



SEL-321 Data Sheet

Phase and Ground Distance Relay, Direction Overcurrent Relay, Fault Locator



Major Features and Benefits

- Four Zones of Phase and Ground Distance Protection:
 - Mho characteristic phase element
 - Mho and quadrilateral characteristic ground elements
- Supports all standard tripping schemes
- Phase, negative-sequence, and residual overcurrent protection
- Two independent negative-sequence directional elements
- Apply to single- and three-pole trip installations
- Out-of-step tripping and blocking
- Unique load-encroachment logic
- Oscillography data and an 11-cycle event report
- Up to 16 contact outputs and 8 contact inputs in the One I/O Board version
- Up to 32 contact outputs and 16 contact inputs in the Two I/O Board version
- SELLOGIC® control equations
- Three serial communications ports
- Front-panel setting and display
- Automatic self-testing; Fault locating; Metering

General Description

The SEL-321 Relay protects, controls, and monitors EHV, HV, and subtransmission lines. The relay contains all protective elements and control logic to protect any overhead transmission line.

The relay is a complete protective relay package for pilot and non-pilot schemes. The following list highlights a few of the protective features of the SEL-321 relay.

- Four zones of phase and ground distance protection
- Independent internal, user-settable timers delay Zone 2, 3, or 4 phase and ground elements for time-stepped coordination with downstream relays
- Any zone may be set forward or reversed
- Independently set phase and ground distance elements
- Ground distance can be selected for mho characteristic, quadrilateral characteristic, or both
- Quadrilateral characteristic on ground distance element adds sensitivity for high-resistance faults, compensates for load flow, and prevents over- and underreaching
- Positive-sequence memory polarization provides expanded resistive coverage for phase and ground faults
- Independent phase, negative-sequence, and residual time-overcurrent elements
- Four levels of instantaneous/definite time negative-sequence and residual overcurrent elements
- Typical operating time of one cycle for three-phase faults

- Oscillography and event reporting data
- Front-panel setting and display

SEL-321 Relay Benefits

The relay offers a large number of protective elements and features. You tailor the relay to your particular application using SELOGIC control equations to select specific functions.

If your protection requirements change, the relay is readily adapted by entering new settings. The logic required for the new scheme is enabled, and those settings are entered. This allows change or expansion at no cost since additional protective relays or logic cards are not required.

The relay has six independent setting groups. With this increased flexibility, the relay may be configured for virtually any operating condition: substitute line relay, line configuration changes, source changes, etc.

Benefits gained using the SEL-321 relay include:

- Application flexibility
- Simplified settings: set only the elements you are using
- Relay is readily expanded to more complex schemes at no cost
- SELOGIC control equations allow you to program the relay to meet any application needs
- Fault locator reduces patrol and outage time
- Communications handle remote interrogation
- Self-testing increases relay availability

Applications

Versatility

The SEL-321 relay handles all overhead line protective relaying applications because it is both versatile and economical. The programming versatility of the relay allows use in pilot and non-pilot schemes.

The relay fits a large number of applications. Basic schemes can be implemented by only selecting the elements used for that relay application. For more complex schemes, select more protective elements.

Communication Schemes

The SEL-321 is the ideal relay for use in communications-based schemes. Dedicated SELOGIC control equations allow selection of relay elements to

perform specific functions when external conditions are met. In addition to the communications scheme logic, the SEL-321 provides time-stepped backup protection without the need for external wiring modifications or dedicated input contacts.

The SEL-321 overcomes typical deficiencies associated with communications-based schemes. Most communications-based schemes are vulnerable to conditions that may result in an incorrect trip if logic is not provided to account for them.

For example:

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

While communications equipment circuitry can account for these shortcomings, it may not be available for applications where only the protective relaying is being upgraded, or when dependence on this external circuitry is neither economical nor desirable.

The SEL-321 logic accounts for the deficiencies listed above. If the communication channel is lost or out of service, time-step backup protection is provided without special switching of detection detection schemes. The SEL-321 is capable of supporting permissive overreaching transfer trip scheme, direct and permissive underreaching transfer trip schemes, direct transfer trip schemes, and directional comparison blocking and unblocking schemes.

Obsolete Relay Replacement

The SEL-321 is an ideal replacement for aging or obsolete electromechanical relays. If protective relays are to be upgraded at one terminal only, it is important that relays have measuring principles compatible with surrounding terminals.

Compact size and simple field wiring make replacement of electromechanical relays with an SEL-321 especially convenient in crowded substations. Both horizontal and vertical mounting configurations are available. The required panel cutout dimensions are equivalent to that of a single electromechanical distance relay, which eliminates panel cutting where relays already exist. Event-reporting and fault-locating features economically provide valuable engineering and operating information, eliminating the need for event recorders and oscilloscopes in most applications. A negligible instrument transformer burden makes the SEL-321 an attractive alternative for overburdened current and potential transformers.

Applications include:

- Single- or multiple-zone relaying schemes
- Time-stepped distance schemes
- Communications assisted schemes
- Single- and three-pole tripping
- Overcurrent protection with phase or ground distance supervision
- Replacement of electromechanical relays
- Substitute line relay

Operating Principles

Mho Distance

The SEL-321 uses mho characteristics for phase and ground distance protection. *Figure 1* illustrates the impedance characteristics of the phase and ground distance elements.

