SEL-300G Generator Relay

The SEL-300G Generator Relay is a comprehensive, multifunction relay intended for primary and/or backup protection for any size synchronous machine.

Features

Protection

- 100% Stator Ground
- Phase (optional) or Ground Differential
- Volts/Hertz
- Reverse or Low Forward Power
- Backup Overcurrent Protection
- Negative-Sequence Overcurrent
- Loss-of-Field
- Six-8
- Step Over-/Under-frequency with Time Accumulators
- Over-/Undervoltage
- Inadvertent Energization
- Loss-of-Potential
- Synchronism Check (optional)
- Out-of-Step (1 or 2 blinder schemes)

Monitoring and Metering

- Full Event Reports and Sequential Events Records (SER)
- Breaker Monitor and Battery Monitor
- High Accuracy Metering

Communications

- ASCII and Binary Communications on EIA-232 and/or EIA-485 Ports
- IRIG-B Time Code Input

Control

- Advanced SELOGIC® Control Equations for Traditional or Custom Logic Implementation

Applications

The SEL-300G Relay can be applied in primary or backup applications for complete generator or unit protection.

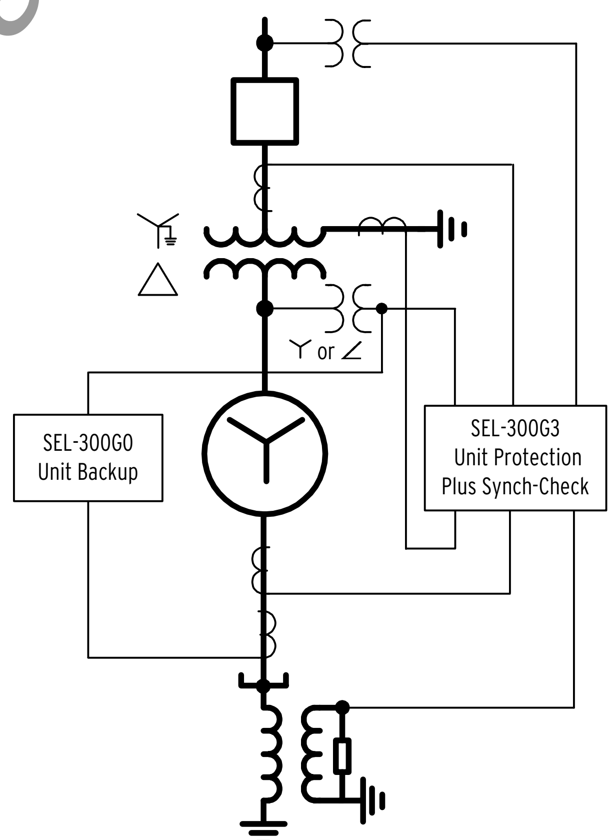


Figure 1 Typical Application.

Functional Overview

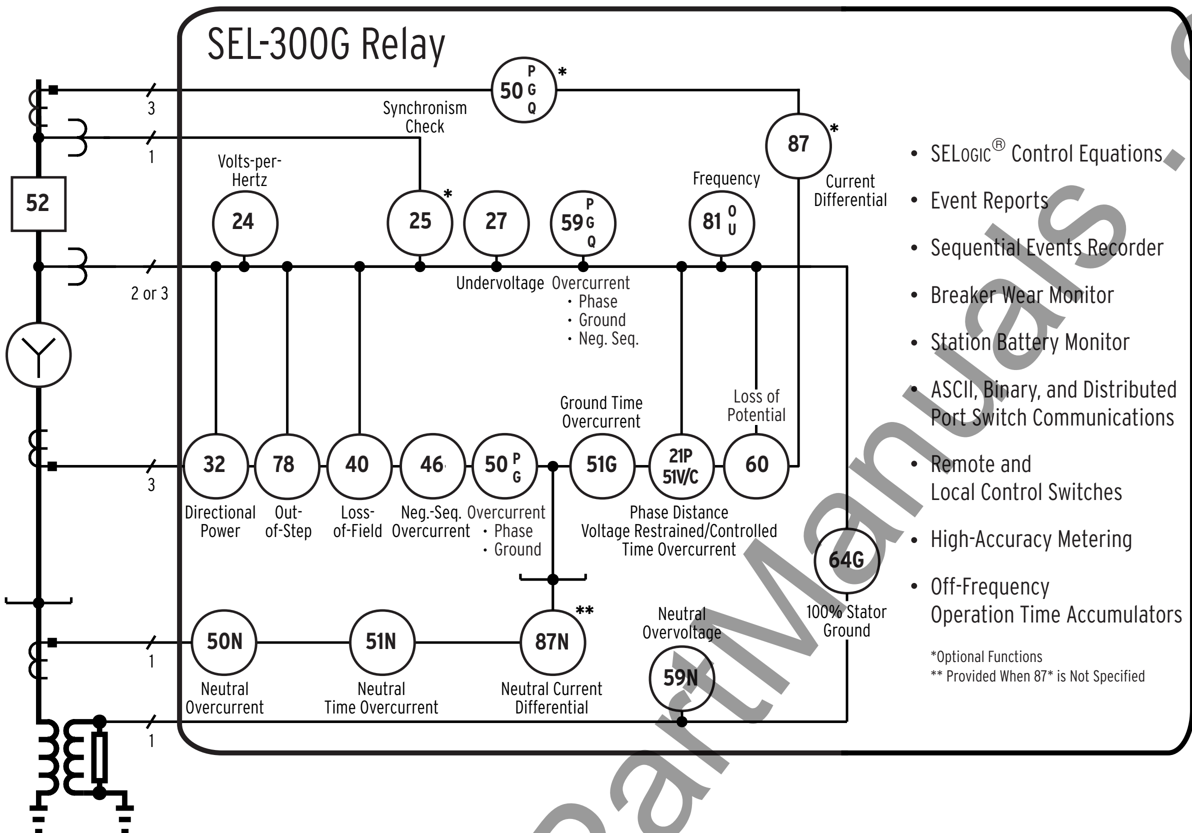


Figure 2 Functional Overview.

SEL-300G Relay Features/Benefits

AC Analog Inputs

The SEL-300G Relay has between eight and eleven analog inputs, depending on the options selected. All analog inputs are recorded for event reporting and oscillography.

Optional Differential Protection

When specified, the SEL-300G Relay detects stator faults using a secure, sensitive current differential function. This function provides a sensitive percentage-restrained differential element and an unrestrained element. The differential function provides the unique capability of [pwer transformer and ct connection compensation. This allows you to conveniently include the unit step-up transformer in the generator differential zone using wye-connected cts for both input sets.

User-programmable second-harmonic blocking detects transformer inrush when the differential zone includes the generator step-up transformer. The dual-slope percentage restraint characteristic improves element security for through-fault conditions.

Optional Ground Differential Protection

SEL-300G Relays that do not include the optional percentage-restrained differential elements described above are equipped with a ground differential function that provides selective ground fault detection for solidly grounded and low-impedance grounded generators. This function helps protect generators on multimachine busses, because the element does not respond to ground faults on the parallel generators.

Optional Synchronism Checking

You can specify the SEL-300G Relay with a built-in synchronism checking function. The synch-check function is extremely accurate and provides supervision for acceptable voltage window and maximum percentage difference, maximum and minimum allowable slip frequency, target closing angle, and breaker closing delay. The synch-check report gives complete information on the three latest paralleling operations, including generator and system voltages and frequencies, slip frequency, and phase angle when the close was initiated. The relay also keeps a running average of the breaker close time.

100 Percent Stator Ground Detection

The SEL-300G Relay detects stator ground faults on high-impedance grounded generators using a conventional neutral-overvoltage element with a third-harmonic voltage differential detection scheme for 100% stator winding coverage. The neutral overvoltage element detects winding ground faults in approximately 85% of the winding. Faults closer to the generator neutral do not result in high neutral voltage but are detected using third-harmonic neutral and terminal voltages. The combination of the two measuring methods provides ground fault protection for the full winding.

Directional Power Detection

Sensitive directional power elements in the SEL-300G Relay provide antimotoring and/or low forward power tripping. Two elements having independent time-delays and sensitivities are provided. Directly trip the generator under loss-of-prime mover conditions to prevent prime movers from motoring, or use low forward power indication as a tripping interlock when an orderly shutdown is required.

Over-Excitation Protection

The SEL-300G Relay provides one definite-time for alarm and one composite inverse-time volts/hertz element. The composite inverse-time characteristic may be enabled with a two-step definite-time characteristic, a definite/inverse-time characteristic, or a simple inverse-time characteristic.

Loss-of-Field Protection

Two offset positive-sequence mho elements detect loss-of-field conditions. Settable time-delays help reject power swings that pass through the machine impedance characteristic. By using the included directional supervision, one of the mho elements can be set to coordinate with the generator minimum excitation limiter and its steady state stability limit.

