SEL-311C Protection and Automation System

Powerful Solutions for Transmission Line Protection

Major Features and Benefits

The SEL-311C 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 out-of-step blocking and a four-shot recloser provides the user with a variety of step-distance and communications-assisted tripping schemes. Event reports, sequential events recorder, circuit breaker contact wear monitor, and substation battery monitor are all standard features. Two communication ports supporting MIRRORED BITS™ communications and extensive automation features are also standard. A local display panel, expanded I/O, and Distributed Network Protocol (DNP Version 3.00 Level 2) are available as optional functions.

- **Protection.** Protect transmission lines using a combination of four zones of phase- and ground-distance elements in communications-assisted schemes with directional overcurrent element backup protection. Patented Capacitance Voltage Transformer (CVT) transient overreach logic enhances security of Zone 1 distance elements. *Best Choice Ground Directional Element*™ 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 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 DNP Version 3.00 Level 2 with point-mapping is also available.

Functional Overview

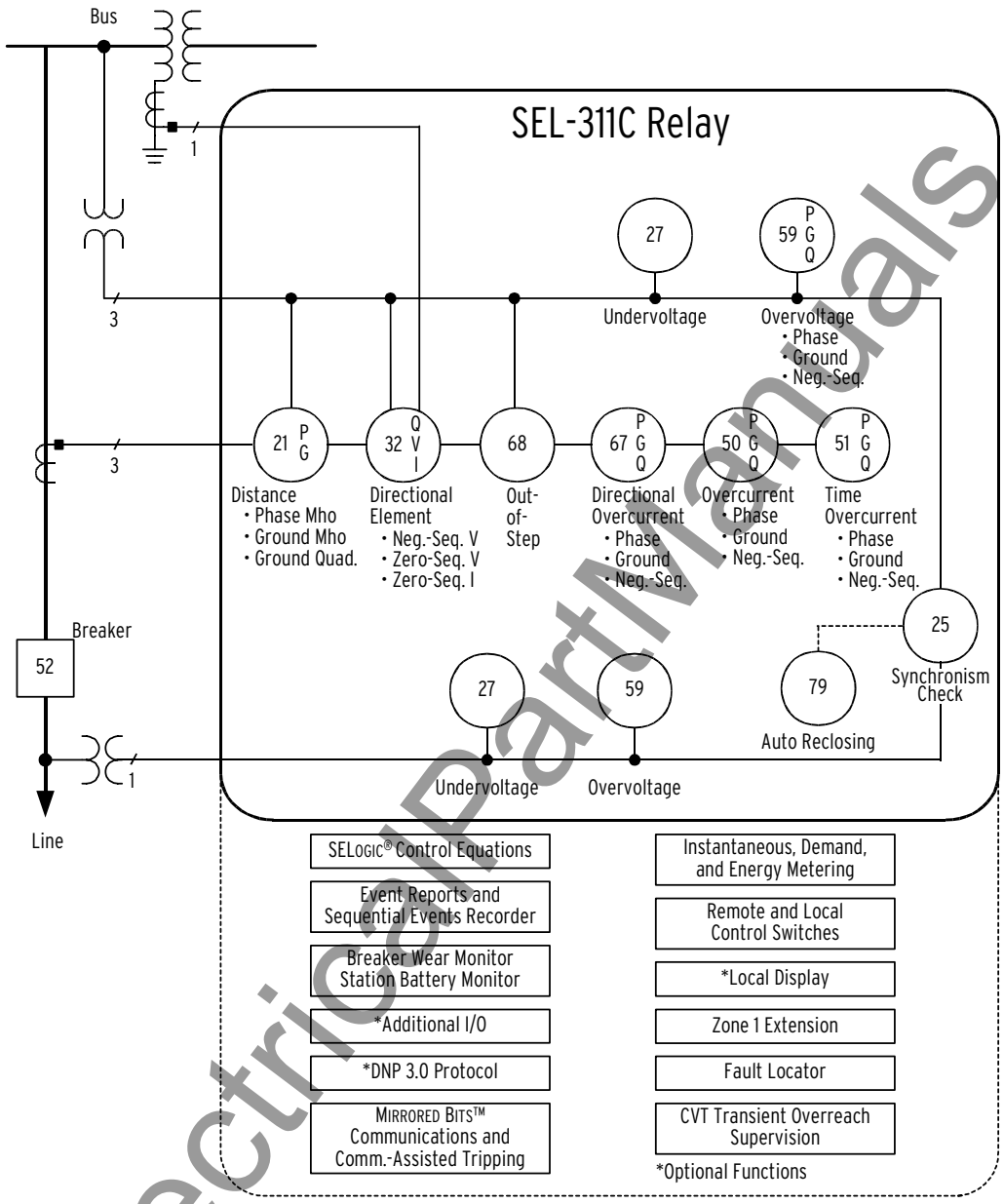


Figure 1 Functional Diagram

Protection Features

The SEL-311C Relay contains all necessary protective elements and control logic to protect overhead transmission lines and underground cables. It includes four zones of phase and ground mho distance elements plus four zones of ground quadrilateral distance elements. These distance elements, together with overcurrent functions, are applied in communications-assisted and 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 virtually any operating condition: 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 numbers are identical to SEL-221 series relays, simplifying migration to the SEL-311C Relay.