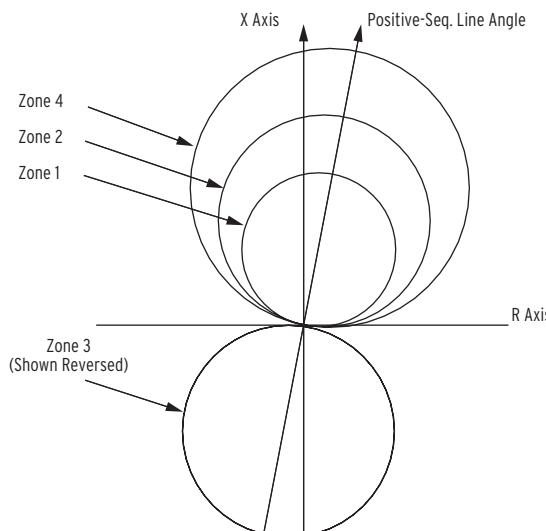


Figure 1 Phase and Ground Mho Distance Characteristics

All mho elements use positive-sequence polarization that expand in proportion to the source impedance, and provide positive, secure operation for close-in faults.

Figure 2 shows the forward-reaching mho characteristic for a forward phase-to-phase fault. The mho circle expands to the source impedance Z_S , but never more than the set relay reach, Z_R .

Positive-sequence memory polarization provides added security during the open-pole period when used in single-pole trip applications.

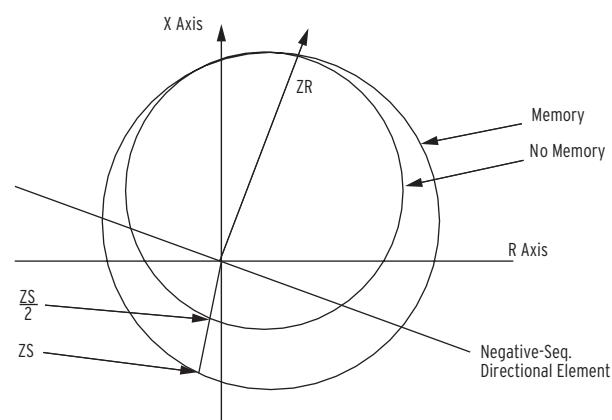


Figure 2 Phase-to-Phase Element Response for a Forward Phase-to-Phase Fault

Quadrilateral Distance

The relay also provides ground quadrilateral characteristics. The top line of the quadrilateral characteristic compensates for load flow to avoid under- and overreaching. The ground mho and quadrilateral distance elements may be used individually or concurrently.

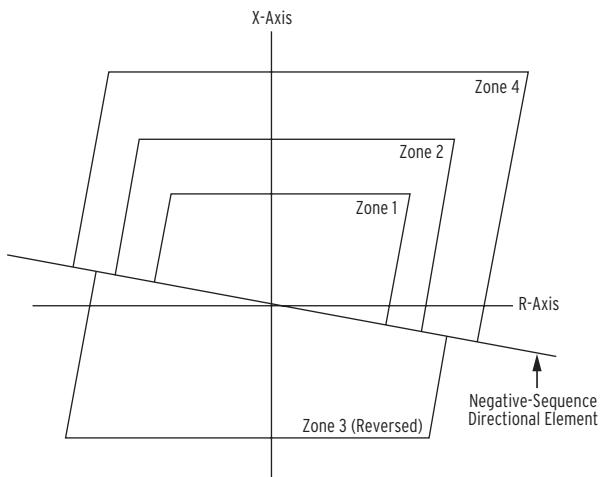


Figure 3 Quadrilateral Ground Distance Characteristics

Overcurrent Elements

Phase, negative-sequence, and residual overcurrent elements provide primary or backup protection. Phase and ground distance elements can supervise the overcurrent elements for greater selectivity.

Negative-Sequence Directional Element

The relay uses a unique negative-sequence directional element, which calculates the negative-sequence impedance at the relaying point. Thresholds are set that declare the fault in the forward or reverse direction. *Figure 4* illustrates the negative-sequence directional measurement technique.