Out-of-Step Protection

SEL-300G Relays utilize either a single blinder or double blinder, depending on user selection, to detect an out-of-step condition. In addition to the blinders, the scheme uses a mho circle that restricts the coverage of the out-of-step function to the desired extent. Furthermore, both schemes contain current supervision and Torque Control to supervise the operation of the out-of-step element.

Negative-Sequence Overcurrent Protection

Negative-sequence current heats the rotor at a higher rate than positive-sequence or ground current. The negative-sequence definite-time element provides alarm for early stages of an unbalanced condition. The inverse-time overcurrent element provides tripping for sustained unbalance conditions to prevent machine damage. The inverse-time negative-sequence element provides industry standard I_2^2t protection curves.

System Backup Protection

The SEL-300G Relay offers you the choice of three methods for performing system backup protection. Phase mho distance elements, a voltage-restrained phase time-overcurrent element, and a voltage-controlled phase time-overcurrent element are all available; you simply enable the element you wish to use.

Ground Overcurrent Elements

Neutral (I_N) overcurrent elements detect ground faults in low-impedance grounded and solidly grounded machines. Torque-Control these elements using an optoisolated contact input or internal logic conditions.

Over-/Undervoltage Protection

Phase undervoltage and overvoltage elements are included for creating protection and control schemes such as

- ➤ Torque-control for the overcurrent protection.
- ➤ Trip/alarm or event report triggers for voltage sags and swells.

Desired definite time-delay may be added using a SELOGIC control equation timer.

Negative- and zero-sequence overvoltage elements are included for protection and control.

Loss-of-Potential Logic

Relay functions that use phase voltages or symmetrical component voltages rely on valid inputs to make the correct decisions. The SEL-300G Relay includes loss-of-potential logic that detects one, two, or three potentially blown fuses. This logic is unique as it does not require settings and is useful in all applications (patent pending). This logic replaces traditional voltage unbalance schemes that require inputs from two vt sets.

Inadvertent Energization Detection

Occasionally, the unit breaker for an out-of-service generator is closed inadvertently. The SEL-300G Relay detects this condition using voltage, current, and other supervisory conditions you select through a SELOGIC control equation.

Frequency Protection

Six levels of over- or underfrequency elements detect abnormal machine operating conditions. Use the independently time-delayed output of these elements to trip or alarm. Phase undervoltage supervision prevents undesired frequency element operation during start-up, shut-down, and faults, and while the field is deenergized.

SEL-300G Relay frequency elements have high accuracy and low overshoot. For a step frequency change of ±5 Hz, the steady-state plus transient error is less than 0.01 Hz.

The SEL-300G Relay tracks the total time-of-operation in up to six off-nominal frequency bands. If the off-nominal time-of-operation exceeds one of the independent time set points, the relay can trip or alarm.

Event Report and Sequential Events Recorder (SER)

You select event trigger conditions and event report length: 15 or 30 cycles. The voltage, current, frequency, and element status information contained in each report confirms relay, scheme, and system performance for every operation. The latest twenty-nine 15-cycle event reports (or fifteen 30-cycle event reports) are stored in nonvolatile memory. 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.

The 1/4-cycle report is one-fourth the size of the 1/16-cycle report. Therefore, it is quicker to retrieve and analyze. This advantage is especially valuable following a major disturbance. The full 1/16 sample/cycle report can be retrieved when conditions warrant closer scrutiny.

The relay SER feature stores the latest 512 entries. Use this feature to gain a broad perspective at a glance. An SER entry is triggered by items such as input/output change of state occurrences and element pickup/dropout. The relay also supports user naming of internal conditions and relay inputs. These settable names appear in the SER report and simplify operation analysis.

The IRIG-B time-code input synchronizes the SEL-300G Relay time to within ±5 ms of the time-source input. A convenient source for this time code is the SEL-2020 Communications Processor.

Demand Current Thresholds

Settable demand current thresholds are available for phase, negative-sequence, and ground/residual demand measurements. When demand current exceeds a threshold, the respective Relay Word bit PDEM, QDEM, GDEM, or NDEM asserts.

Two types of demand-measuring techniques are offered: thermal and rolling.

When you select thermal demand measuring, PDEM, QDEM, GDEM, or NDEM alarm for generator overload, negative-sequence unbalance, residual, or neutral unbalance, respectively. The demand ammeter time constant can be set to any value between 5 and 60 minutes.

Breaker Wear Monitor

Breakers experience mechanical and electrical wear every time they operate. Breaker manufacturers publish maintenance curves and tables that relate interrupted current to the number of close-to-open (C/O) operations. These data usually are presented in a table in the inspection and maintenance section of the breaker manual.

Every time the breaker trips, the relay counts the close-to-open operation and records the magnitude of the unfiltered current in each phase. When the result of this record exceeds the threshold set by the breaker wear curve (see *Figure 3*), the relay asserts the corresponding Breaker Contact Wear Alarm bit: BCWA, BCWB, or BCWC. This method of monitoring breaker wear is solidly based on breaker ratings from the breaker manufacturer.

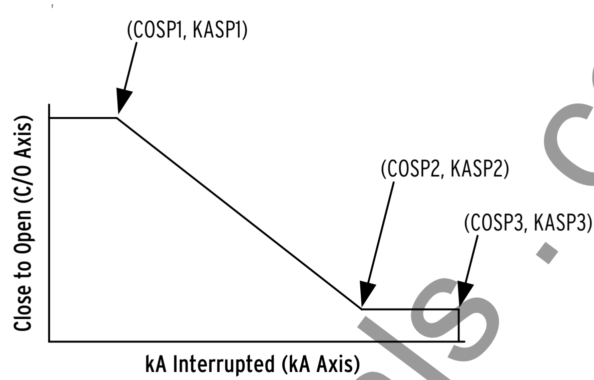


Figure 3 Breaker Contact Wear Curve Settings.

Extensive Metering Capabilities

This relay provides extensive high accuracy metering capabilities. $V_{A,B,C}$ and $I_{A,B,C}$ metering accuracies are 0.1% of input at nominal frequency (voltages: 33.5 V < VAC < 150 V; currents: measured current is greater than 10% of the nominal current rating).

Metered quantities include phase voltages and currents, differential quantities, sequence voltages and currents, power, frequency, substation battery voltage, energy (including demand) along with maximum/minimum logging of selected quantities.

Station Battery Monitor

The relay measures and reports the substation battery voltage presented to the power supply terminals. The relay includes two settable threshold comparators and associated Relay Word bits (DCLO, DCHI) for alarm and control. For example, if the battery charger fails, the measured dc falls below the DCHI pickup threshold and DCHI drops out. Program this bit to a “b” contact connected to SCADA or an annunciator panel to notify operation personnel before the substation battery voltage falls to dangerous levels. Or, monitor the DCHI bit in the SEL-2020 Communications Processor and trigger messages, telephone calls, or other actions.

The measured dc voltage is reported in the METER display and the VDC column of the event report. Use the event report column 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.

Two Independent Setting Groups

The relay stores two 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-300G Relay ideal for adapting the protection to changing system conditions.

When you switch groups, you switch logic settings as well as relay element settings. Groups can be programmed for different operating conditions, such as station maintenance, seasonal operations, or emergency loading contingencies.

Additional Features

Configurable Front-Panel

The SEL-300G Relay LCD display includes the Display Point feature that, when used with the high-accuracy metering function, replaces separate panel meters. The relay provides a rolling display of up to eight alphanumeric messages plus meter quantities you select. Each display lasts one second before automatically scrolling to the next pair of messages. This feature allows you to examine the state of the protected machine and review the metered quantities without pressing front-panel buttons or decoding complicated menus.

Operator Controls and Serial Communications

The SEL-300G Relay is equipped with three EIA-232 serial ports (one on the front panel and two on the rear panel) and one isolated EIA-485 serial port (relay rear panel). Each serial port operates independently of the other serial ports. The serial ports provide full access to event history, relay status, and meter information. Three-level password access provides security for control and setting operations.

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.

Advanced SELOGIC Control Equations

Advanced SELOGIC control equations allow you to assign the relay inputs to suit your application, logically combine selected relay elements for various control functions, and assign output relays 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 included are shown in *Table 1*.

Use this Boolean-type logic to

- ➤ Define which elements or conditions control each output contact (except ALARM).
- ➤ Define the function of the digital inputs. For example, use this feature to switch between the two available setting groups using conditions such as control switch position, as indicated by control input.
- ➤ Define which elements and conditions trigger event reports.
- ➤ Define which elements and conditions add entries to the SER.
- ➤ Select the elements that trip for various conditions.
- ➤ Create breaker trip and close circuit monitoring logic.

Configure the contact outputs to operate when any of the protective elements and/or logic outputs assert. Implement complete protective schemes using a minimum of wiring and panel space. Programmable contact closure simplifies testing by indicating pickup and dropout of only those elements under test.