Mho Distance Elements

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

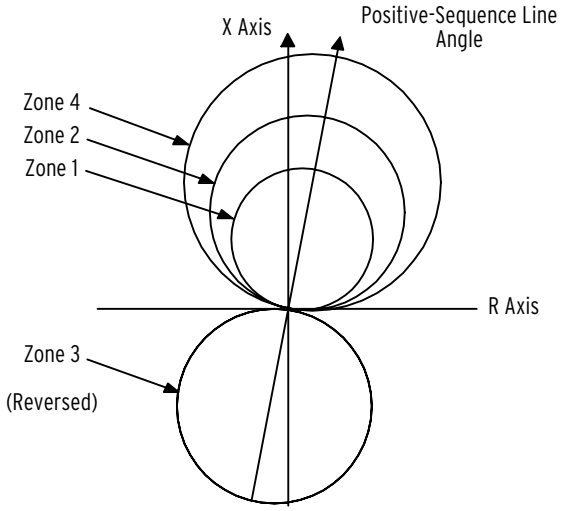


Figure 2 Phase and Ground Mho Distance Characteristics

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.

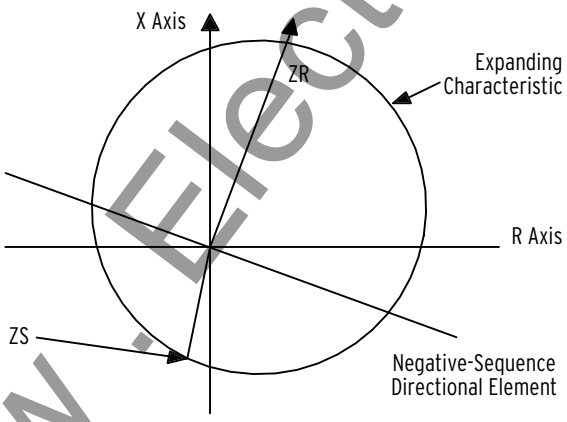


Figure 3 Phase-to-Phase Element Response for a Forward Phase-to-Phase Fault

Load Encroachment

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

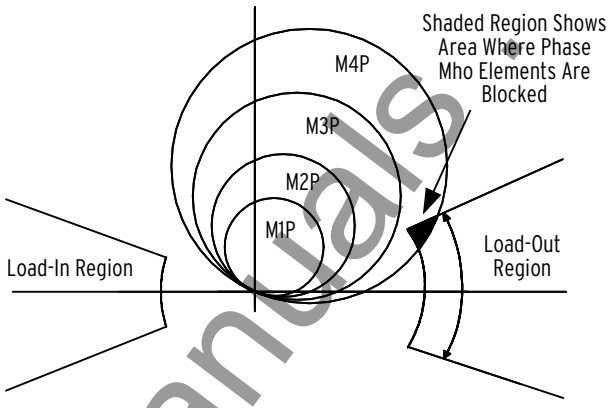


Figure 4 Load-Encroachment Characteristic

Quadrilateral Distance Elements

The SEL-311C Relay provides four zones of quadrilateral ground-distance characteristics. The top line of the quadrilateral characteristic automatically tilts with load flow to avoid under- and overreaching. The ground mho and quadrilateral distance elements may be used individually, concurrently, or not at all.

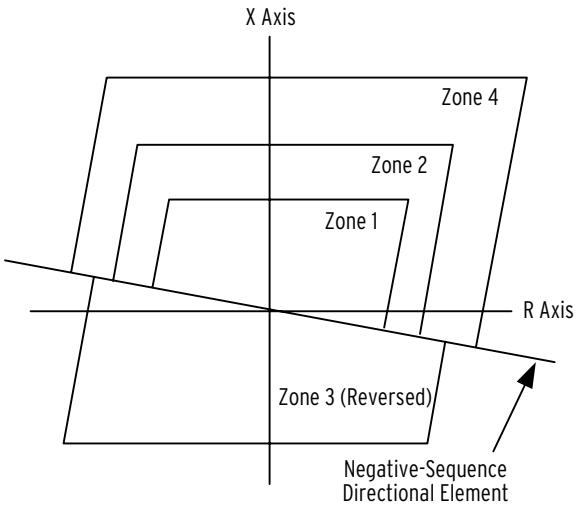


Figure 5 Quadrilateral Ground-Distance Characteristics

Each of the eight ground-distance elements have 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 and k0 compensates for zero-sequence mutual coupling between parallel lines.

Overcurrent Elements

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

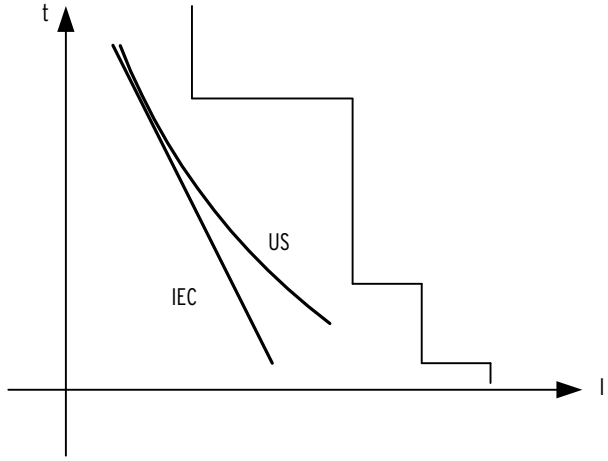


Figure 6 Instantaneous, Definite-Time, and Inverse Time-Overcurrent Characteristics

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-311C Relay 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.)

Undervoltage and Overvoltage Elements For Extra Protection and Control

Phase undervoltage, overvoltage, and sequence overvoltage elements 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.

Monitoring and Metering

Complete Metering Capabilities

Extensive metering capabilities are provided by the SEL-311C Relay, as shown in Table 2. Metering accuracies are provided in the General Specifications section on page 13.