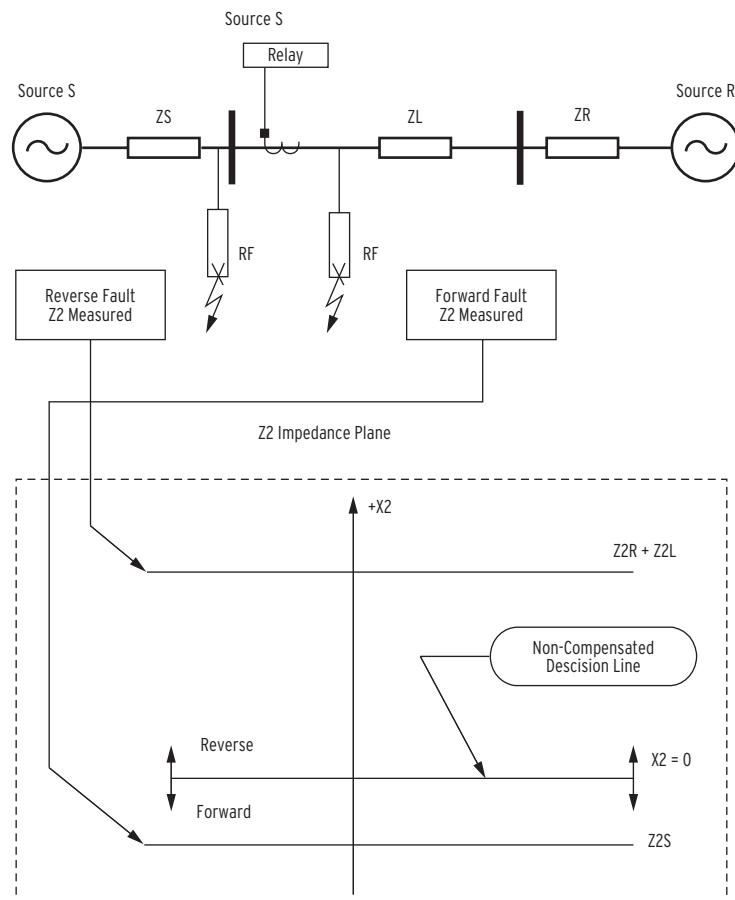


Figure 4 Negative-Sequence Directional Element Measurement

Load Encroachment

A load-encroachment feature prevents operation of the phase elements under high load conditions. This unique feature permits load to enter a predefined area of the phase distance characteristic without causing a tripout. *Figure 5* shows the load-encroachment characteristic.

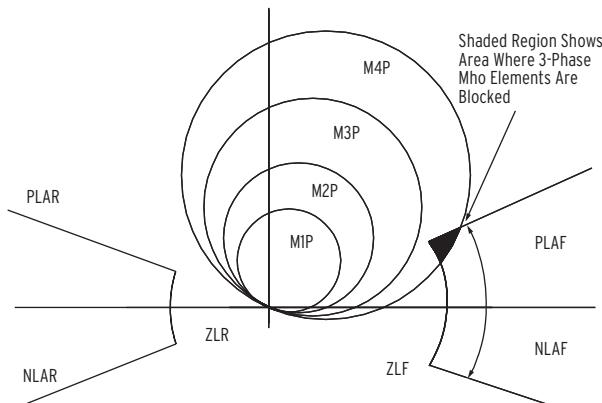


Figure 5 Load-Encroachment Characteristic

Scheme Selection

With a simple setting, any of the four zones of phase and ground distance protection may be set in the forward or reverse direction. The number of phase or ground distance zones is selectable.

Select mho and/or quadrilateral characteristic for ground distance. Mho elements give speed; quadrilateral elements give sensitivity. Each of the eight ground elements has its own reach setting.

Ground Distance Elements

The ground distance elements include two zero-sequence compensation factors (k_{01} , k_0). This allows compensation for remote faults when there are intermediate sources of zero-sequence current; such as lines with tapped transformer banks with a grounded-wye configuration.

Additional Features

Front-Panel Display

The LCD display, *Figure 6*, gives detailed information pertaining to a fault detected by the relay, by displaying meter information, relay self-test status information, and settings parameters.

Sixteen LEDs on the front panel give targeting information, fault type, and type of tripping.

Time-Overcurrent Elements

There are three independent time-overcurrent elements: phase for backup phase fault protection, negative-sequence for sensitive phase-to-phase fault detection or ground fault detection, and residual for ground fault detection.

Torque Control

The phase overcurrent element may be torque-controlled by the Zone 2 phase distance elements. The negative-sequence and residual overcurrent elements may be torque-controlled by the Zone 2 ground distance or negative-sequence directional elements.

Negative-Sequence/Residual Overcurrent

There are four levels of instantaneous/definite time negative-sequence and residual overcurrent protection. Each level provides backup protection. The instantaneous output of each level finds use in the communications scheme and control logic.

Communications-Based Schemes

The relay supports the following communications-based protection schemes:

- Permissive Overreaching Transfer Trip (POTT)
- Permissive Underreaching Transfer Trip (PUTT)
- Directional Comparison Unblocking (DCUB)
- Directional Comparison Blocking (DCB)
- Direct Underreaching Transfer Trip (DUTT)
- Direct Transfer Trip (DTT)

Current reversal logic provides for POTT, DCUM, and DCB scheme applications. To preserve the security of the parallel healthy line, the relay uses reverse Zone 3 elements, timers, and associated logic to block permissive tripping in POTT and DCUB schemes. In DCB schemes, the block trip signal transmission time is extended to allow time for the remote Zone 2 elements to drop out.

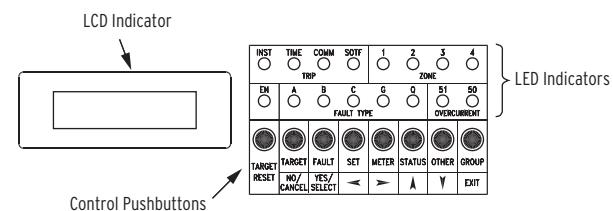


Figure 6 SEL-321 Front-Panel Layout

Serial Communications Ports

The relay has three serial communications ports for local or remote access to relay settings, meter, and fault data. Two serial ports are on the rear panel, and a local interface port is provided on the relay front panel. Remote communications allow operators to retrieve relay fault and meter information from a central control station.

A multi-level password security scheme impedes unauthorized access to the relay. A lower level password allows examination of relay settings, meter data, and event records. Setting changes are available only from the upper password level. Line breaker control functions are also protected with a third level of password protection.

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.

Event Reporting and Oscillography

The relay generates an 11-cycle event report following each system disturbance detected by the relay or upon command. The report provides four cycles of prefault data and seven cycles of postfault data. The data in each report includes voltages, currents, relay element status, and relay inputs and outputs. The report also includes the calculated fault location, date, and time of the event.

This information simplifies postfault analysis and improves understanding of simple and complex protective scheme operation. This relay stores the last twelve event reports for local or remote retrieval.

