DNP3 Level 2 protocol with point mapping (optional).

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-2032 or an SEL-2030 Communications Processor, SCADA serial port, and/or RTU for local or remote communication. The SEL-311A is compatible with the SEL-DTA2 Display/Transducer Adapter.

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.

Table 4 Serial Port Command Summary

Access Level	Prompt	Serial Port Command	Command Description	Corresponding Front-Panel Pushbutton
0	=	**ACC**	Go to Access Level 1	
0	=	**QUI**	Quit to Access Level 0	
1	=>	**2AC**	Go to Access Level 2	
1	=>	**BAC**	Go to Access Level B	
1	=>	**BRE**	Breaker monitor data	{OTHER}
1	=>	**COM**	MIRRORED BITS communications	
1	=>	**DAT**	View/change data	{OTHER}
1	=>	**EVE**	Event reports	
1	=>	**GRO**	Display active setting group number	{GROUP}
1	=>	**HIS**	Event summaries/histories	{EVENTS}
1	=>	**INI**	Display I/O configuration	
1	=>	**IRI**	Synchronize to IRIG-B	
1	=>	**MET**	Metering data	{METER}
1	=>	**SER**	Sequential Events Recorder	
1	=>	**SHO**	Show/view settings	{SET}
1	=>	**STA**	Relay self-test status	{STATUS}
1	=>	**SUM**	Display Event Summary	{EVENTS}
1	=>	**TAR**	Display relay element status	{OTHER}
1	=>	**TIM**	View/change time	{OTHER}
1	=>	**TRI**	Trigger an event report	
B	==>	**BRE *n***	Preload/reset breaker wear	{OTHER}
B	==>	**CLO**	Close breaker	
B	==>	**GRO *n***	Change active setting group	{GROUP}
B	==>	**OPE**	Open breaker	
B	==>	**PUL**	Pulse output contact	{CNTRL}
2	=>>	**CON**	Control remote bit	
2	=>>	**COP**	Copy setting group	
2	=>>	**LOO**	Loopback	
2	=>>	**PAS**	View/change passwords	{SET}
2	=>>	**SET**	Change settings	{SET}
2	=>>	**VER**	Display version and configuration information	

Command Summary

Table 4 alphabetically lists the serial port commands within a given access level. Much of the information available from the serial port commands is also available via the front-panel pushbuttons. The correspondence between the serial port commands and the front-panel pushbuttons is also given in *Table 4*.

The serial port commands at the different access levels offer varying levels of control:

- The Access Level 1 commands primarily allow the user to look at information only (settings, metering, etc.), not change it.
- The Access Level B commands primarily allow the user to operate output contacts or change the active setting group.
- The Access Level 2 commands primarily allow the user to change relay settings.

SEL communications processors are often applied as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-311A. 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 (*Figure 10*).

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 availability.

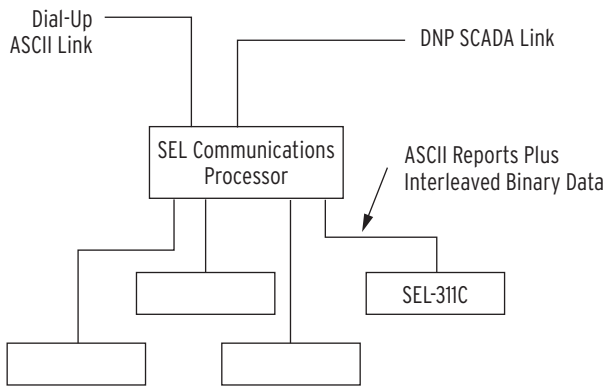


Figure 10 Example Communications System

Use SEL-2800 series fiber-optic transceivers for direct fiber communications between SEL-311A Relays and other SEL devices up to 50 miles (80 km) distant (see *Figure 11*). Improve security and dependability through shared information.