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.

Table 2 Metering Capabilities

Quantities	Description	
Currents	$I_{A,B,C,P}$	Input currents
	I_G	Residual ground current ($I_G = 3I0 = I_A + I_B + I_C$)
Voltages	$V_{A,B,C}$	Wye-connected voltage inputs
	V_S	Synchronism-check voltage input
Power	$MW_{A,B,C,3P}$	Single-phase and three-phase megawatts
	$MVAR_{A,B,C,3P}$	Single-phase and three-phase megavars
Energy	$MWh_{A,B,C,3P}$	Single-phase and three-phase megawatt hours, in and out
	$MVARh_{A,B,C,3P}$	Single-phase and three-phase 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	$MW_{A,B,C,3P}$	Single-phase and three-phase megawatts, in and out
	$MVAR_{A,B,C,3P}$	Single-phase and three-phase megavars, in and out

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, or 60 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.

Long Event Summary

Each time the relay generates a standard event report, it also generates a corresponding Long 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
- Prefault and fault phase and polarizing current levels
- Prefault 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 a Long 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-311C Relay time to within ±5 ms of the time-source input. A convenient source for this time code is the SEL-2020 or SEL-2030 Communications Processor (via Serial Port 2 on the SEL-311C Relay).

Substation Battery Monitor for DC Quality Assurance

The SEL-311C Relay 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 the SEL-2020 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.

Breaker Monitor Feature Allows for Intelligent 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 versus interruption levels and operation count. The SEL-311C Relay breaker monitor feature compares the breaker manufacturer's published data to the interrupted current.

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 7), the relay can alarm via the output contact or the optional front-panel display. With this kind of information, breaker maintenance is scheduled in a timely, economical fashion.

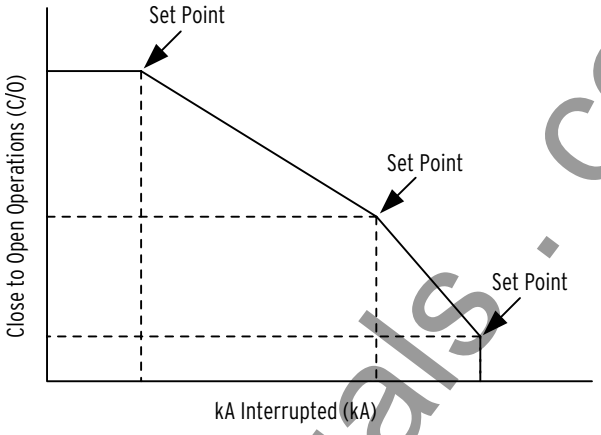


Figure 7 Breaker Contact Wear Curve and Settings

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-311C Relay 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 prefault 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 long event summaries.

Automation

Flexible Control Logic and Integration Features

Use the SEL-311C 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 bits to trip test, enable/disable reclosing, trip/close the breaker, etc.

Eliminate RTU-to-relay wiring with 16 remote control points. Set, clear, or pulse remote control points 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 points. 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.
- Full access to event history, relay status, and meter information from the serial ports.
- Settings and group switching have password control.
- DNP Version 3.00 Level 2 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.

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-2020, an RTU, and other substation devices with metering information, relay element, input and output statuses, time-tags, open and close commands, 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.

Unique Capabilities

Relay-to-Relay Digital Communications (MIRRORED BITS)

The SEL patented MIRRORED BITS technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS can operate simultaneously on any two serial ports.

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 pilot 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 communications-assisted schemes applied to three-terminal transmission lines.

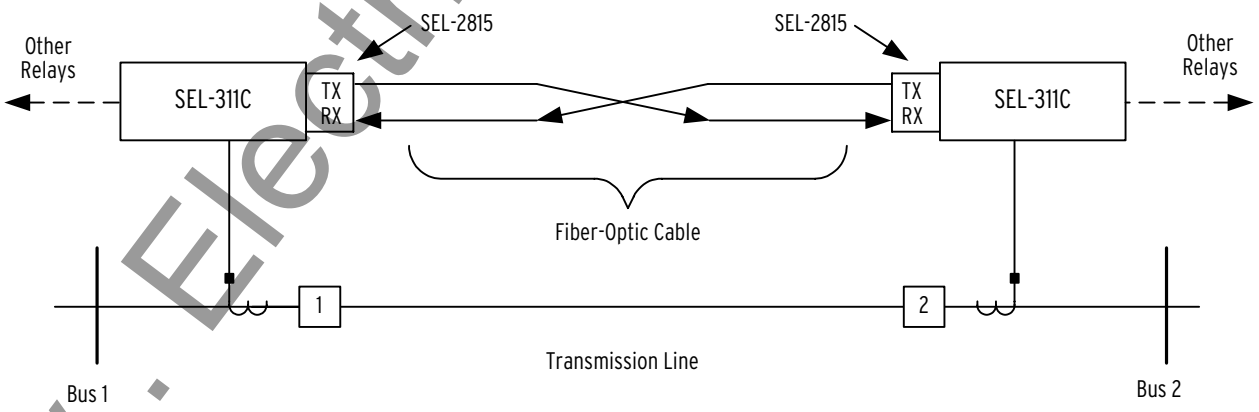


Figure 8 Integral Communications Provides Secure Protection, Monitoring, and Control

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-311C Relay 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 Logic Supervises Directional Elements

The SEL-311C Relay 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.