The general purpose SELOGIC control equation timers in each setting group eliminate the need for external timers for custom protection or control schemes. Each timer has independent time-delay pickup and dropout timers. You program the input(s) to each timer. Assign the timer output to output contacts or use it in tripping or other control scheme logic.

Contact Inputs and Outputs

The SEL-300G Relay provides six optoisolated contact inputs and eight output contacts. The contact inputs are assignable for control functions, monitoring logic, and general indication. Except for a dedicated alarm output, each output contact is independently programmable using SELOGIC control equations. All relay output contacts are rated for trip duty.

The optional I/O board is available with either standard or high-current interrupting output contacts that interrupt up to 10 A of inductive current.

All output contacts are jumper-configurable as either “a” or “b” contacts. The output contact next to the ALARM contact is jumper configurable to follow the ALARM contact.

Table 1 SELOGIC Control Equation Operators

Symbol	Operator	Description
+	OR	One element on either side of a + symbol must assert before the condition is true.
*	AND	Elements on both sides of the * symbol must assert before the condition is true.
!	Invert	Inverts the element immediately following the ! symbol.
( )	Parentheses	Enclose elements and inputs inside these parentheses to be operated on by the +, !, or * operators. Use these parentheses in SELOGIC control equations to minimize setting entries and create IF-THEN-ELSE statements.
/	Rising Edge	Requires that the element to the right of the / symbol be dropped out one processing interval and not the next before the logic condition is true.
\	Falling Edge	Requires that the element to the right of the \ symbol be picked up one processing interval and not the next before the logic condition is true.

Guideform Specifications

Protection, control, and monitoring for the generator shall be provided by a microprocessor-based package.

The relay shall provide protection over the operating frequency range of 20–70 Hz. Protection functions shall include the following:

- Two-zone, positive-sequence impedance mho element for loss-of-field detection (40).
- 100% stator ground fault detection based on measurement of neutral overvoltage plus neutral and terminal third-harmonic voltage differential with settable sensitivity (64G).
- Out-of-Step protection based on single or double blinders.
- Overexcitation detection based on volts/hertz measurement. One definite-time and a composite definite/inverse-time element shall be provided (24).
- Negative-sequence overcurrent elements, including definite-time and inverse-time operating characteristics (46).
- Two sensitive directional power elements with flexibility to provide antimotoring, over-power, or low-forward power indication (32).
- Two-zone phase distance or voltage restrained and voltage controlled phase time-overcurrent element for backup protection (21P/51V/51C).
- Residual and neutral instantaneous, definite-time, and inverse-time nondirectional overcurrent elements (50/51).
- Phase, positive-sequence, negative-sequence, and residual overvoltage elements (59).
- Inadvertent energization protection (50/27).
- Unit breaker failure protection (50BF).
- Supervision of voltage-based protection functions by loss-of-relaying-potential detection logic (60).
- Six over-/underfrequency elements (81).
- Percentage restraint and unrestrained phase current differential elements as an option (87), ground differential (87N) provided when 87 is not selected.
- Synchronism checking (25) element available as an option.
- Two independent relay setting groups.

The relay shall include metering and monitoring functions to indicate the following:

- Measured current and voltage magnitudes and phase angles. Third-harmonic neutral and terminal voltage magnitudes. Volts/Hertz, percent of nominal.
- Single- and three-phase real and reactive power (MW, MVAR) and power factor (PF).
- Single- and three-phase real and reactive directional energy (MWh, MVARh).
- System frequency and station battery voltage.
- Demand quantities: phase, negative-sequence, residual, and neutral currents, MW and MVAR.
- Maximum and minimum log for Ia, Ib, Ic, Ig, In, Va, Vb, Vc, Vn, 3∅ MW, and MVAR.
- Unit breaker contact wear based on current interrupted and close-to-open operations.
- DC battery voltage monitoring and metering.

The relay shall provide access to the above data via a front-panel LCD display and the following serial ports:

- Three EIA-232 serial ports, one located on the relay front panel.
- One isolated EIA-485 serial port.

Serial ports shall support ASCII-text communication. Serial port relay setting entry shall be possible using an off-the-shelf PC-based terminal emulation package.

The relay shall provide

- Six configurable optoisolated control inputs.
- Seven programmable output contacts.
- A self-test ALARM contact.
- Output contacts rated for tripping duty per IEEE C37.90 standards.
- Programmable output contacts flexible to support AND, OR, and INVERT Boolean operations of internal relay elements and logic outputs.
- Available options to increase the contact I/O count.
- Available options for high-current interrupting contact outputs.

The relay shall retain in nonvolatile memory

- A sequence of events record consisting of the 512 latest time-tagged events.
- No fewer than 15 latest event reports containing voltage and current measurements, contact input and output status, and relay element conditions. Record formats displaying 4 and 16 samples per cycle shall be available.

The relay shall accept IRIG-B time code synchronization and include a battery-backed time clock to retain date and time during deenergization.

The relay shall include extensive self-testing and an alarm output contact indication of self-test warning or failure conditions or removal of dc power.

Hardware Overview

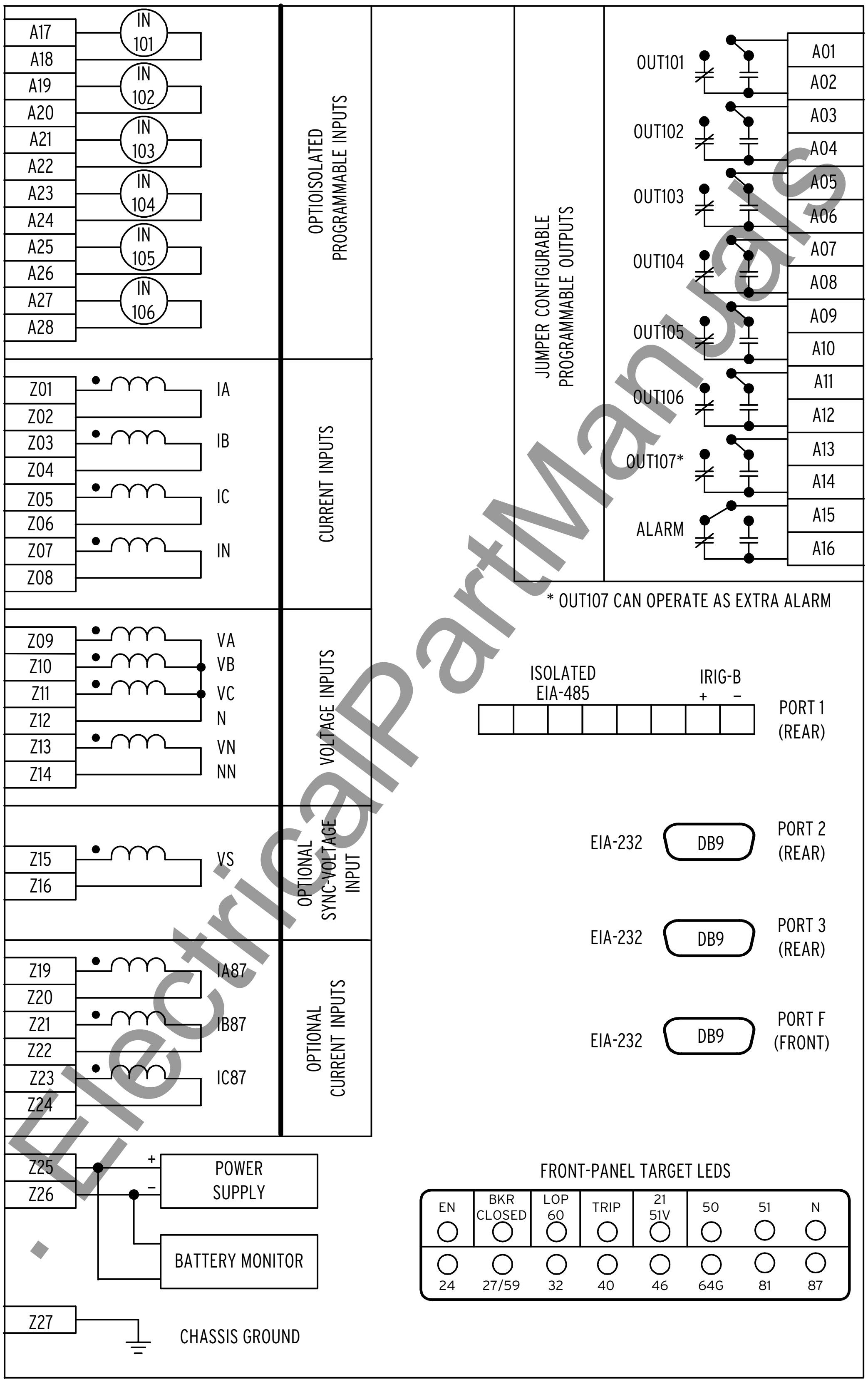


Figure 4 SEL-300G30H Relay Inputs, Outputs, and Target Diagram.