Two formats of event reports are available. The default event report allows you to quickly review a routine relay operation. This event report displays the important voltage, current, protective element status, input and output contact status in quarter-cycle increments for the full eleven cycles. The ASCII Hex data is also used for oscillography with the SEL-5601 program.

SELOGIC Control Equations

SELOGIC control equations put relay logic in the hands of the relay application engineer. 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 consist of ANDing, ORing, or inverting the individual Relay Word elements. Any element in the Relay Word can be used in the SELOGIC control equations.

Configure the contact outputs to operate when any of the protective elements and 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.

Contact Inputs and Outputs

The SEL-321 relay series provides 8 contact inputs and 16 contact outputs in the one I/O board version. A two I/O board version is available with 16 contact inputs and 32 contact outputs. The contact inputs are assigned for control functions, monitoring logic, and general indication. Except for a dedicated alarm output, each contact output is independently programmable using SELOGIC control equations. All relay output contacts are rated for trip duty.

Wiring Diagrams

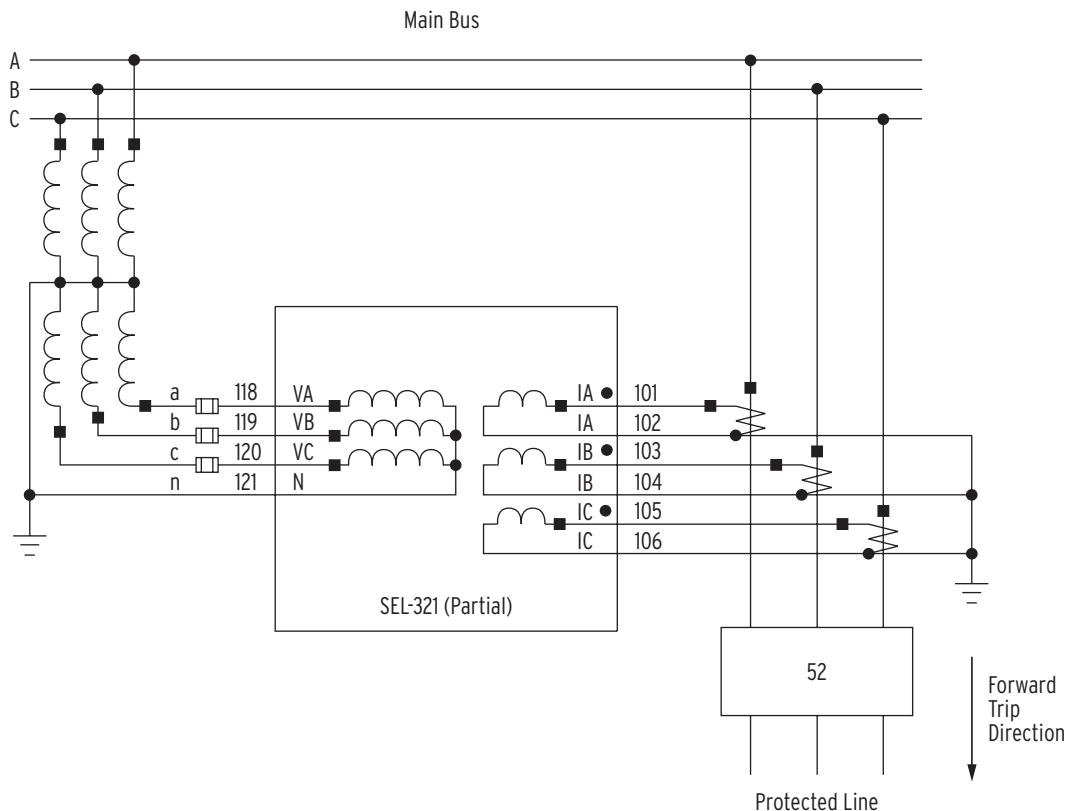
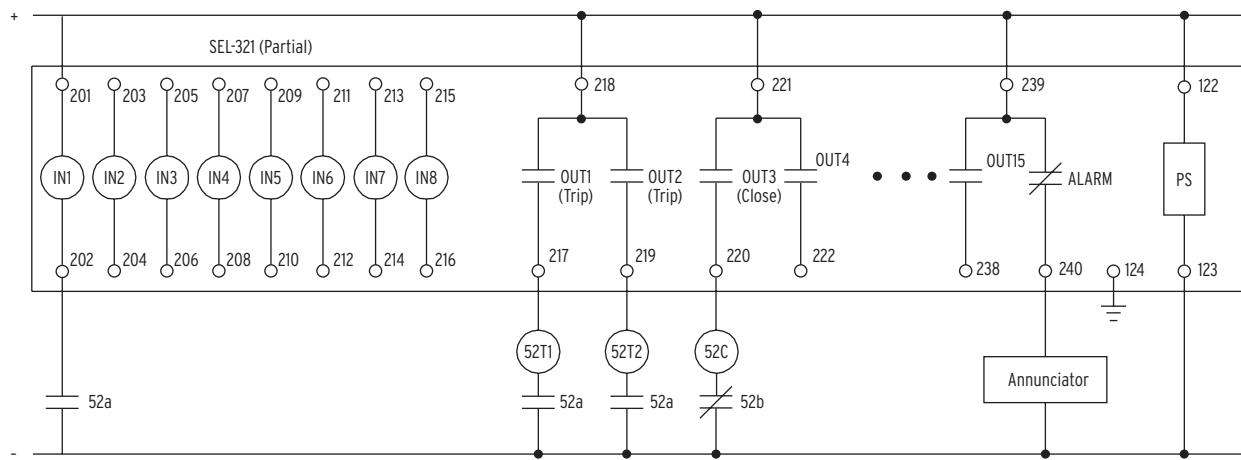


Figure 7 SEL-321 Relay External AC Current and Voltage Connections



NOTE: All inputs and outputs are assignable.