Additional Features

Communications-Assisted Tripping Schemes

The SEL-311C Relay is the ideal relay for use in transmission pilot-based tripping schemes. Schemes supported include:

- Permissive Overreaching Transfer Tripping (POTT) for two- or three-terminal lines.
- Directional Comparison Unblocking (DCUB) for two- or three-terminal lines.
- Directional Comparison Blocking (DCB).
- Permissive and Direct Underreaching Transfer Trip (PUTT and DUTT, respectively).
- Direct Transfer Tripping (DTT).

Use the SELOGIC control equation TRCOMM to program specific elements, combinations of elements, inputs, etc., to perform communication scheme tripping and other scheme functions. The communication logic of this relay easily handles the following challenges:

- Current reversals.
- Breaker open at one terminal.
- Weak-infeed conditions at one terminal.
- Switch-onto-fault conditions.

Time-step distance and time-overcurrent protection provide reliable backup operation should the channel be lost.

Front-Panel Display

An optional LCD display provides fault data, metering quantities, relay self-test status, and setting parameters.

Status and Trip Target LEDs

The SEL-311C Relay includes 16 status and trip target LEDs on the front panel. These targets are shown in Figure 9 and explained in Table 4.

Table 4 Description of Target 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

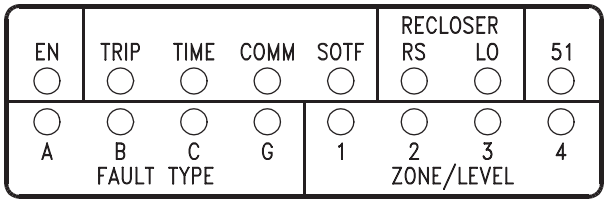


Figure 9 Status and Trip Target LEDs

Contact Inputs and Outputs

The base model SEL-311C Relay includes 8 output contacts and 6 optoisolated inputs. An additional 12 outputs and 8 inputs are available. 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.

Guideform Specification

The microprocessor-based relay shall provide a combination of functions including protection, monitoring, control, fault locating, and automation. Relay self-checking functions shall be included. Specific operational and functional requirements are as follows:

- **Phase Fault Distance Protection.** The relay shall incorporate four zones of mho distance protection for detection of phase faults. Two zones shall be settable for either forward or reverse direction. The mho elements shall use positive-sequence memory polarization.
- **CVT Transient Blocking.** The relay shall detect CVT transients and block the operation of overreaching Zone 1 distance elements.
- **Out-of-Step Characteristics.** The relay shall detect stable and unstable power swings. User settings shall determine whether the relay trips or blocks tripping.
- **Zero-Sequence Compensation Factor.** The relay shall include two zero-sequence compensation factors, one for underreaching ground distance and one for overreaching ground distance. Magnitude and phase angle of each zero-sequence compensation factor shall be independently adjustable.
- **Overcurrent Fault Protection.** The relay shall incorporate phase, residual ground, and negative-sequence overcurrent elements. For added security, directional elements, load encroachment logic, and torque control capability (internal and external) shall be provided.
- **Ground Fault Distance Protection.** The relay shall incorporate four zones of mho distance and four zones of quadrilateral distance protection for ground fault protection. Two zones of each type shall be selectable for either the forward or reverse direction.
- **Phase Under- and Overvoltage Elements.** The relay shall incorporate under- and overvoltage elements for protection and control.
- **Sequence Overvoltage Elements.** The relay shall incorporate positive-, negative-, and zero-sequence overvoltage elements for protection and control.
- **Auto-Reclosing Control.** The relay shall incorporate a four shot recloser with four independently set open time intervals. Independently set reset times from reclose cycle and from lockout shall be available.
- **Synchronism Check.** The relay shall include two synchronism check elements with separate maximum angle settings. The synchronism check function shall compensate for breaker close time and allow different sources of synchronizing voltage (VA, VB, VC, VAB, VBC, VCA).
- **Applications Templates.** The relay shall have reduced setting step-distance, POTT, and DCB schemes available in application settings templates.
- **Event Reporting and Sequential Events Recorder.** The relay shall be capable of automatically recording disturbance events of 15, 30, or 60 cycles. Events shall be stored in nonvolatile memory. The relay shall also include a Sequential Events Recorder (SER) that stores the latest 512 entries.
- **Status and Trip Target LEDs.** The relay shall include 16 status and trip target LEDs.
- **Circuit Breaker Monitor.** The relay shall include a breaker wear monitor function with a user programmable breaker monitor curve per the breaker manufacturer's recommendations.
- **Substation Battery Monitor.** The relay shall measure and report the substation battery voltage presented to the relay power supply terminals. Two user-selectable threshold parameters shall be provided for alarm and control purposes.
- **Fault Locator.** The relay shall include a fault locating algorithm to provide an accurate estimate of fault location without communications channels, special instrument transformers, or prefault information.
- **Digital Relay-to-Relay Communications.** The relay shall have eight send and eight receive logic elements in each of two communications ports for dedicated relay-to-relay communications.
- **Automation.** The relay shall include sixteen local control elements, sixteen remote control logic points, sixteen latching logic points, and sixteen display messages in conjunction with a local display panel included in the relay. The relay shall have the capability to display custom messages.
- **Relay Logic.** The relay shall include programmable logic functions for a wide range of user configurable protection, monitoring, and control schemes.

➤ **Communications.** The relay shall include three independent EIA-232 and one EIA-485 serial ports for external communications. Two ports shall support relay-to-relay eight bit direct logic communication.

➤ **IRIG-B.** The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal.