Wiring Diagrams

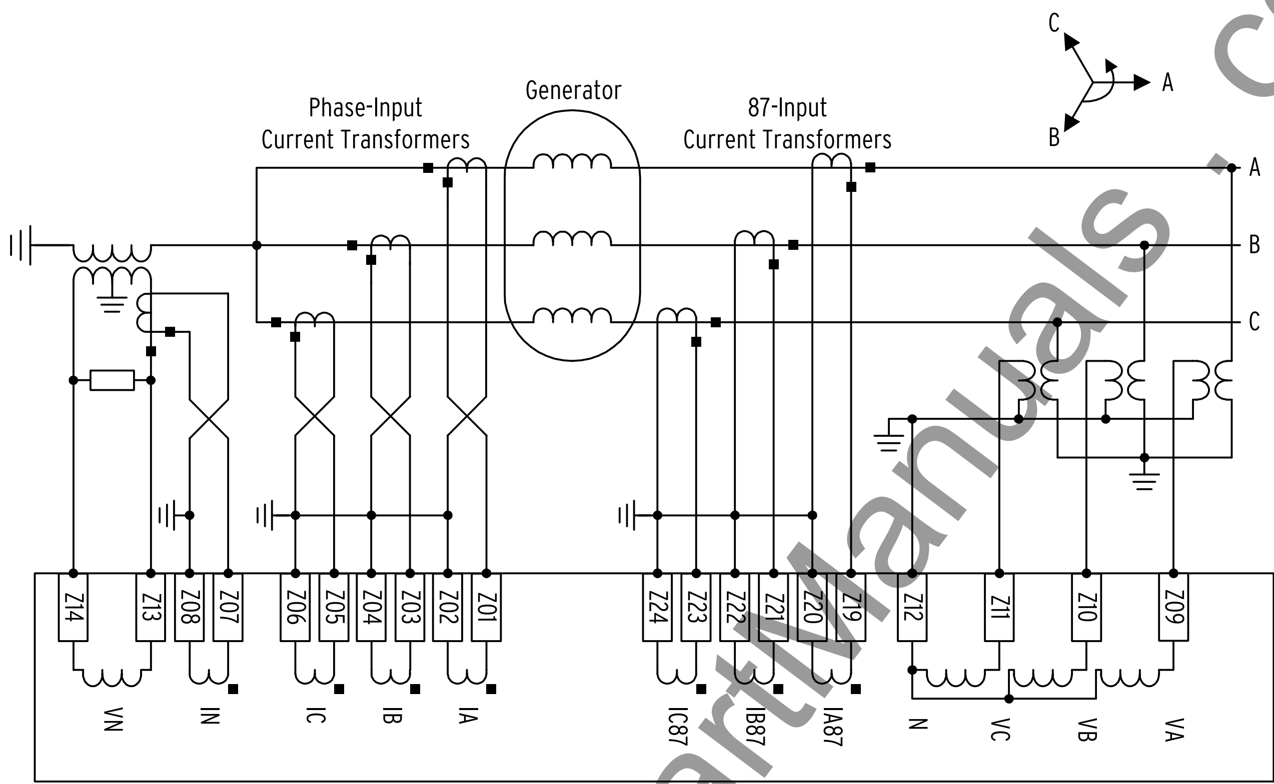


Figure 5 SEL-300G Relay Typical AC Current and Four-Wire Wye Voltage Connection.

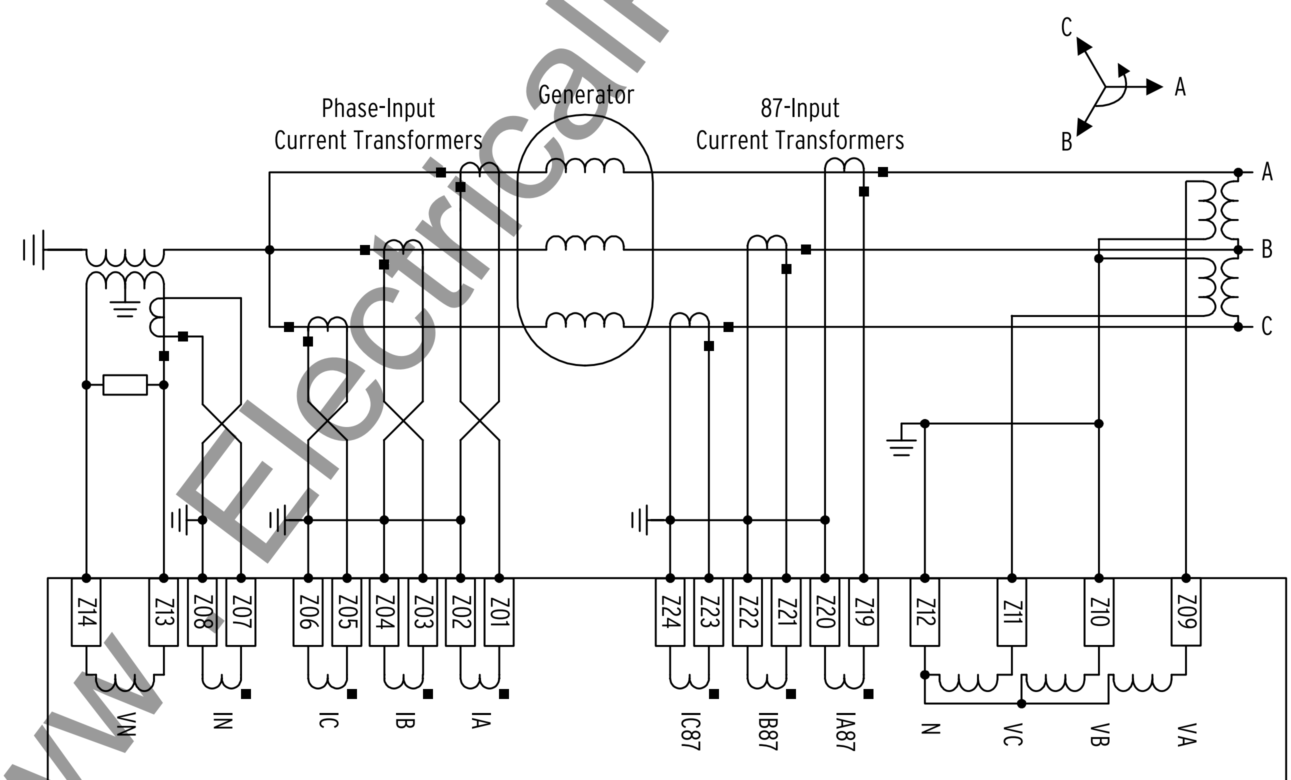


Figure 6 SEL-300G Relay Typical AC Current and Open-Delta Voltage Connections.