Figure 8 SEL-321 Relay External DC Connection Diagram (Typical—One I/O Board Version Shown)

Front- and Rear-Panel Diagrams

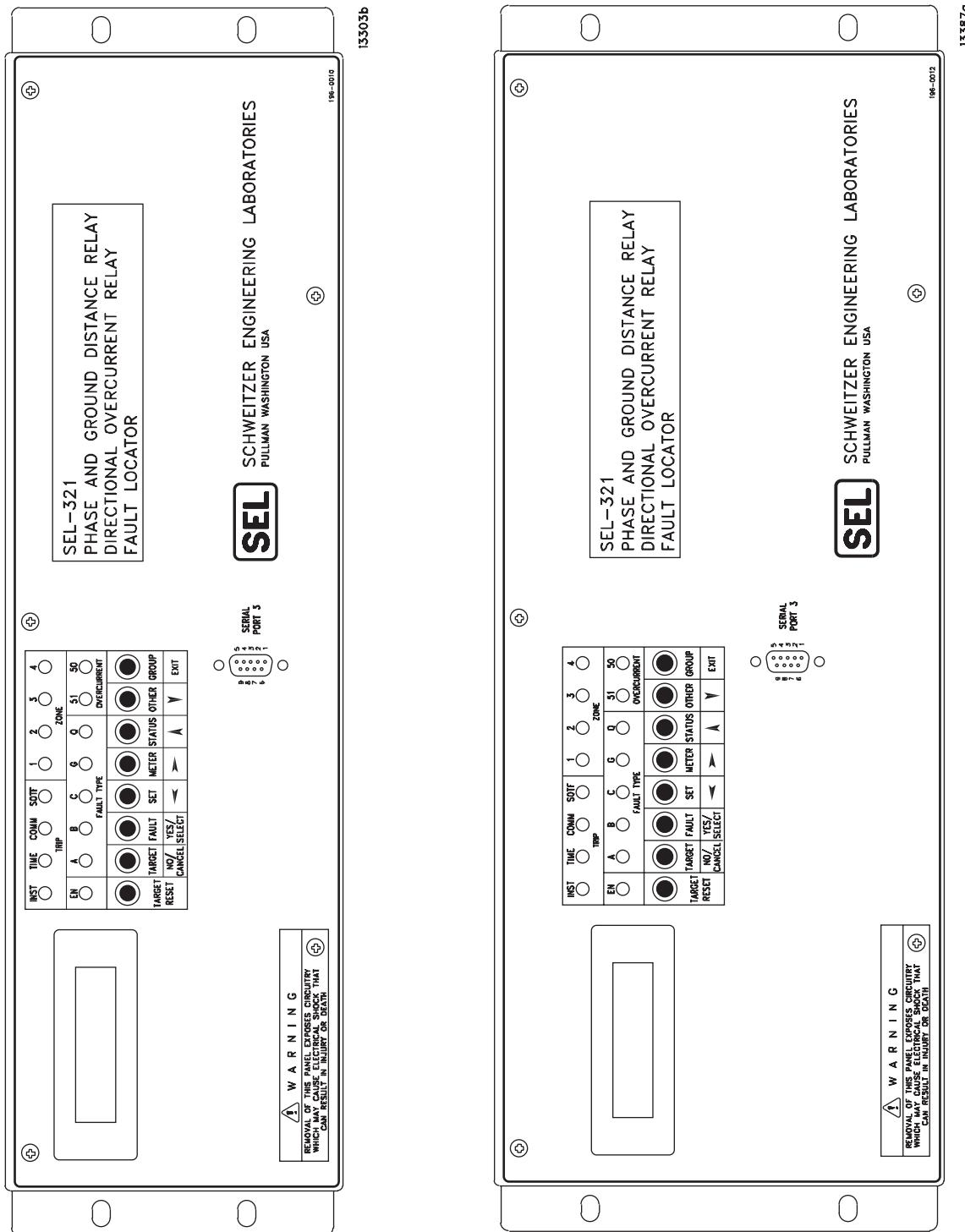


Figure 9 SEL-321 Front Panel Diagrams

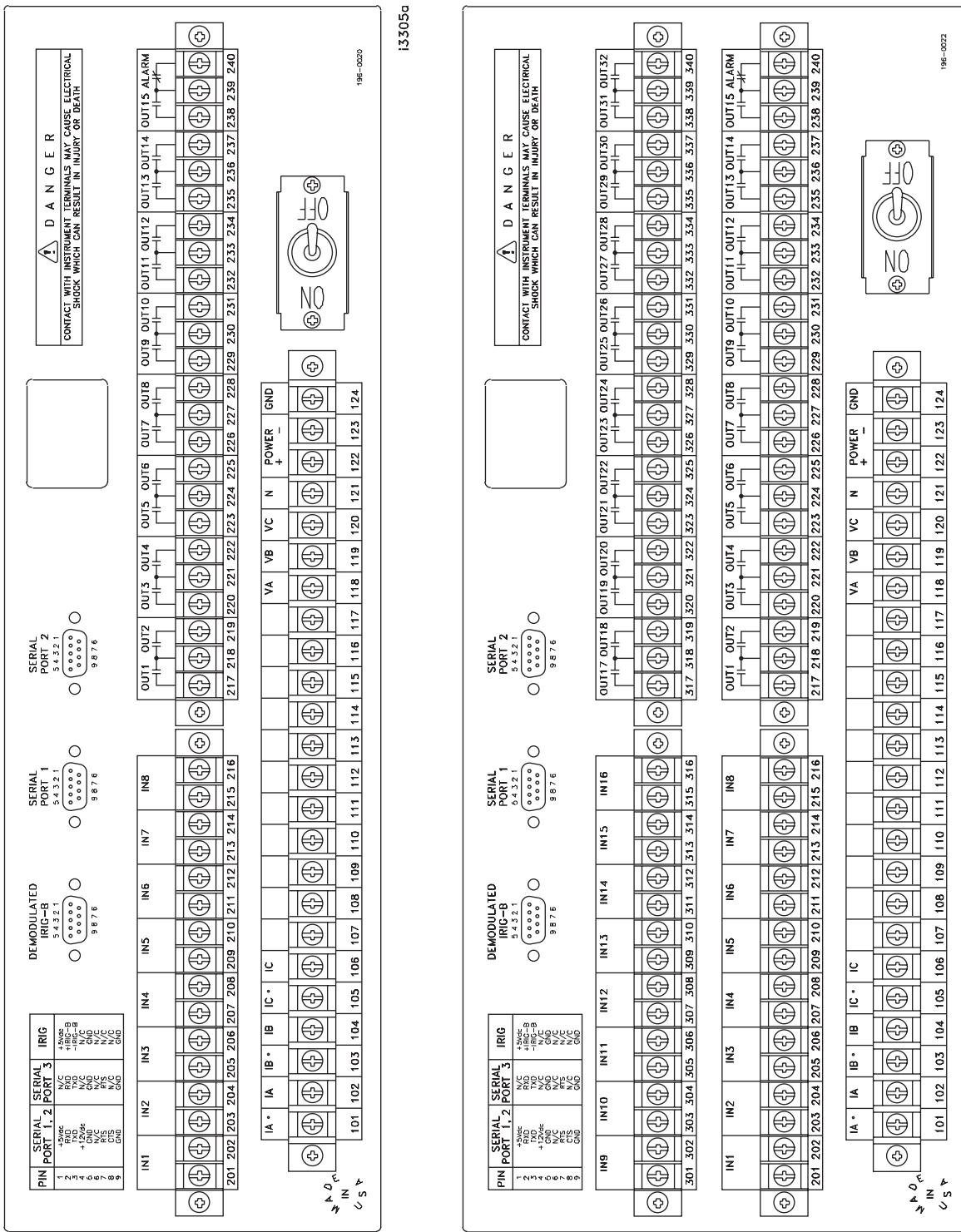


Figure 10 SEL-321 Rear Panel Diagrams

Relay Dimensions

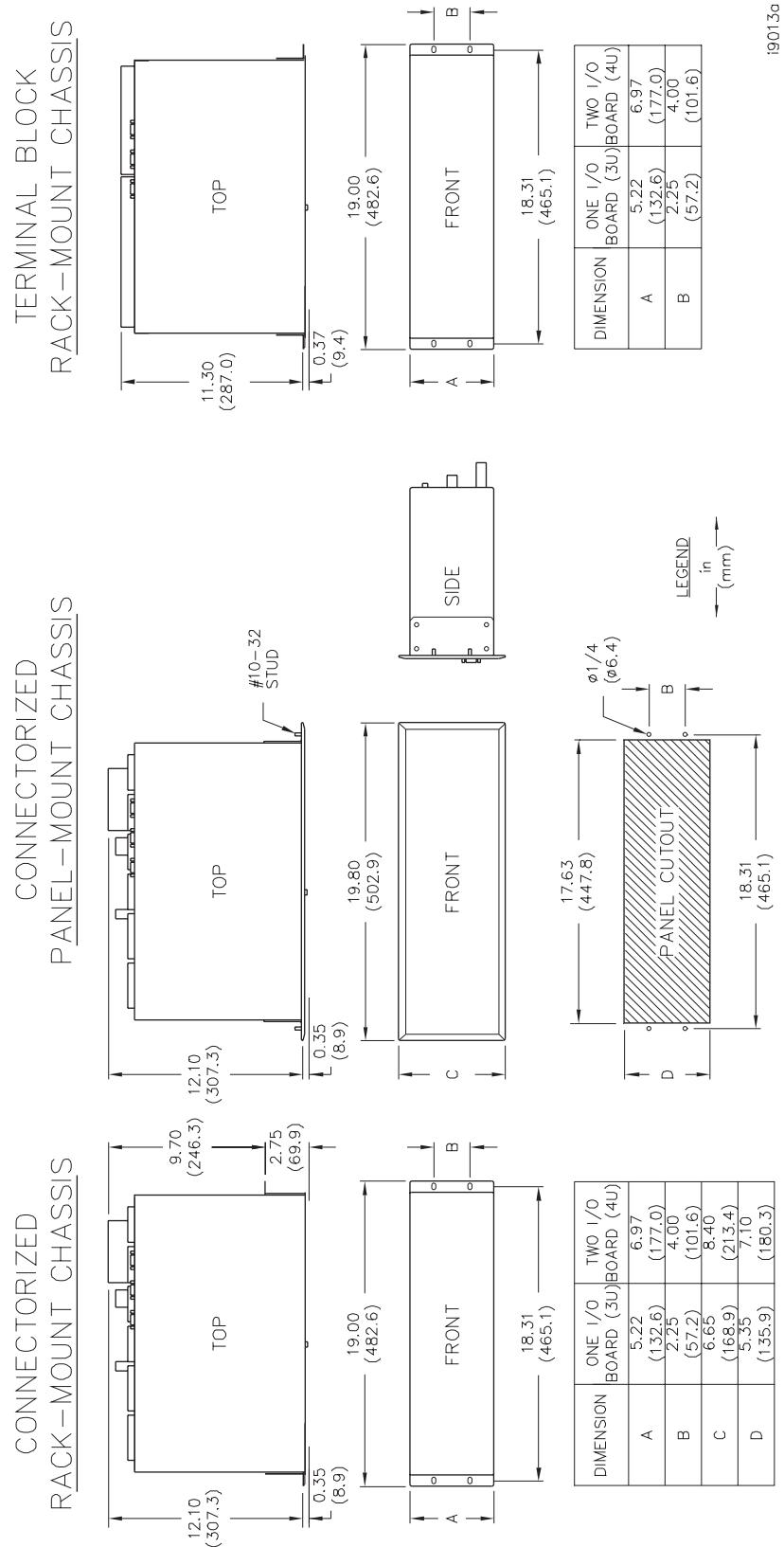


Figure 11 SEL-321 Dimensions for Rack- and Panel-Mount Models

Specifications

General

Voltage Inputs: 67 V_{L-N}, three-phase four-wire connections.
150 V_{L-N} continuous (connect any voltage from 0 to 150 Vac)
365 Vac for 10 seconds

Burden: 0.13 VA at 67 V
0.45 VA at 120 V

Current Inputs:

5 A nominal: 15 A continuous, 500A for 1 second, linear to 100 A symmetrical
1250 A for 1 cycle

Burden: 0.27 VA at 5 A
1.31 VA at 15 A

1 A nominal: 3 A continuous, 100A for 1 second, linear to 20 A symmetrical
250 A for 1 cycle

Burden: 0.13 VA at 1 A
1.31 VA at 3 A

Output Contacts

Standard: (Per IEC 255-0-20-1974, using the simplified method of assessment)

Make: 30 A
Carry: 6 A continuous carry
1 s Rating: 100 A
MOV Protection: 270 Vac/360 Vdc; 40 J
Pickup Time: <5 ms
Dropout Time: <8 ms
Breaking Capacity (10000 operations):

48 V 0.5 A L/R = 40 ms
125 V 0.3 A L/R = 40 ms
250 V 0.2 A L/R = 40 ms

Cyclic Capacity (2.5 cycle/second):

48 V 0.5 A L/R = 40 ms
125 V 0.3 A L/R = 40 ms
250 V 0.2 A L/R = 40 ms