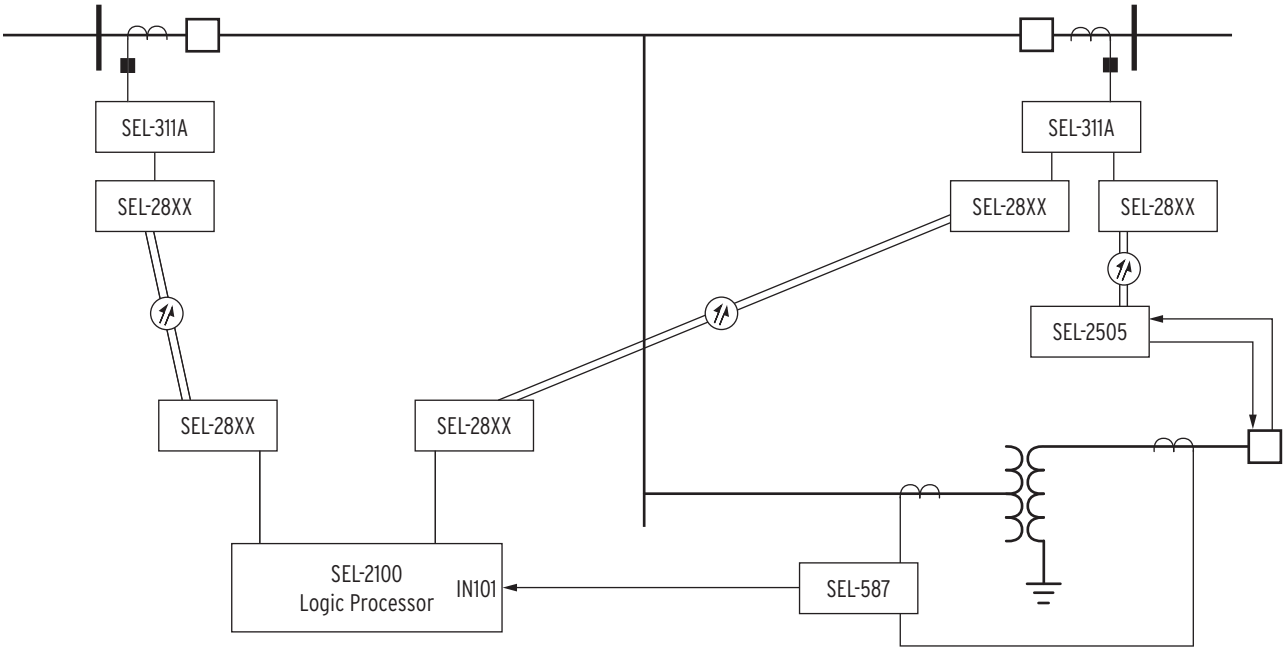


Figure 11 SEL-311A Communications Connections Example

Unique Capabilities

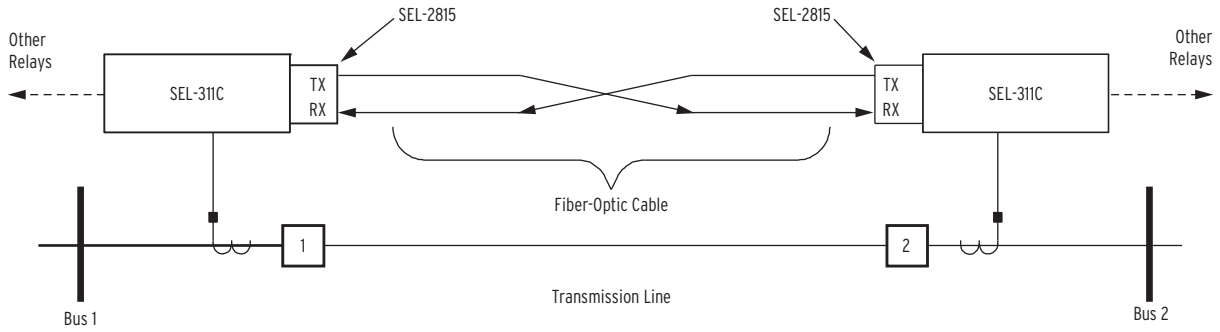


Figure 12 Integral Communications Provide Secure Protection, Monitoring, and Control

Relay-to-Relay Digital Communications (MIRRORED BITS)

The SEL patented MIRRORED BITS technology provides bidirectional relay-to-relay digital communications. In the SEL-311A, 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 applied to 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-311A 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-311A 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.

Additional Features

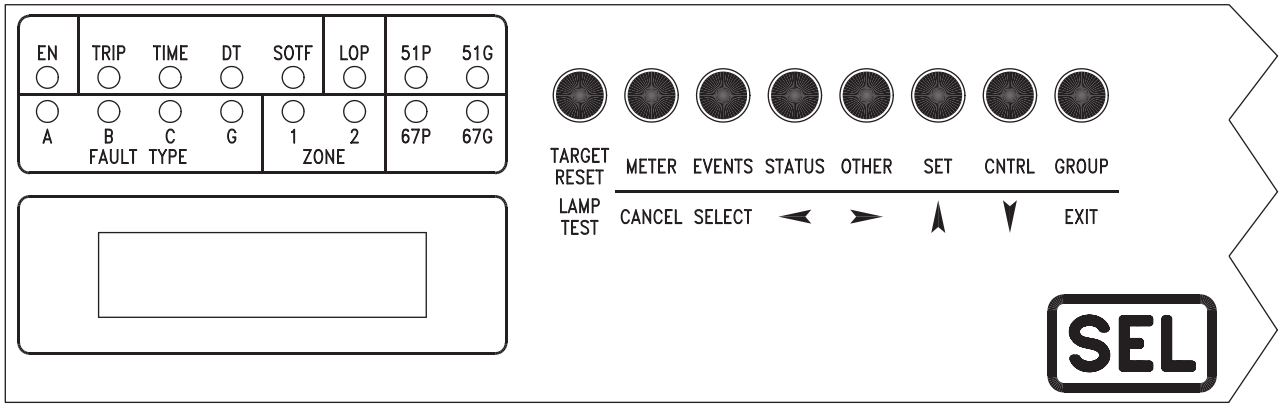


Figure 13 Status and Trip Target LEDs, Front-Panel Display and Pushbuttons

A close-up view of the user interface portion of the SEL-311A front panel is shown in *Figure 13*. It includes an optional two-line, 16-character LCD, 16 LED target indicators, and 8 pushbuttons for local communication.