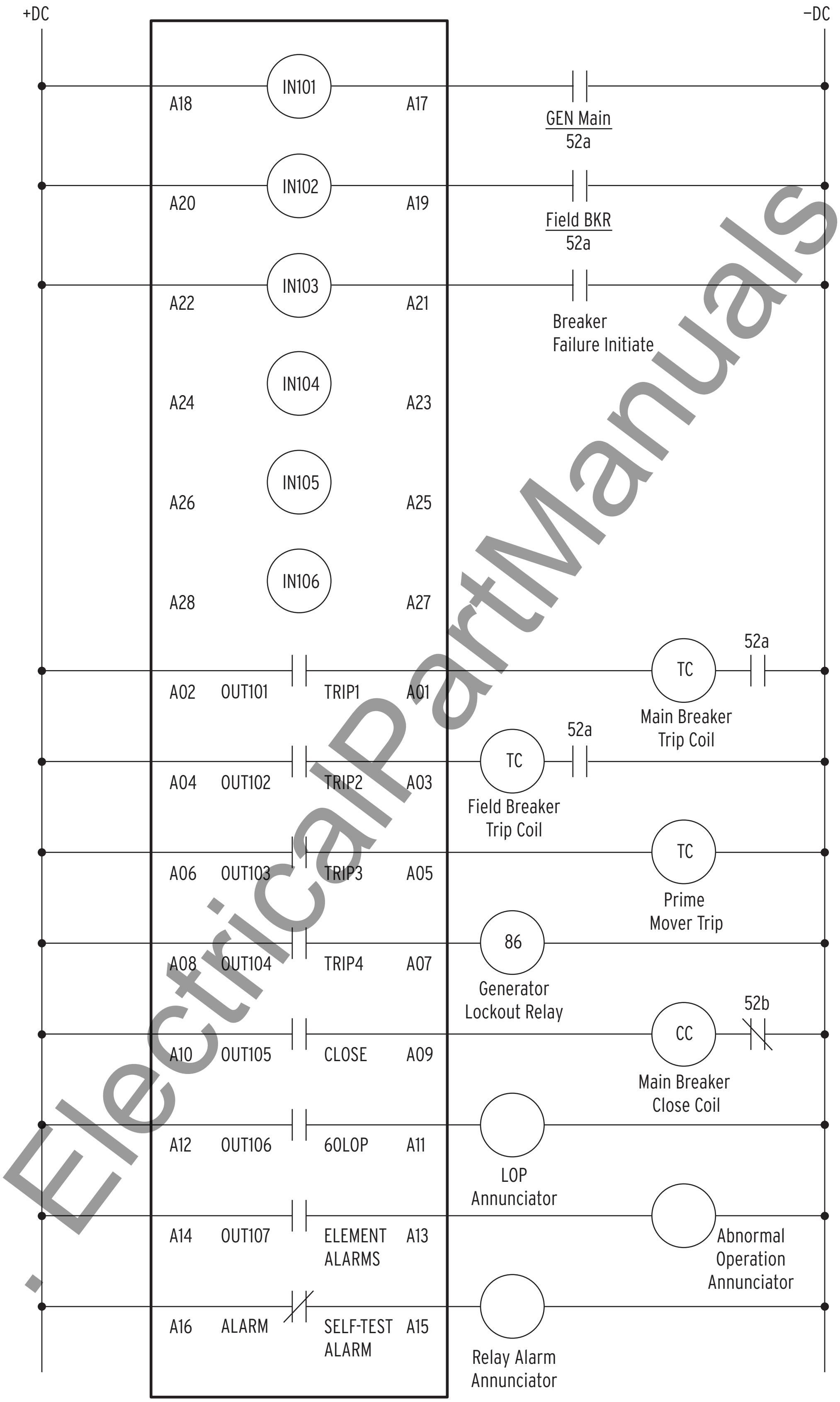
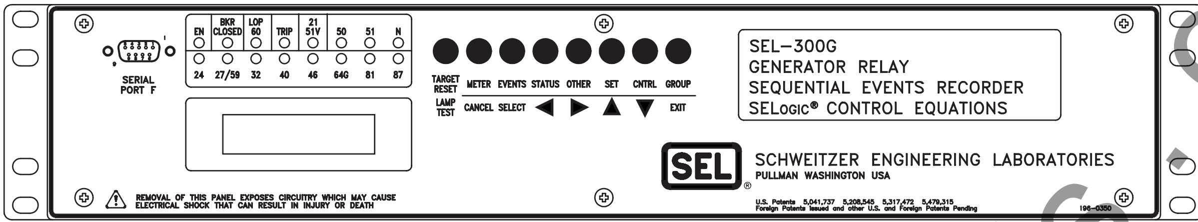
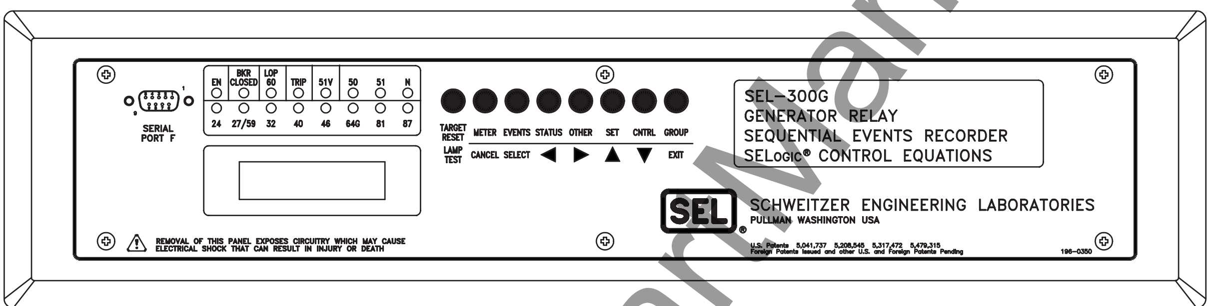


Figure 7 SEL-300G Relay Typical Minimum DC External Connections.

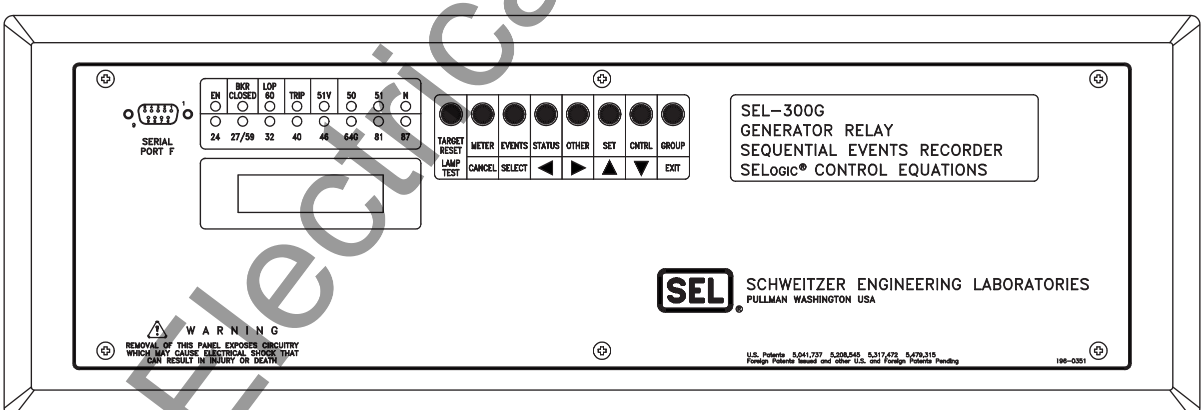
Front- and Rear-Panel Drawings



2U Rack-Mount Front Panel

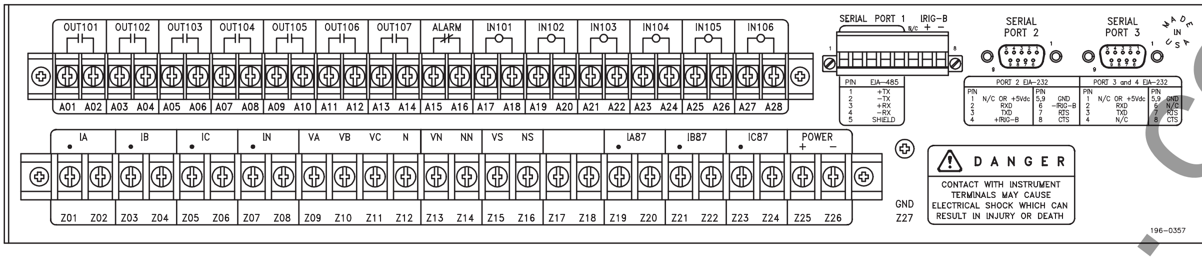


2U Panel-Mount Front Panel

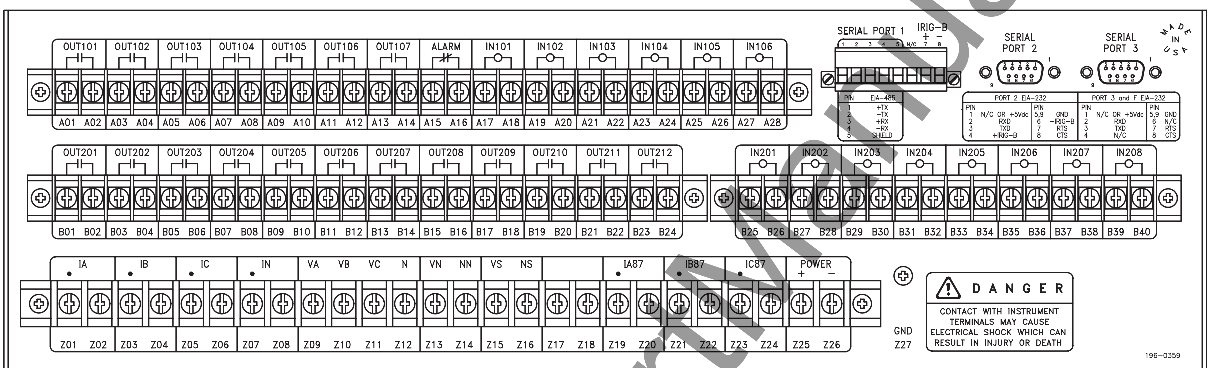


3U Panel-Mount Front Panel

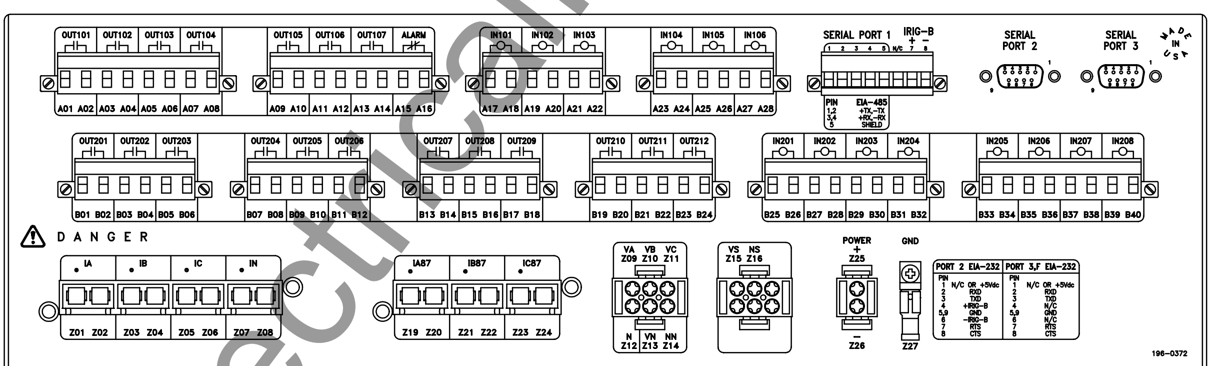
Figure 8 SEL-300G Front Panel Drawings.