High Current Interrupting Option

Make: 30 A
Carry: 6 A continuous carry at 70°C
MOV Protection: 330 Vdc
Pickup Time: <5 ms
Dropout Time: <8 ms
Breaking Capacity (10000 operations):

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

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

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

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

Fast High-Current Interrupting Option

Make: 30 A
Carry: 6 A continuous carry
MOV Protection: 330 Vdc for differential surge protection
Pickup Time: <200 µs
Dropout Time: <8 ms (typical)

Breaking Capacity (10000 operations):

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

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

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

Note: Fast high-current interrupting outputs are not polarity dependent.
Note: Make per IEEE C37.90:1989.

Optoisolated Inputs

Standard Fixed Inputs

250 Vdc	Pickup 200–300 Vdc; Dropout 150 Vdc
125 Vdc	Pickup 105–150 Vdc; Dropout 75 Vdc
48 Vdc	Pickup 38.4–60 Vdc; Dropout 28.8 Vdc
24 Vdc	Pickup 15.0–30 Vdc

Fixed Level-Sensitive Inputs

250 Vdc	On for 200–300 Vdc; off below 150 Vdc
125 Vdc	On for 105–150 Vdc; off below 75 Vdc
48 Vdc	On for 38.4–60 Vdc; off below 28.8 Vdc

Note: Nominal input current is 4 mA.

Time-Code Input