Front-Panel Display (Optional)

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 5*.

Table 5 Description of LEDs

Target LED	Function
EN	Relay powered properly and self-tests okay
TRIP	Indication that a trip occurred
TIME	Time-delayed trip
DT	Direct trip
SOTF	Switch-onto-fault trip
LOP	Loss-of-potential
FAULT TYPE	
A, B, C	Phases involved in fault
G	Ground involved in fault
ZONE/LEVEL	
1–2	Trip by Zone 1–2 distance elements and/or Level 1–2 overcurrent elements
51P, 51G	Time-overcurrent element trip for phase and ground
67P, 67G	Directional overcurrent element for phase and ground

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.

Contact Inputs and Outputs

The model SEL-311A 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.

Status and Trip Target LEDs

The SEL-311A includes 16 status and trip target LEDs on the front panel. These targets are shown in *Figure 14* and explained in *Table 5*.

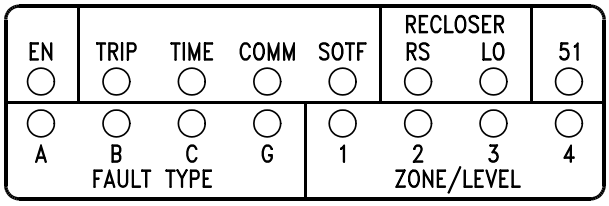


Figure 14 Status and Trip Target LEDs

Wiring Diagram With Dual Terminal Labels

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

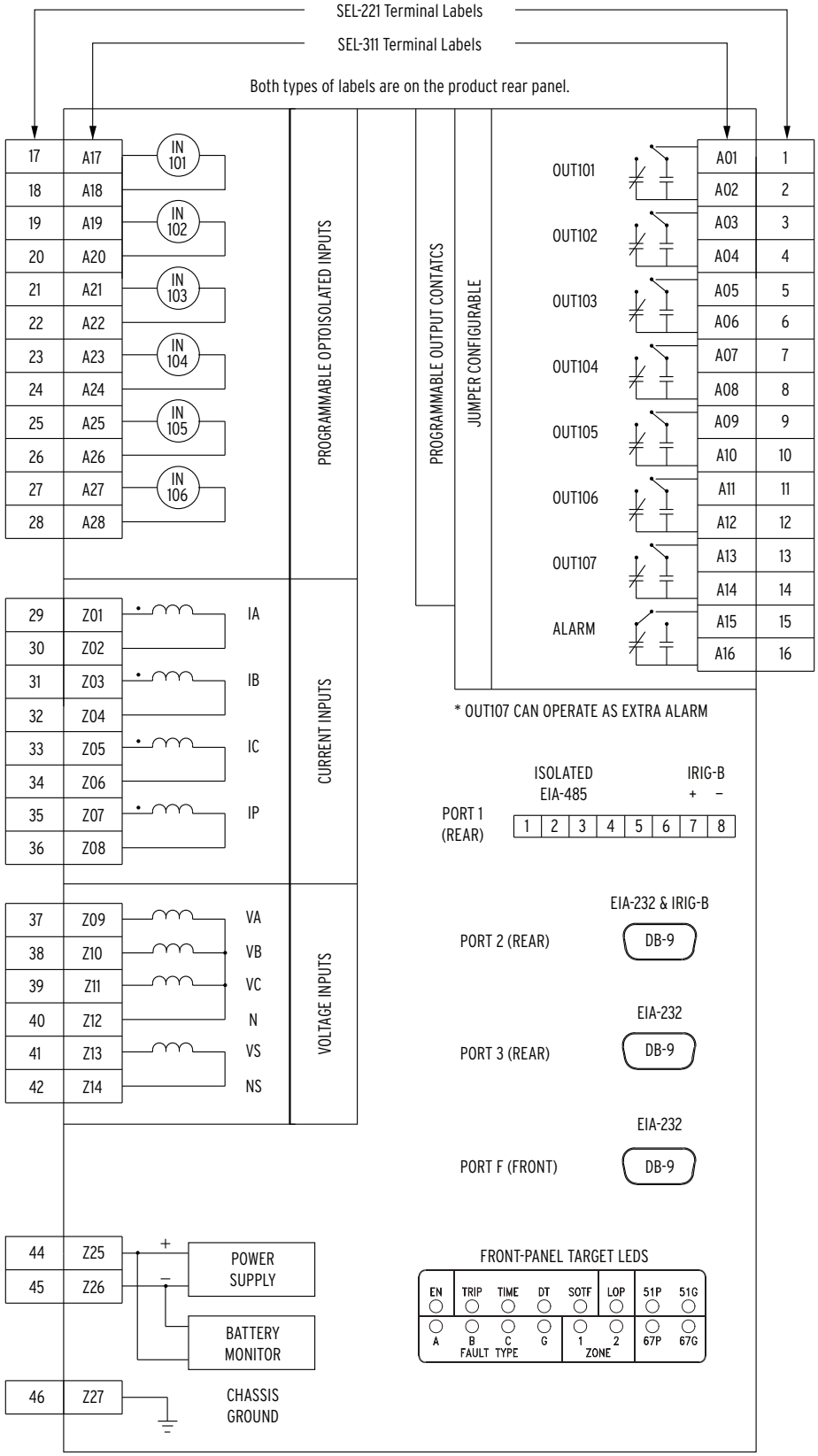


Figure 15 SEL-311A Inputs, Outputs, and Communications Ports

Front- and Rear-Panel Diagrams

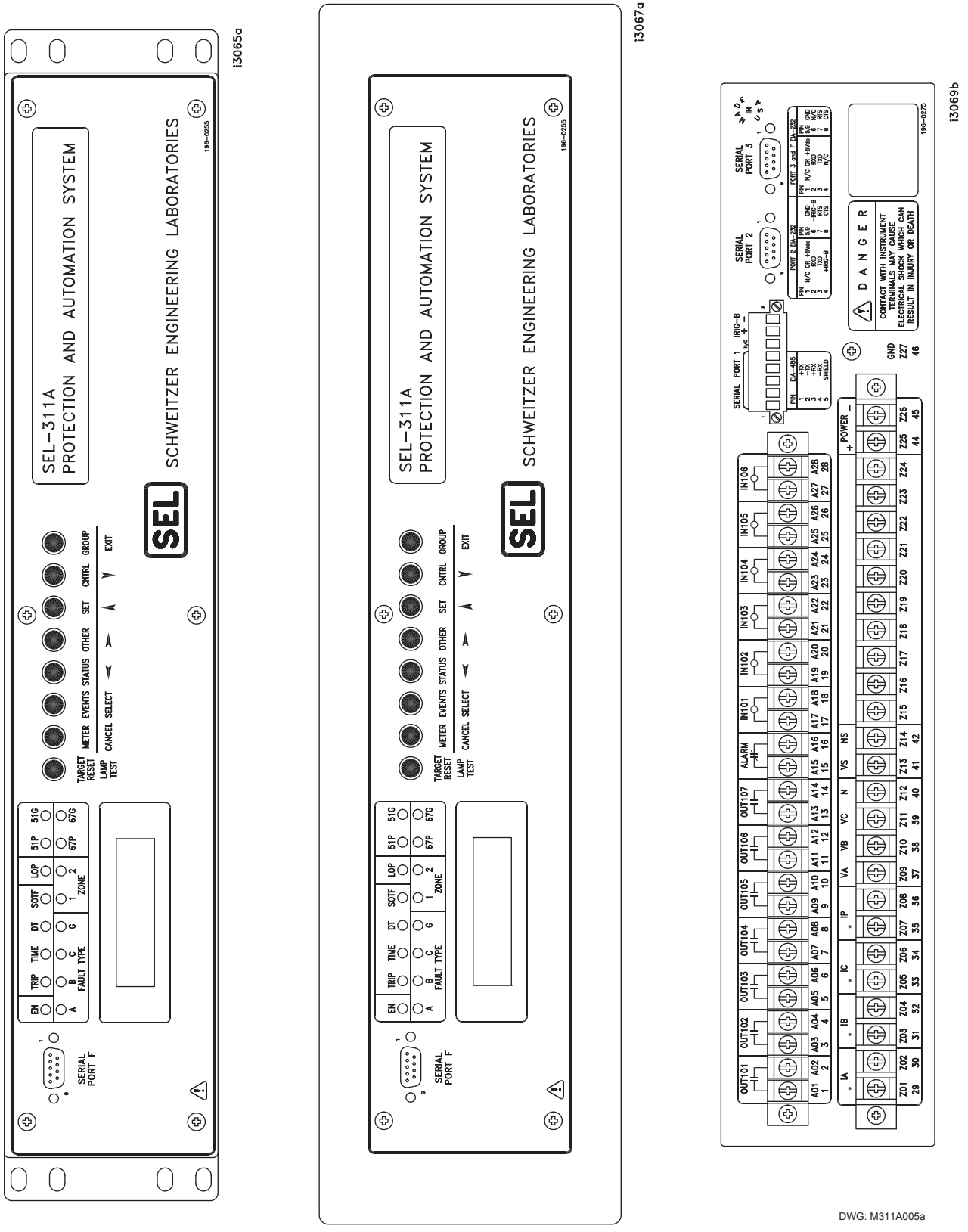


Figure 16 SEL-311A Front- and Rear-Panel Diagrams—Models 0311A00H2 (Rack) and 0311A0032 (Panel)