2U Rear Panel, Terminal Block



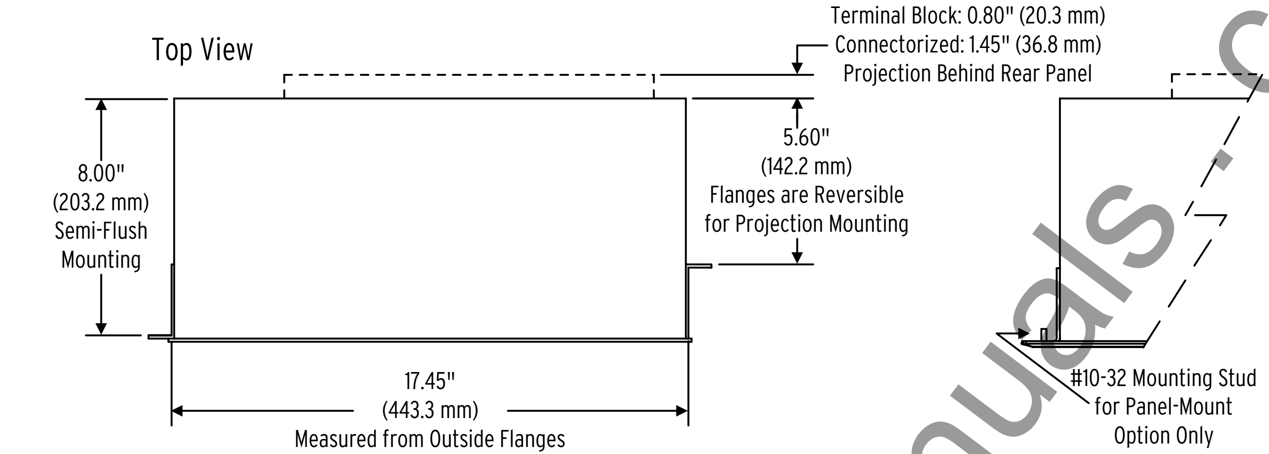
3U Rear Panel, Terminal Block

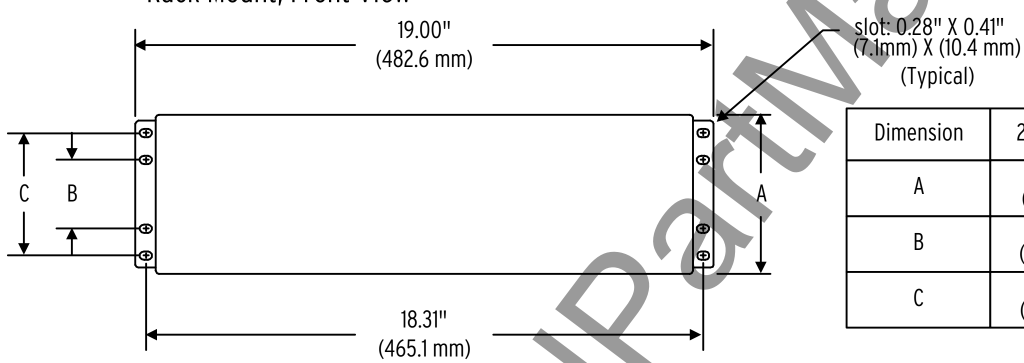


3U Rear Panel, Plug-In Connectors

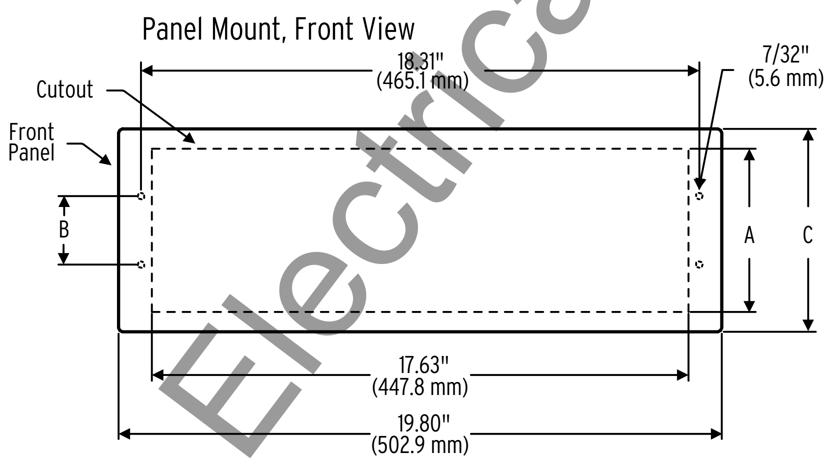
Figure 9 SEL-300G Rear-Panel Drawings.

Relay Dimensions





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" (0.51 mm).
2. Drawing Not to Scale.

Figure 10 SEL-300G Relay Dimensions for Rack- and Panel-Mount Models.
(Horizontal Mounting Shown; Dimensions Also Apply to Vertical Mounting).

Specifications

General Specifications

AC Current Inputs

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

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

AC Voltage Inputs

80–140 V_{L-L}
Note: This is for effective use of Volts/Hertz (24) and Sensitive Directional Power (32) elements.

150 V_{L-N} continuous limit for three-phase, four-wire wye connection.

150 V_{L-L} continuous limit for three-phase, three-wire delta connection.

365 Vac for 10 seconds.

300 V continuous, VN–NN neutral voltage input.

150 V continuous, VS–NS synch voltage input.

Burden: 0.13 VA @ 67 V
0.45 VA @ 120 V
0.80 VA @300 V

Power Supply

125/250 Vdc

Range:	85–350 Vdc or 85–264 Vac
Interruption:	30 ms @ 125 Vdc
Ripple:	100% 50/60 Hz
Burden:	<15 W

24/48 Vdc

Range:	20–60 Vdc
Interruption:	30 ms @48 Vdc
Ripple:	5%
Burden:	<15 W

Output Contacts

Standard

Make:	30 A
Carry:	6 A
1 s Rating:	100 A
MOV Protection:	270 Vac, 360 Vdc, 40 J
Pickup Time:	< 5 ms

Breaking Capacity (100,000 operations):

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

Cyclic Capacity (2.5 cycles/second):

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

High current interruption option:

Make:	30 A
Carry:	6 A
MOV:	330 Vdc, 40 J
Pickup time:	< 5 ms
Dropout time:	< 8 ms

Breaking Capacity (10,000 operations):

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

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

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

Note: Do not use high current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.

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

Optoisolated Inputs

250 Vdc:	Pickup 200–300 Vdc; Dropout 150 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 15.0–30 Vdc

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

Frequency and Rotation

System Frequency:	60 or 50 Hz
Phase Rotation:	ABC or ACB
Frequency Tracking Range:	20–70 Hz

Note: V_A required for frequency tracking.

Communications Ports

EIA-232:	1 Front & 2 Rear
EIA-485:	1 Rear
Baud Rate:	300–38400

Time-Code Input

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

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

Dimensions

See *Figure 10* for exact relay dimensions.