Relay accepts demodulated IRIG-B time-code input.

Communications Ports

EIA-232: 1 front and 2 rear

Power Supply

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

Dimensions

One I/O Board:	5.22" H x 19" W x 11.66" D (133 mm x 483 mm x 296 mm)
Two I/O Boards:	6.97" H x 19" W x 11.66" D (177 mm x 483 mm x 296 mm)

Dielectric Strength

V, I Inputs:	2500 Vac for 10 seconds
Other:	3000 Vdc for 10 seconds (excludes EIA-232)

Operating Temperature

-40° to +85°C (-40° to +185°F)

Environment

Temperature/Humidity:	IEC 68-2-30 Temperature/humidity cycle test—six day (type tested)
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Interference Tests

Surge Withstand:	IEEE C37.90
1 MHz Burst Disturbance:	IEC 60255-22-1
Electrical Fast Transient/Burst:	IEC 801-4

Impulse Test

Impulse:	IEC 255-5 0.5 J, 5000 V IEC 1000-4-5 Installation Class 4
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RFI Tests

IEEE C37.90.2 IEEE Trial-Use Standard, Withstand Capacity of Relay Systems to Radiated Electromagnetic Interference from Transceivers 10 V/M	
Exceptions: 5.5.2 (2) Performed with 200 frequency steps per octave	
5.5.3 Digital Equipment Modulation Test not performed	
5.5.4 Test signal turned off between frequency steps to simulate keying	
Radiated EMI Test:	IEC 255-22-3
Exception:	4.3.2.2 Frequency sweep approximated with 200 frequency steps per octave