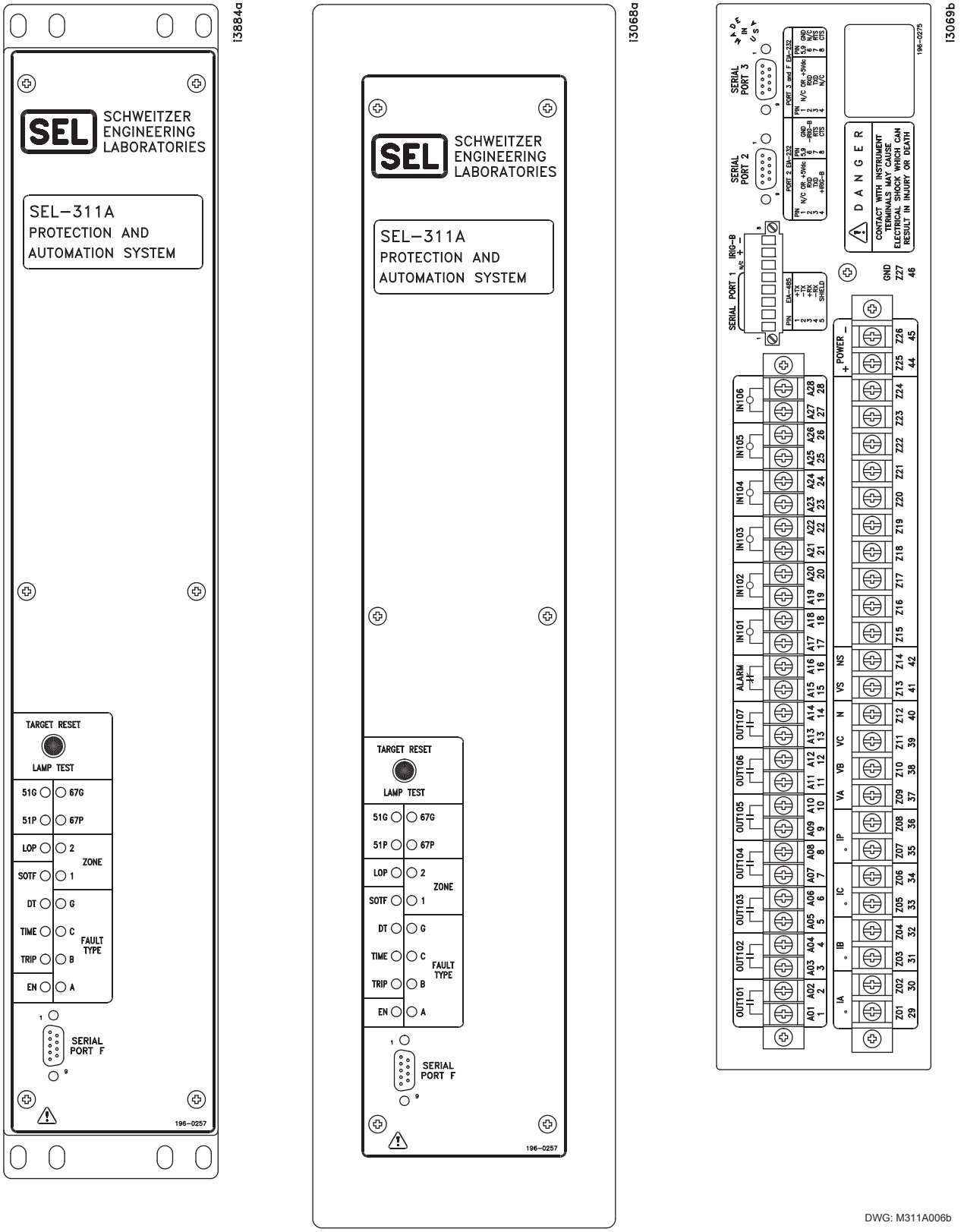


Figure 17 SEL-311A Front- and Rear-Panel Drawings—Models 0311A00V1 (Rack) and 0311A0041 (Panel)