Wiring Diagram With Dual Terminal Labels

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

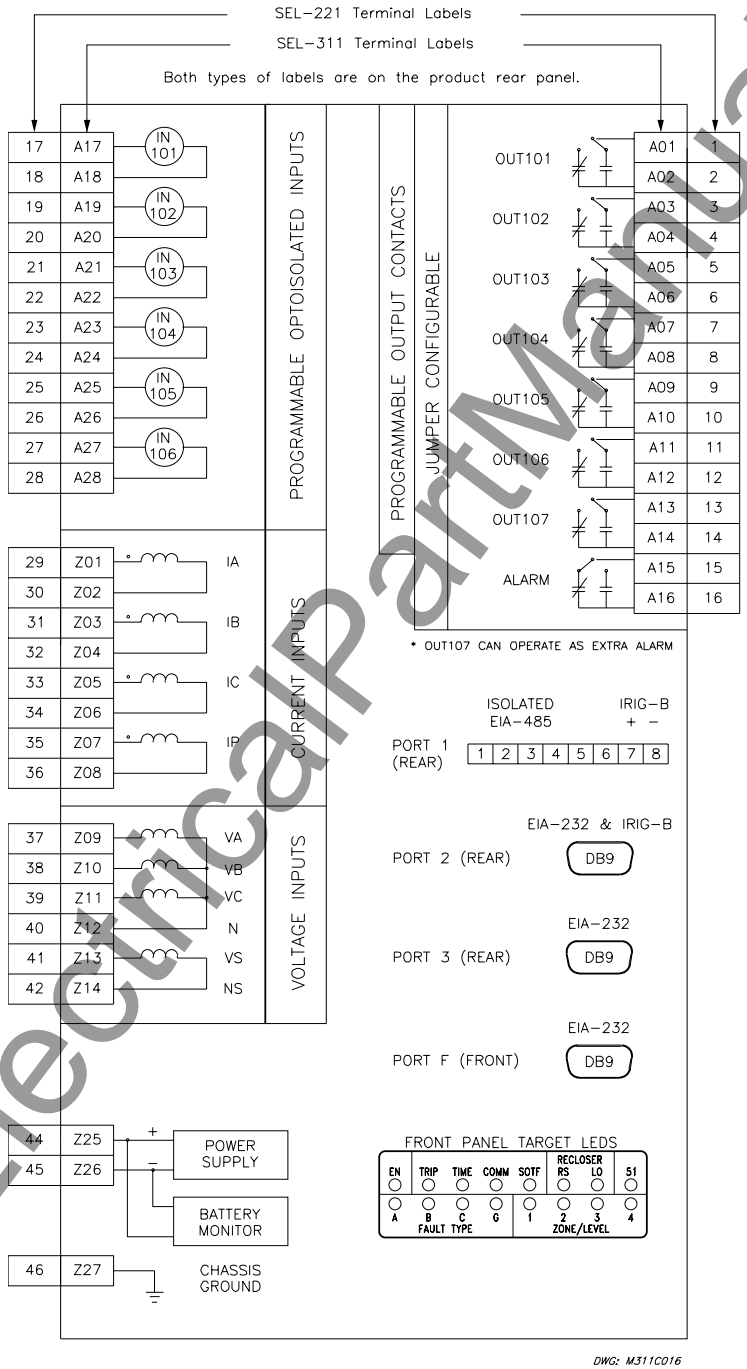
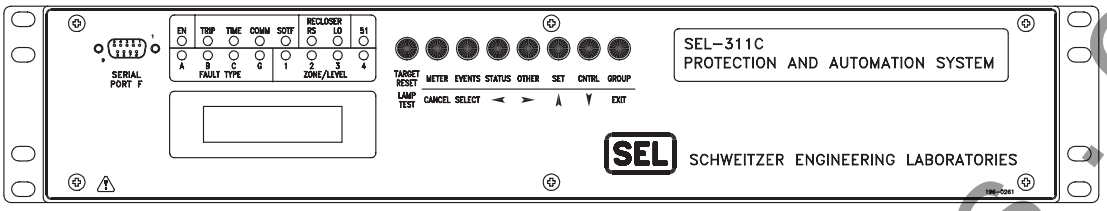


Figure 10 SEL-311C Relay Inputs, Outputs, and Communications Ports

Front- and Rear-Panel Diagrams



Rack-Mount Front Panel With Optional Display

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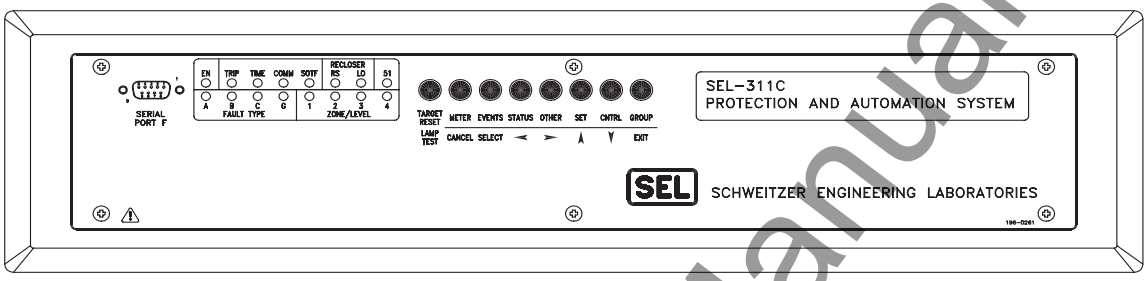
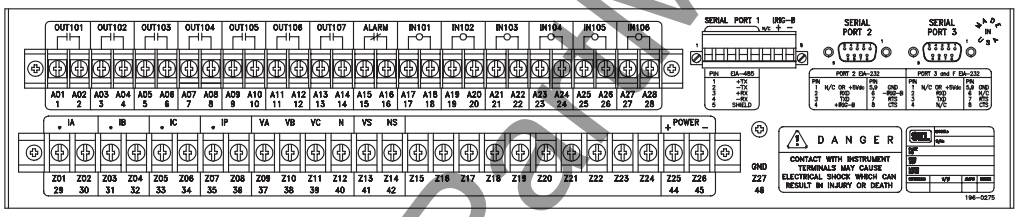
27SEP99