Operating Temperature

–40° to +85°C (–40° to +185°F)

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

Weight

2U Rack Unit

Minimum:	13.5 lbs (6.2 kg)
Maximum:	15 lbs (6.8 kg)

3U Rack Unit

Minimum:	16.5 lbs (7.5 kg)
Maximum:	18.5 lbs (8.4 kg)

Type Tests

Radiated Radio Frequency (900 MHz with modulation):	ENV 50204: 1996, 10 V/m
Cold:	IEC 68-2-1: 1990, Test Ad; 16 hr @ –40°C
Dry Heat:	IEC 68-2-2: 1974 Test Bd; 16 hr @ +85°C
Damp Heat, Cyclic:	IEC 68-2-30: 1980, Test Db; 55°C, 6 cycles, 95% humidity
Dielectric Strength:	IEC 255-5: 1977, IEEE C37.90: 1989, 2500 Vac on analogs, contact inputs, and contact outputs; 3100 Vdc on power supply; 2200 Vdc on EIA-485 communications port
Impulse:	IEC 255-5: 1977, 0.5 J, 5000 V
Vibration:	IEC 255-21-1: 1988, Class 1
Shock and Bump:	IEC 255-21-2: 1988, Class 1
Seismic:	IEC 255-21-3: 1993, Class 2
1 MHz Burst Disturbance:	IEC 255-22-1: 1988, Class 3 (2500 V common & differential mode)
Electrostatic Discharge:	IEC 255-22-2: 1996, EN 61000-4-2: 1995 Level 4
Radiated Radio Frequency:	IEC 255-22-3: 1989, IEC 801-3: 1984, ENV 50140: 1994, IEEE C37.90.2: 1995 10 V/m
Fast Transient Disturbance:	IEC 255-22-4: 1992, EN 61000-4-4: 1995 Level 4
Object Penetration:	IEC 529: 1989 IP 3X
Surge Withstand:	IEEE C37.90.1: 1989, 3000 V oscillatory, 5000 V transient

Certifications

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

ETL: Listed to UL-508 and CSA C22.2 No. 14-95 for Industrial Control Equipment (available only in screw-terminal block version).

CE Mark (available only in screw-terminal block version).

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.

Second-harmonic current and third-harmonic voltage filters are also included for specific protection functions.

Protection and Control Processing

Four times per power system cycle for all elements except out-of-step and loss-of-field elements which are processed two times per power system cycle.

Relay Element Setting Ranges and Accuracies

Phase Mho Distance Element (21)

5 A Model
- Reach: 0.1–100.0 ohms
- Offset: 0.0–10.0 ohms
- Steady-State Impedance Accuracy: ±5%, ±0.1 ohm
- Minimum Phase Current: 0.5 A

1 A Model
- Reach: 0.5–500.0 ohms,
- Offset: 0.0–50.0 ohms
- Steady-State Impedance Accuracy: ±5%, ±0.5 ohm
- Minimum Phase Current: 0.1 A

Maximum Torque Angle Range: 90 – 45°, 1° step

Pickup Time: 33 ms at 60 Hz (Max)

Zone 1 & Zone 2 Definite-Time Delays: 0.00 – 400.00 s

Maximum Time-Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Volts/Hertz Overexcitation Element (24)

Definite-Time Element
- Pickup Range: 100 – 200%
- Steady-State Pickup Accuracy: ±1%
- Pickup Time: 25 ms at 60 Hz (Max)
- Definite-Time Pickup Range: 0.00 – 400.00 s
- Time-Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz (Max)

Composite-Time Element
- Inverse-Time Pickup Range: 100 – 200%
- Inverse-Time Curve: 0.5, 1.0, or 2.0
- Inverse-Time Dial: 0.1–10.0 s
- Inverse-Time Steady-State Pickup Accuracy: ±1%
- Inverse-Time Timing Accuracy: ±4%, ±25 ms at 60 Hz, for V/Hz above 1.05 multiples (Curve 0.5 and 1.0) or 1.10 multiples (Curve 2) of pickup setting
- Definite-Time Pickup Range: 100 – 200%
- Definite-Time Setting Range: 0.00 – 400.00 s
- Pickup Time: 25 ms at 60 Hz (Max)
- Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz
- Linear Reset Time: 0.00 – 400.00 s

Optional Synchronism Checking Function (25) (Models 0300G2 and 0300G3)

Synch-Check Voltage Source: VA, VB, VC, VAB, or VBC

Supervisory Voltage Setting Range: 20.0–200.0 V

Steady-State Voltage Accuracy: ±5%, ±0.1 V

Maximum Percentage Voltage Difference: 1.0–15.0%

Supervisory Slip Frequency Window Element: –1.00 Hz–1.00 Hz

Steady-State Slip Accuracy: ±0.02 Hz

Close Acceptance Angle 1, 2: 0 – 80°

Target Close Angle: –15–15°

Breaker Close Delay: 0.000 – 1.000 s

CloseFailure Angle: 3 – 120°

Steady-State Angle Accuracy: ±0.5°

Maximum Transient Angle Accuracy: ±1.8 • slip ±0.5°

Directional Power Element (32)

Two Definite-Time Elements
- Setting Range: ±0.0015 to ±3.000 pu
- Steady-State Pickup Accuracy: ±0.0015 pu ±2% of setting, INOM = 5 A, VNOM = 120 V, PF ≥ 0.2
- Pickup Time: 25 ms at 60 Hz (Max)
- Definite-Time Setting Range: 0.01–400.00 s
- Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Loss-of-Field Element (40)

Two Mho Zones

5 A Model
- Zone 1 Offset: –50.0 – 0.0 ohms
- Zone 2 Offset: –50.0 – 50.0 ohms
- Zone 1 & Zone 2 Diameter: 0.1–100.0 ohms
- Steady-State Impedance Accuracy: ±0.1 ohm, ±5% of offset + diameter
- Minimum Pos.-Seq. Signals: 0.25 V V1, 0.25 A I1

1 A Model
- Zone 1 Offset: –250.0 – 0.0 ohms
- Zone 2 Offset: –250.0 –250.0 ohms
- Zone 1 & Zone 2 Diameter: 0.5 –500.0 ohms
- Steady-State Impedance Accuracy: ±0.5 ohm, ±5% of offset + diameter
- Minimum Pos.-Seq. Signals: 0.25 V V1, 0.05 A I1

Directional Element Angle: –20.0° – 0.0°

Pickup Time: 50 ms at 60 Hz (Max)

Zone 1 & Zone 2 Definite-Time Delays: 0.00 – 400.00 s

Maximum Definite-Time Delay Accuracy: ±0.1%, ±8.3 ms at 60 Hz

Negative-Sequence Overcurrent Elements (46)

Definite-Time & Inverse-Time Neg.-Seq. I_2 Pickup: 2%–100% of generator rated secondary current

Generator Rated Secondary Current
- 5 A Model: 2.5–10.0 A secondary
- 1 A Model: 0.5–2.0 A secondary

Steady-State Pickup Accuracy
- 5 A Model: ±0.025 A, ±3%
- 1 A Model: ±0.005 A, ±3%

Pickup Time: 50 ms at 60 Hz (Max)

Definite-Time Delay Setting Range: 0.02–999.90 s

Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Inverse-Time Element Time Dial: K = 1 to 100 s

Linear Reset Time: 240 s fixed

Inverse-Time Timing Accuracy: ±4%, ±50 ms at 60 Hz for $|I_2|$ above 1.05 multiples of pickup

Instantaneous/Definite-Time Overcurrent Elements (50)

Phase, Residual Ground, Neutral Protection

Current Pickup (A secondary)
- 5 A Model: 0.25–100.00
- 1 A Model: 0.05–20.00

Steady-State Pickup Accuracy:
- 5 A Model: ±0.05 A, ±3%
- 1 A Model: ±0.01 A, ±3%

Transient Overreach: ±5% of pickup

Pickup Time: 25 ms at 60 Hz (Max) **Note:** 50 ms for 50Q element

Time Delay: 0.00–400.00 s

Timer Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Inverse Time-Overcurrent Elements (51)

Residual Ground and Neutral Protection
- Current Pickup (A secondary)
  - 5 A Model: 0.5–16.0
  - 1 A Model: 0.1–3.2 A
- Pickup Accuracy
  - 5 A Model: ±0.05 A, ±3%
  - 1 A Model: ±0.01 A, ±3%
- Time Dials
  - US: 0.5–15.0, 0.01 steps
  - IEC: 0.05–1.00, 0.01 steps
- Timing: ±4%, ±25 ms at 60 Hz for |I| between 2 and 20 multiples of pickup

Voltage Restrained Phase Time-Overcurrent Element (51V)

- Phase Pickup (A secondary)
  - 5 A Model: 2.0–16.0
  - 1 A Model: 0.4–3.2
- Steady-State Pickup Accuracy
  - 5 A Model: ±0.05 A, ±3%
  - 1 A Model: ±0.01 A, ±3%
- Time Dials
  - US: 0.5–15.0, 0.01 steps
  - IEC: 0.05–1.00, 0.01 steps
- Timing: ±4%, ±25 ms at 60 Hz for |I| between 2 and 20 multiples of pickup
- Voltage Restraint Type: Linear restraint

Voltage Controlled Phase Time-Overcurrent Element (51C)

- Phase Pickup (A secondary)
  - 5 A Model: 0.5–16.0
  - 1 A Model: 0.1–3.2
- Steady-State Pickup Accuracy
  - 5 A Model: ±0.05 A, ±3%
  - 1 A Model: ±0.01 A, ±3%
- Time Dials
  - US: 0.5–15.0, 0.01 steps
  - IEC: 0.05–1.00, 0.01 steps
- Timing: ±4%, ±25 ms for |I| between 2 and 20 multiples of pickup

Instantaneous/Definite-Time Under-(27)/Overvoltage (59) Elements

- Phase & Residual 27/59: 0.0 –200.0 V
- Phase-to-Phase 27/59: 0.0 –200.0 V
- Pos.-, Neg.-, & Zero-Sequence 59: 0.0 –200.0 V
- Steady-State Pickup Accuracy: ±5%, ±0.1 V
- SELOGIC Control Equation Time-Delay Setting Range: 0.00 –3000.00 s

Desired time delay may be added using SELOGIC Control Equation Timers.