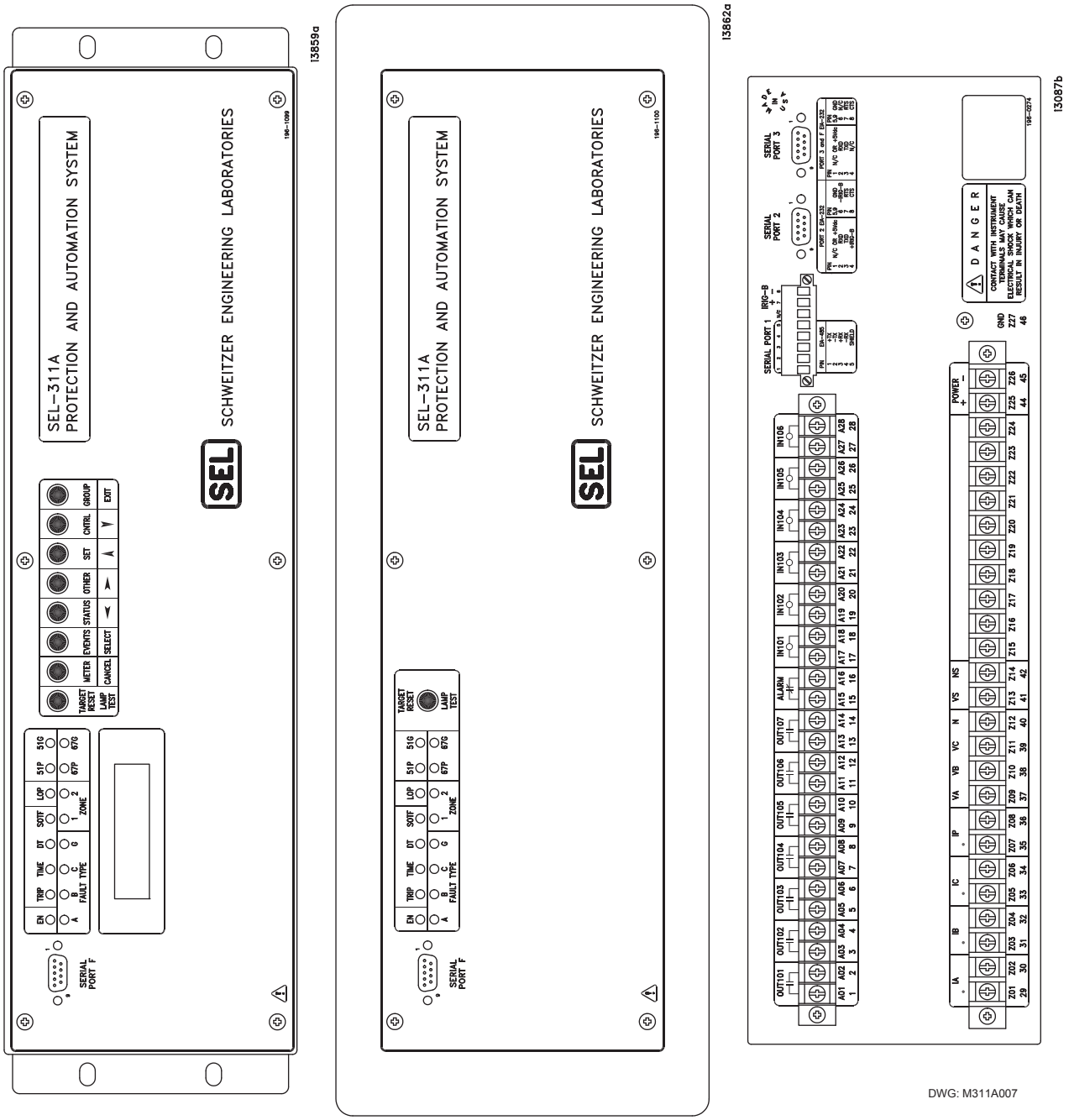


Figure 18 SEL-311A Front- and Rear-Panel Drawings—Models 0311A01H2 (Rack) and 0311A0131 (Panel)