Vibration and Shock Tests

IEC 255-21-1 and -2 Class 1 Test	
Exception:	
4.1.4 Vibration Response Amplitude Tolerance increased to $\pm 25\%$ (two I/O board version, rear-panel plug-in connectors only)	

Electrostatic Discharge Test

ESD:	IEC 801-2 Severity Level 3
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Weight

One I/O board:	20 lbs (9.1 kg); shipping weight 32 lbs (14.5 kg)
Two I/O boards:	26.5 lbs (12 kg); shipping weight 40.6 lbs (18.5 kg)

Relay Elements**Phase Mho Distance**

Secondary Reach Setting Range:	0.05–64 Ω at the line angle
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Ground Mho Distance

Secondary Reach Setting Range:	0.05–64 Ω at the line angle
$ k_{01} $ and $ k_0 $ setting range*:	0–4
Angle k_{01} and k_0 setting range*:	$\pm 180^\circ$ in 0.1° steps

Zone 1 zero-sequence factor K01 is independent of k0 factor for all other zones.*

* Note: Same setting applies to Quadrilateral Ground Distance

Quadrilateral Distance

Second Reactive Reach:	0.05–64 Ω
Second Resistance Reach:	0.05–50 Ω
Nonhomogeneous Factor (T, degrees):	$\pm 20^\circ$ in 0.1° steps

Out-of-Step Distance

Secondary Reactance Setting Range:	± 96 Ω
Secondary Resistance Setting Range:	± 70 Ω

Load Encroachment Detection

Secondary Impedance Setting Range:	0.05–64 Ω
Forward Load Angle Setting (in degrees):	-90° to $+90^\circ$
Reverse Load Angle Setting (in degrees):	$+90^\circ$ to 270°

Distance Element Accuracy

Secondary Steady-State Error:	$\pm 5\%$ of set reach ± 0.01 Ω at line angle (LA) for $V > 5$ V and $I > 2$ A $\pm 10\%$ of set reach ± 0.01 Ω at LA for $1 \text{ V} < V < 5 \text{ V}$ and $1 \text{ A} < I < 2 \text{ A}$
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Transient Overreach Error: $\pm 5\%$ of set reach, plus steady-state error**Negative-Sequence Directional Element**

Secondary Positive-Sequence Current Restraint Range:	0.02–0.5
Secondary Forward Directional Current Supervision:	0.25–5 A
Secondary Reverse Directional Current Supervision:	0.25–5 A
Secondary Forward Directional Impedance Setting:	± 64 Ω
Secondary Reverse Directional Impedance Setting:	± 64 Ω

Supervisory Overcurrent

Phase	
Secondary Pickup Setting Range:	0.5–100 A, ± 0.05 A, $\pm 3\%$ of setting
Supervises ground distance	

Phase-to-Phase

Secondary Pickup Setting Range:	1.0–170 A, ± 0.05 A, $\pm 3\%$ of setting
Supervises phase distance	
Positive-Sequence	
Secondary Pickup Setting Range:	1.0–100 A, ± 0.05 A, $\pm 3\%$ of setting

Supervises OOS logic

Residual

Secondary Pickup
 Setting Range: 0.5–100 A, ± 0.05 A, $\pm 3\%$ of setting
 Transient Overreach: $\pm 5\%$ of pickup
 Supervises ground distance

Directional Time-Overcurrent

Selectable Curve Shape: Moderately inverse (US) or Longtime Standby (IEC)
 Inverse (US) or Standard Inverse (IEC)
 Very Inverse (US or IEC)
 Extremely Inverse (US or IEC)

Phase Pickup setting range: 0.5–16 A, ± 0.05 A, $\pm 3\%$ of setting

Neg.-Seq. pickup setting range: 0.5–16 A, ± 0.05 A, $\pm 3\%$ of setting

Residual Pickup setting range: 0.5–16 A, ± 0.05 A, $\pm 3\%$ of setting

Time Dial setting range: 0.5–15 in 0.01 steps (US)
 0.05–1 in 0.01 steps (IEC)

Timing: $\pm 4\%$ and ± 1.55 cycles for current magnitude between 2 and 20 multiples of pickup.

Nondirectional Residual/Neg.-Seq. Overcurrent

Secondary Pickup setting range: 0.25–80 A, ± 0.05 A, $\pm 3\%$ of setting

Transient Overreach: $\pm 5\%$ of pickup

Overvoltage

Pickup: 0–150 V, $\pm 5\%$ of setting, ± 1 V
 Transient Overreach: $\pm 5\%$ of pickup

Undervoltage

Pickup: 0–100 V, $\pm 5\%$ of setting, ± 1 V
 Transient Overreach: $\pm 5\%$ of pickup

Miscellaneous Timers

Step Distance Time Delay: 0–2000 cycles

Communications Scheme Time Delay 0–2000 cycles

DCB Carrier Coordination Time Delay: 0–60 cycles

Short Delay Time Delay 0–2000 cycles

Long Delay Time Delay: 0–8000 cycles

Loss-of-Potential Set Time Delay 0–60 cycles

Notes

Notes

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SCHWEITZER ENGINEERING LABORATORIES

2350 NE Hopkins Court • Pullman, WA 99163-5603 USA

Phone: +1.509.332.1890 • Fax: +1.509.332.7990

Internet: www.selinc.com • E-mail: info@selinc.com



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