Panel-Mount Front Panel Without Optional Display

i1424.dwg
27SEP99



2U Rear Panel With Dual Terminal Numbers, No Additional I/O Board

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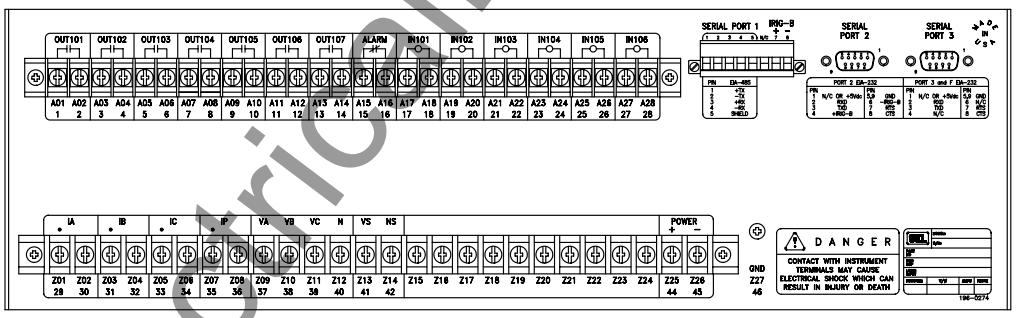
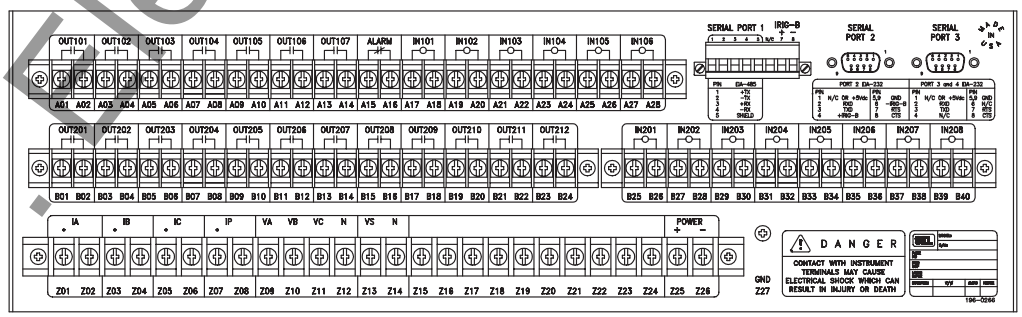
26AUG99