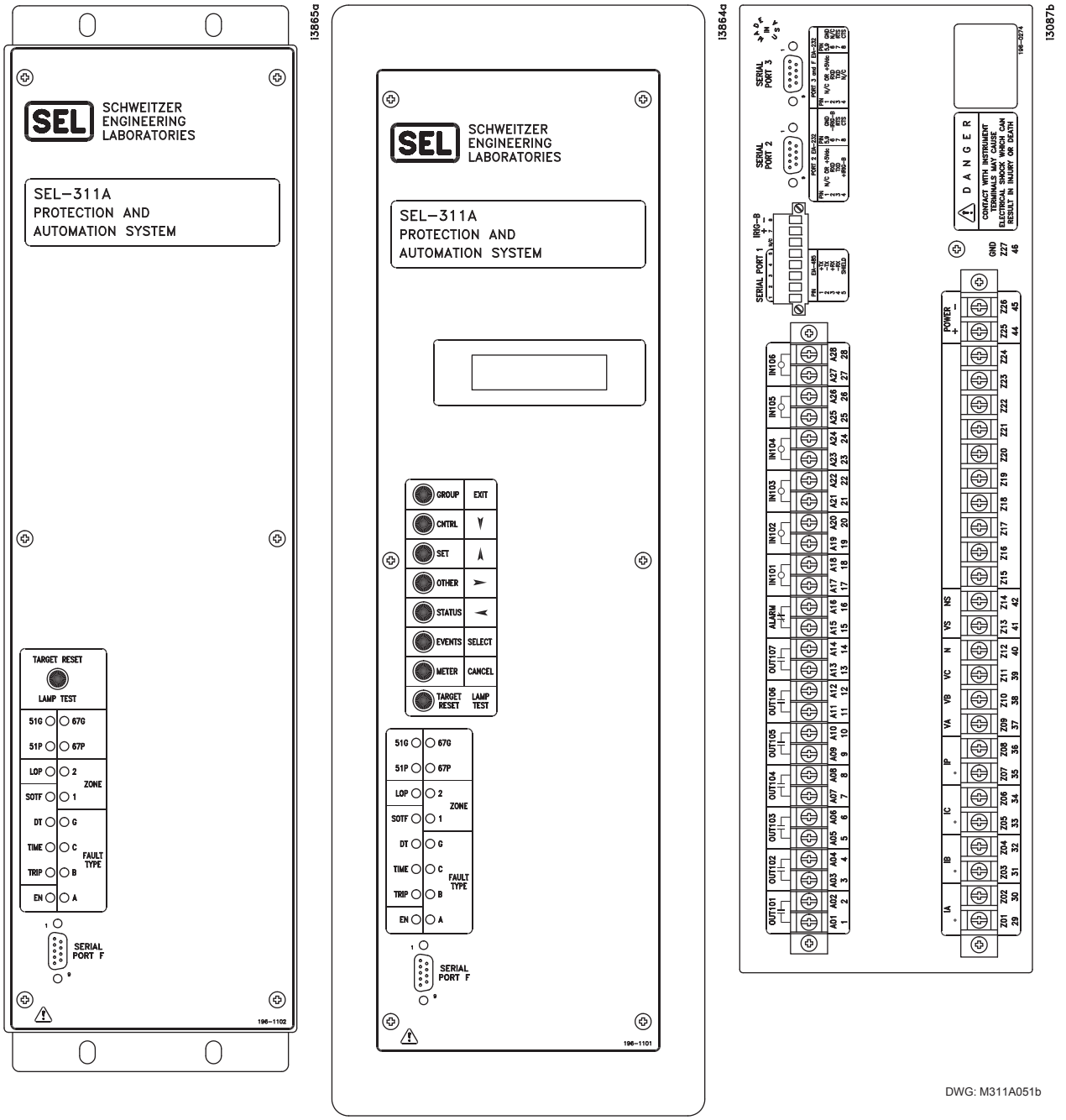


Figure 19 SEL-311A Front- and Rear-Panel Drawings—Models 0311A01V1 (Rack) and 0311A0142 (Panel)