100 Percent Stator Ground Protection (64G)

- Neutral Fundamental Overvoltage 64G1: 0.0 –150.0 V
- Steady-State Pickup Accuracy: ±5%, ±0.1 V
- Pickup Time: 25 ms at 60 Hz (Max)
- Definite-Time Delay: 0.00–400.00 s
- Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz
- Third-Harmonic Voltage Differential or Third-Harmonic Neutral Undervoltage Pickup 64G2: 0.1–20.0 V
- Steady-State Pickup Accuracy: ±5%, ±0.1 V
- Third-Harmonic Voltage Differential Ratio Setting Range: 0.0 to 5.0
- Pickup Time: 50 ms at 60 Hz (Max)
- Definite-Time Delay: 0.00–400.00 s
- Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Out-of-Step Element (78)

5 A Model
- Forward Reach: 0.1–100.0 ohms
- Reverse Reach: 0.1–100.0 ohms
- Single Blinder
  - Right Blinder: 0.1–50.0 ohms
  - Left Blinder: 0.1–50.0 ohms
- Double Blinder
  - Outer Resistance Blinder: 0.2–100.0 ohms
  - Inner Resistance Blinder: 0.1–50.0 ohms
- Steady-State Impedance Accuracy: ±0.1 ohm, ± 5% of diameter
- Pos.-Seq. Current Supervision: 0.25–30.00 A

1 A Model
- Forward Reach: 0.5–500.0 ohms
- Reverse Reach: 0.5–500.0 ohms
- Single Blinder
  - Right Blinder: 0.5–250.0 ohms
  - Left Blinder 0.5–250.0 ohms
- Double Blinder
  - Outer Resistance Blinder: 1.0–500.0 ohms
  - Inner Resistance Blinder: 0.5–250.0 ohms
- Steady-State Impedance Accuracy: ±0.5 ohm, ± 5% of diameter
- Pos.-Seq. Current Supervision: 0.05–6.00 A

- Pickup Time: 50 ms at 60 Hz (Max)
- Definite-Time Timers: ±0.1%, ±8.3 ms at 60 Hz

Definite-Time Under/Overfrequency Elements (81)

- Frequency: 20–70 Hz, 0.01 Hz steps
- Pickup Time: 32 ms at 60 Hz (Max)
- Time Delays: 0.03–400.00 s
- Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz
- Supervisory 27: 0–150V, ±5%, ±0.1 V
- Steady-State *plus* Transient Overshoot: ±0.01 Hz

Optional Differential Elements (87) (Models 0300G1 and 0300G3)

- Restrained Element Pickup: 0.04–1.0 • TAP
- Steady-State Pickup Accuracy
  - 5 A Model ±0.1 A, ±5%
  - 1 A Model ±0.02 A, ±5%
- Slope 1 Range: 5–100%
- Slope 2 Range: OFF, 50–200%
- Slope 1 Limit: 1–16 • TAP
- 2nd-Harmonic Blocking Percentage: OFF, 5–100%
- Unrestrained Element Pickup: 1.0–20.0 • TAP
- Steady-State Pickup Accuracy
  - 5 A Model: ±0.1 A, ±5%
  - 1 A Model: ±0.02 A, ±5%
- TAP Range: $TAP_{MAX}/TAP_{MIN} \leq 7.5$
  - 5 A Model: 0.5–160.0 A secondary
  - 1 A Model: 0.1–32.0 A secondary
- Restrained Element Pickup Time: 24/28/38 ms (Min/Typ/Max)
- Unrestrained Element Pickup Time: 13/20/32 ms (Min/Typ/Max)

Note: Pickup time accuracies listed at 60 Hz

Optional Ground Differential Elements (87N) (Models 0300G0 and 0300G2)

- Ground Differential Pickup
  - 5 A Model 0.10–15.00 A
  - 1 A Model 0.02–3.00 A
- Ratio CTR/CTRN: 1.0–40.0
- Steady-State Pickup Accuracy
  - 5 A Model ±0.05, ±3%
  - 1 A Model ±0.01, ±3%
- Pickup Time: 25 ms at 60 Hz (Max)
- Time Delays: 0.00 – 400.00 s
- Maximum Definite-Time DelayAccuracy: ±0.1%, ±4.2 ms at 60Hz

Demand Ammeter Elements

- Demand Ammeter Time Constants: 5, 10, 15, 30, or 60 min
- Demand Ammeter Threshold Range
  - 5 A Model: 0.5–16.0 A
  - 1 A Model: 0.1–3.2 A
- Steady-State Pickup Accuracy
  - 5 A Model: ±0.05 A, ±3%
  - 1 A Model: ±0.01 A, ±3%

Inadvertent Energization Logic

- Time-Delay Pickup & Dropout Timers: 0.00 – 400.00 s
- Maximum Definite-Time Delay Accuracy: ±0.1%, ±4.2 ms at 60 Hz

Breaker Failure Protection

Implement using nondedicated overcurrent element and SELOGIC Control Equation Variable Timer.

- Phase Overcurrent Pickup (A secondary)
  - 5 A Model: 0.25–100 .00 A
  - 1 A Model: 0.05–20.00 A

Steady-State Pickup Accuracy

5 A Model:	±0.05 A, ±3%
1 A Model:	±0.01 A, ±3%
Time-Delay Pickup & Dropout Timers:	0.00–3000.00 s
Maximum Definite-Time Delay Accuracy:	±0.1%, ±4.2 ms

SELogic Control Equation Variable Timers

16 Time-Delay Pickup & Dropout Timers:	0.00–3000.00 s
Maximum Definite-Time Delay Accuracy:	±0.1%, ±4.2 ms at 60 Hz

Substation Battery Voltage Monitor

Station Battery Voltage Monitor Pickup Ranges:	35–300 Vdc
Measuring Accuracy:	±2%

Metering Accuracy

Accuracies are specified at 20°C and at nominal system frequency unless noted otherwise.

Voltages V_A, V_B, V_C, V_N, V_S, $3V_0$, V_1, V_2, V_{AB}, V_{BC}, V_{CA}:	±0.1%, ±0.02 V (33.5–150.0 V)
Currents I_A, I_B, I_C:	5 A Nominal ±1 mA, ±0.1% (0.5–10.0 A)
	1 A Nominal ±0.2 mA, ±0.1% (0.1–2.0 A)

Temperature coefficient:
$[(0.0002\%)/(°C)^2] * (\_\_°C - 20°C)^2$
(see example below)

Phase Angle Accuracy:	±0.5°
Currents I_N, I_{A87}, I_{B87}, I_{C87}, I_1, $3I_0$, $3I_2$	5 A Nominal ±0.05 A, ±3% (0.5–100.0 A)
	1 A Nominal ±0.01 A, ±3% (0.1–20.0 A)

MW / MVAR (A, B, C, and 3-phase; 5 A nominal; wye-connected voltages)

Accuracy (MW / MVAR)	**at load angle**
for 0.5 A ≤ phase current < 1.0 A:	
0.70% / –	0° or 180° (unity power factor)
0.75% / 6.50%	±8° or ±172°
1.00% / 2.00%	±30° or ±150°
1.50% / 1.50%	±45° or ±135°
2.00% / 1.00%	±60° or ±120°
6.50% / 0.75%	±82° or ±98°
– / 0.70%	±90° (power factor = 0)
for phase current ≥ 1.0 A :	
0.35% / –	0° or 180° (unity power factor)
0.40% / 6.00%	±8 or ±172°
0.75% / 1.50%	±30° or ±150°
1.00% / 1.00%	±45° or ±135°
1.50% / 0.75%	±60° or ±120°
6.00% / 0.40%	±82° or ±98°
– / 0.35%	±90° (power factor = 0)

Metering accuracy calculation example for currents I_A, I_B, and I_C due to preceding stated temperature coefficient:

For temperature of 40°C, the additional error for currents IA, IB, and IC is:
$[(0.0002\%)/(°C)^2] * (40°C - 20°C)^2 = 0.08\%$

SCHWEITZER ENGINEERING LABORATORIES
2350 NE Hopkins Court • Pullman, WA 99163-5603 USA
Phone: (509) 332-1890 • Fax: (509) 332-7990
Internet: www.selinc.com • E-mail: info@selinc.com