3U Rear Panel With Dual Terminal Numbers, No Additional I/O Board

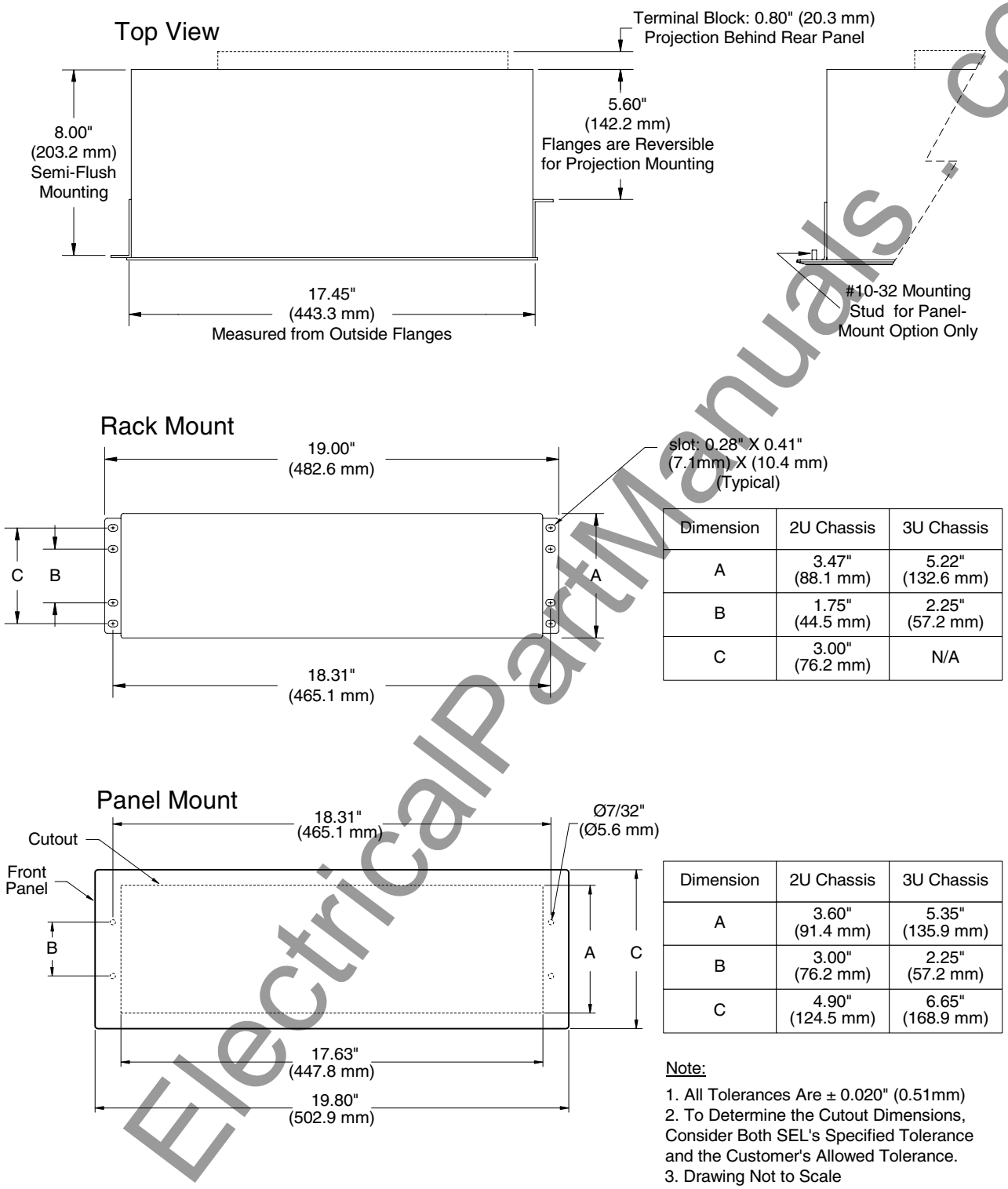
i1430.dwg
14SEP99



3U Rear Panel With Additional I/O Board

i1431.dwg
28SEP99

Figure 11 SEL-311C Relay Front- and Rear-Panel Diagrams



Dimension	2U Chassis	3U Chassis
A	3.47" (88.1 mm)	5.22" (132.6 mm)
B	1.75" (44.5 mm)	2.25" (57.2 mm)
C	3.00" (76.2 mm)	N/A

Dimension	2U Chassis	3U Chassis
A	3.60" (91.4 mm)	5.35" (135.9 mm)
B	3.00" (76.2 mm)	2.25" (57.2 mm)
C	4.90" (124.5 mm)	6.65" (168.9 mm)

Note:

1. All Tolerances Are ± 0.020" (0.51mm)
2. To Determine the Cutout Dimensions, Consider Both SEL's Specified Tolerance and the Customer's Allowed Tolerance.
3. Drawing Not to Scale

Figure 12 SEL-311C Relay Dimensions for Rack- and Panel-Mount Models (Horizontal Mounting Shown; Dimensions Also Apply to Vertical Mounting)

General Specifications

Features and Functions

AC Voltage Inputs

67 V_{L-N}, three-phase, four-wire connection.
150 V_{L-N} continuous (connect any voltage from 0 to 150 Vac). 365 Vac for 10 seconds.
Burden: 0.13 VA @ 67 V
0.45 VA @ 120 V

AC Current Inputs

5 A Nominal, 15 A continuous, 500 A for 1 second, linear to 100 A symmetrical. 1250 A for 1 cycle
Burden: 0.27 VA @ 5 A;
2.51 VA @ 15 A

1 A Nominal, 3 A continuous, 100 A for 1 second, linear to 20 A symmetrical. 250 A for 1 cycle
Burden: 0.13 VA @ 1 A
1.31 VA @ 3 A

Frequency and Rotation

60/50 Hz system frequency and ABC/ACB phase rotation are user-settable.
Frequency Tracking Range: 40.1–65 Hz (V_A required for frequency tracking)

Output Contacts

IEC 255-0-20: 1974, using the simplified method of assessment.
Make: 30 A
Carry: 6 A
MOV Protected: 270 Vac, 360 Vdc continuous
Pickup/Dropout Time: <5 ms
Breaking Capacity (L/R = 40 ms):
48 V 0.5 A 10,000 operations
125 V 0.3 A 10,000 operations
250 V 0.2 A 10,000 operations
Cyclic Capacity (L/R = 40 ms):
48 V 0.5 A 2.5 cycles/second
125 V 0.3 A 2.5 cycles/second
250 V 0.2 A 2.5 cycles/second

High-current Interruption Option (DC Only)
Make: 30 A
Carry: 6 A
MOV protected: 330 Vdc continuous
Pickup/Dropout Time: <5 ms
Breaking Capacity:
10 A 10,000 operations
48/125V (L/R = 40 ms)
250 V (L/R = 20 ms)
Cyclic Capacity:
10 A 4 cycles in 1 second, followed by 2 min. idle for thermal dissipation.
48/125 V (L/R=40 ms)
250 V (L/R=20 ms)

Note: Do not use high-current interrupting output contacts to switch ac control signals.

Optoisolated Input Ratings

4 mA (nominal) input current.
Voltage ranges:
24 Vdc: on for 15–30 Vdc
48 Vdc: on for 38.4–60 Vdc; off below 28.8 Vdc
110 Vdc: on for 88.0–132 Vdc; off below 66 Vdc
125 Vdc: on for 105–150 Vdc; off below 75 Vdc
250 Vdc: on for 200–300 Vdc; off below 150 Vdc

Time-Code Input

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

Serial Ports

Front- and Rear-Panel EIA-232 Ports: 300–38400 baud
Rear Panel EIA-485 port: 300–38400 baud
EIA-485 Isolation: 2100 Vdc

Weight

2U rack unit height relay: 13 lbs. (5.92 kg)
3U rack unit height relay: 16 lbs. (7.24 kg)

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

Four times per power system cycle.