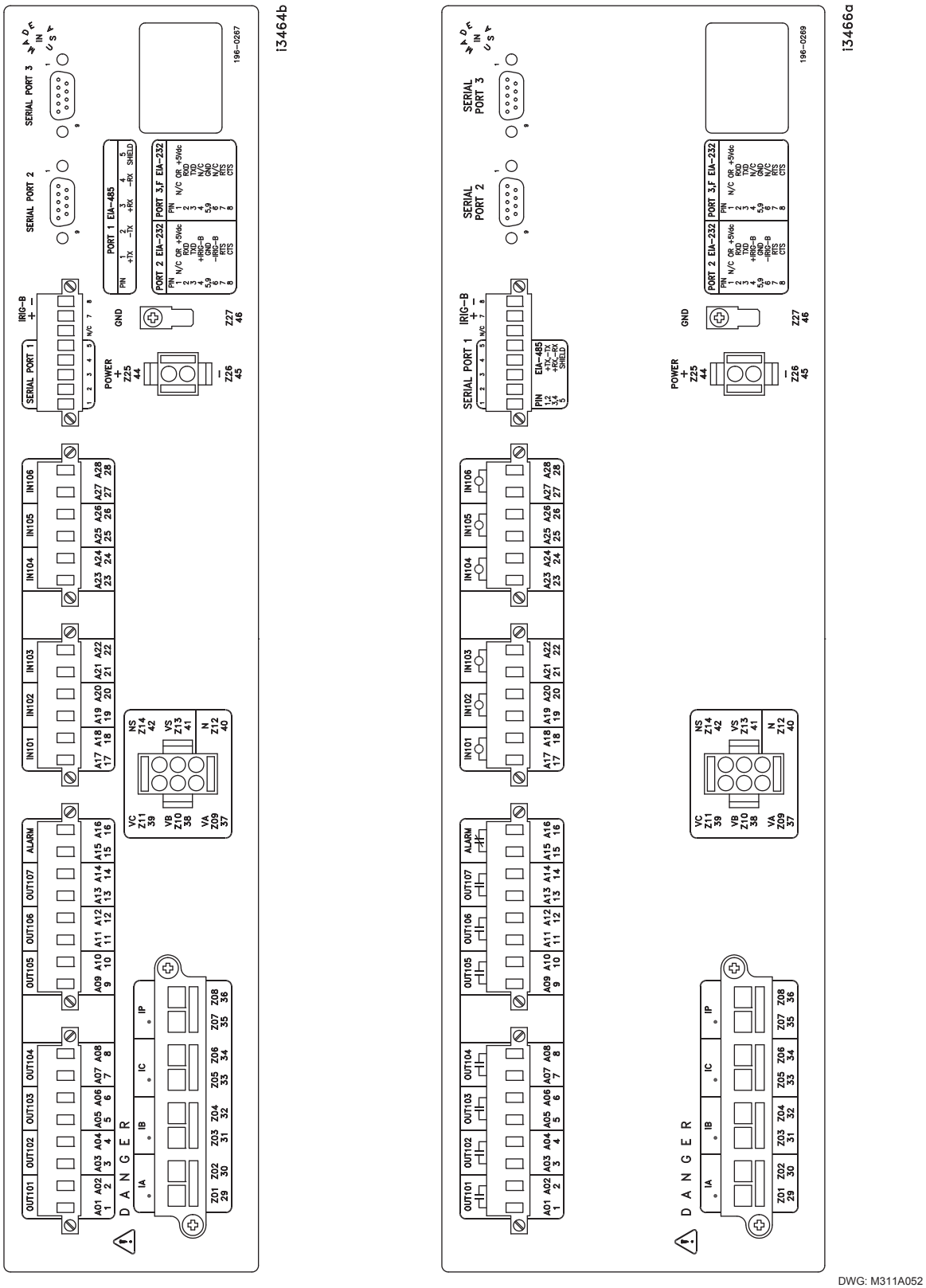
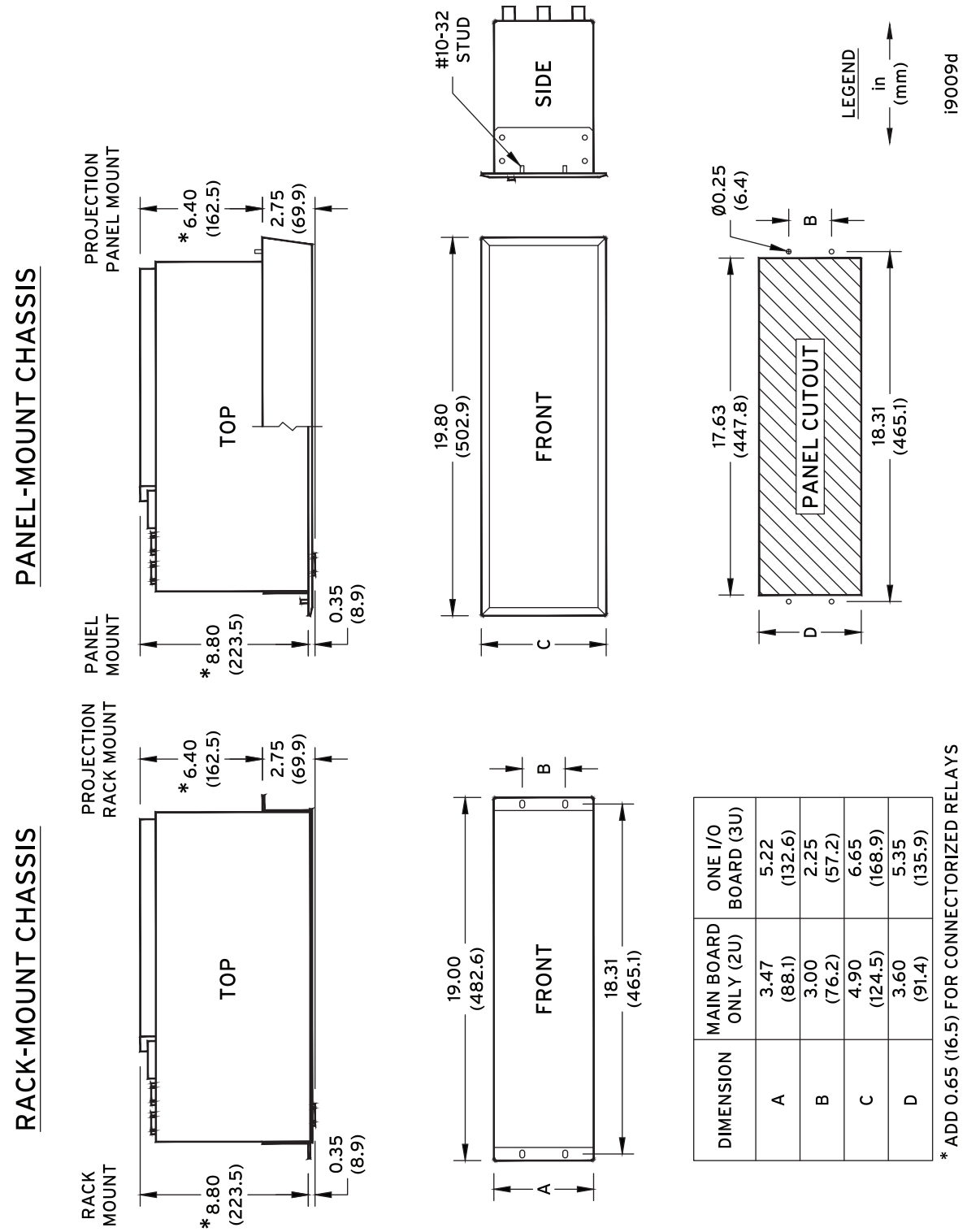


Figure 20 SEL-311A Connectorized® Rear-Panel Drawing

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)

For projection rack mounting, brackets must be reversed. Horizontal mounting shown; dimensions also apply to vertical mounting.

Figure 21 Dimensions for Rack- and Panel-Mount Models

Specifications

Important: Do not use the following specification information to order an SEL-311A. 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_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

Note: 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:	±1.0°
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% ±2 V 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

Phase Distance Elements

Zones 1–2 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 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR < 30
Transient Overreach:	< 5% of setting plus steady-state accuracy

Zones 1–2 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 3.11* and *Figure 3.12* in the instruction manual.

Mho and Quadrilateral Ground-Distance Elements

Zones 1–2 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 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR < 30
Transient Overreach:	<5% of setting plus steady-state accuracy

Zones 1–2 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
Max. Operating Time:	See pickup and reset time curves in *Figure 3.11* and *Figure 3.12* 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 3.11* and *Figure 3.12* in the instruction manual.

Time-Overcurrent Elements

Pickup Range:	OFF, 0.25–16.00 A, 0.01 A steps (5 A nominal) OFF, 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

Notes

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com

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