Element Ranges and Accuracy

Mho Phase Distance

Zones 1–4 Impedance Reach
Setting:
OFF, 0.05–64 Ω secondary, 0.01Ω steps (5 A nominal)
OFF, 0.25–320 Ω secondary, 0.01 Ω steps (1 A nominal)
Accuracy:
±5% of setting at line angle (LA) for 30≤SIR≤60
±3% of setting at LA for SIR<30
Transient Overreach: <5% of setting plus steady state accuracy

Zones 1–4 Phase-to-Phase Current Fault Detectors (FD)
Setting:
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
Max. Operating Time: See pickup and reset time curves in Section 3 of the instruction manual.

Mho and Quadrilateral Ground Distance Range

Zones 1–4 Impedance Reach
Mho Element Reach:
OFF, 0.05–64 Ω secondary, 0.01 Ω steps (5 A nominal)
OFF, 0.25–320 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Reactance Reach:
OFF, 0.05–64 Ω secondary, 0.01 Ω steps (5 A nominal)
OFF, 0.25–320 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Resistance Reach:
OFF, 0.05–50 Ω secondary, 0.01 Ω steps (5 A nominal)
OFF, 0.25–250 Ω secondary, 0.01 Ω steps (1 A nominal)
Accuracy:
±5% of setting at LA for 30≤SIR≤60
±3% of setting at LA for SIR<30
Transient Overreach: <5% of setting plus steady state accuracy

Zones 1–4 Phase and Residual Current Fault Detectors (FD)
Setting:
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 Section 3 of the instruction manual.

Instantaneous/Definite-Time Overcurrent

Pickup:
0.25–100.00 A, 0.01 A steps (5 A nominal)
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
Max. Operating Time: See pickup and reset time curves in Section 3 of the instruction manual.

Time-Overcurrent Elements

Pickup:
0.50–16.00 A, 0.01 A steps (5 A nominal)
0.10–3.20 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:
0.50–15.00, 0.01 steps (US)
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:
- 0.0–150.0 V, 0.01 V steps (various elements)
- 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:
- 0.005–0.500 Hz, 0.001 Hz steps

Slip Frequency Pickup Accuracy:
- ±0.003 Hz

Phase Angle: 0º–80º, 1º steps
Phase Angle Accuracy: ±2º

Timers

Pickup:
- 0.00–999,999.00 cycles, 0.25-cycle steps (reclosing relay and some programmable timers)
- 0.00–16,000.00 cycles, 0.25-cycle steps (some programmable and other various timers)

Pickup and dropout accuracy for all timers:
- ±0.25 cycles and ±0.1% of setting

Substation Battery Voltage Monitor

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

Metering Accuracy

Voltages V_A, V_B, V_C, V_S:
- ±0.67 V secondary

Currents I_A, I_B, I_C, I_P:
- ±1 mA and ±1% (0.5–15 A) (5 A nominal)
- ±0.2 mA and ±1% (0.1–5 A) (1 A nominal)

Ratings, Type Tests, & Certifications

Operating Temperature Range

–40°C to +85°C
–40°F to +185°F
- IEC 68-2-1: 1990 Basic environmental testing procedures, Part 2: Tests—Test Ad: Cold
- IEC 68-2-2: 1974 Basic environmental testing procedures, Part 2: Tests—Test Bd: Dry Heat

Power Supply

125/250 V: 85–350 Vdc or 85–264 Vac
24/48 V: 20–60 Vdc
<15 W Total Burden

Type Tests

Dielectric: 2500 Vac, 10 seconds
Environment:
- IEC 68-2-30: 1980 Basic environmental testing procedures, Part 2: Tests, Test Db and guidance: Damp heat, cyclic.
- IEC 529: 1989-11 Degrees of Protection Provided by Enclosures—IP30 (IP54 from the front panel using the SEL-9103 Front Cover Dust and Splash Protection, available for horizontal rack-mount models only).

RFI and Immunity:
- IEC 801-4: 1988 Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment, Part 4: Electrical Fast Transient/Burst Requirements.
- IEC 255-22-1: 1988 Electrical Disturbance Tests for Measuring Relays and Protection Equipment, Part 1: 1 Mhz Burst Disturbance Tests.
- IEC 255-22-3: 1989 Electrical Relays, Section 3: Radiated Electromagnetic Field Disturbance Tests.
- IEC 255-22-4: 1992 Electrical Disturbance Tests for Measuring Relays and Protection Equipment, Section 4: Fast Transient Disturbance Test.
- IEEE C37.90.1: 1989 IEEE SWC Tests for Protective Relays and Relay Systems.
- IEEE C37.90.2: 1987 IEEE Trial-Use Standard, Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers, 10 V/m.

Impulse:
- IEC 255-5: 1977 Electrical Relays, Part 5: Insulation Tests for Electrical Relays, Section 6: Dielectric Tests, Series C.

ESD:
- IEC 255-22-2: 1996 Electrical Disturbance Tests for Measuring Relays and Protective Equipment, Section 2: Electrostatic Discharge Tests.

Vibration and Shock:
- IEC 255-21-1: 1988 Electrical relays, Part 21: Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protection Equipment.
- IEC 255-21-2: 1988 Electrical Relays, Part 21: Vibration, shock, bump, and Seismic Tests on Measuring Relays and Protection Equipment.
- IEC 255-21-3: 1993 Electrical Relays, Part 21: Vibration, Shock, Bump, and Seismic Tests on Measuring Relays and Protection Equipment.

Certifications

ISO: Relay is designed and manufactured using ISO-9001 certified quality program.
CE: CE Mark.

Schweitzer Engineering Laboratories

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