Schweitzer Engineering Laboratories, Inc. SEL-2431 Data Sheet

Optimize Your System Voltage Profile

Major Features and Benefits

➤ **Distribution Automation Ready.** Interface with either on-the-fly settings changes over DNP, or master controller direct-operate interface.

➤ **Flexible Communications.** Easily interface with your network with the Industry's most network connectable regulator controller.

➤ **Programmable Without a Laptop.** Connect a USB flash drive to upload new settings, upgrade firmware, retrieve existing settings, or retrieve reports from the SEL-2431.

➤ **Expandable, Removable Memory.** Connect a USB flash drive and enable Automatic Backup to write all common reports to the USB for long-term storage and easy retrieval.

➤ **IEEE C37.118 Synchrophasor Protocol.** Identify connected phase of downstream voltage regulators by coordinating with synchrophasor measurements in the substation.
- **Communications Options.** Easily integrate into your existing communications scheme with SEL protocols, DNP, and a wide variety of Ethernet and serial communications cards.
- **Flexible Retrofit Kits.** Interface to existing regulators on your system with wiring retrofit kits.
- **System Connections.** Accommodate wye-, delta-, or open-delta regulator configurations.
- **Simple Settings.** Quickly commission new controls with a minimal number of simple settings.
- **Detailed Event Reporting.** Ease maintenance, troubleshooting, and system analysis with detailed oscillographic event reporting with motor current and Sequential Events Recorder (SER).
- **Rugged Construction.** Rely on the durability of a regulator control built and tested to protective relay standards in a die-cast aluminum chassis.
- **10-Year Warranty.** SEL stands behind its products with an unmatched world-wide 10-year warranty.
- **IRIG-B Input.** Synchronize all regulators to a single time source for improved reporting and monitoring.
- **Configurable HMI.** Customize the HMI to your needs with configurable LEDs and operator pushbuttons.
- **Extensive Metering and Monitoring.** Keep an eye on your system with comprehensive metering functions: Load Profile, Max/Min, demand, and peak demand.
- **Comprehensive Operating Modes.** Adapt to complex installations with unique operating modes.
- **Adaptable SELOGIC®.** Meet the unique demands of your system with customizable logic and operation functions.

## Functional Overview

![Functional Overview Diagram](image-url)

**Figure 1 Ethernet-Connected Voltage Regulator Controls**
Figure 2  Voltage Regulator Control Retrofit With SEL-2431

Easily install your new SEL-2431 voltage regulator control by using the wiring harness that matches the voltage regulator.

Remove existing voltage regulator control.
Figure 3 Functional Diagram
Device Overview

Use default messages, or program as many as 32 custom display points.

Type A USB Port

Front-panel status LEDs provide simple indication of control and system status.

Ethernet Link Lights (if equipped)

2 x 20 character LCD display

Navigation buttons provide easy access without a PC.

Use default pushbuttons, or program your own pushbutton actions and LED indicators.

User-configurable label kit

Pushbutton or toggle switch options for raise/lower operation.

Solid die-cast aluminum casing

Optional snap-in serial communications card

Optional snap-in Ethernet or serial communications card

Simple/quick plug-in retrofit harness.

Self-shorting, Connectorized® CT connector

Easy-to-wire I/O
Compatibility and Retrofit Kits

SEL-2431 Voltage Regulator Control retrofit kits are available for the supported regulator makes and models. The kits can be included as part of the SEL-2431 part number at the time a control is ordered, or they can be ordered separately using the part numbers in Table 1.

Table 1  SEL-2431 Retrofit Kits

<table>
<thead>
<tr>
<th>Retrofit Kit</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens/Allis-Chalmers: 10-position Polarized</td>
<td>9253002</td>
</tr>
<tr>
<td>Disconnect Switch (PDS) Interface</td>
<td></td>
</tr>
<tr>
<td>Howard Industries: 10-position Connector</td>
<td>9253003</td>
</tr>
<tr>
<td>Terminal Strip (CTS) Interface</td>
<td></td>
</tr>
<tr>
<td>Cooper/McGraw-Edison: 18-/10-position Fanning</td>
<td>9253004</td>
</tr>
<tr>
<td>Strip (Traditional Interface)</td>
<td></td>
</tr>
<tr>
<td>Cooper: 20-position Connector (Dead-front</td>
<td>9253005</td>
</tr>
<tr>
<td>Interface)</td>
<td></td>
</tr>
<tr>
<td>GE: Fork-terminal Connections (Traditional</td>
<td>9253006</td>
</tr>
<tr>
<td>Interface to Cabinet NN Terminals)</td>
<td></td>
</tr>
<tr>
<td>GE: 24-position Connector (Power Disconnect</td>
<td>9253007</td>
</tr>
<tr>
<td>Interface)</td>
<td></td>
</tr>
<tr>
<td>Generic Fork Terminals for Cooper/</td>
<td>9253055</td>
</tr>
<tr>
<td>McGraw-Edison</td>
<td></td>
</tr>
<tr>
<td>Generic Fork Terminals for Siemens/</td>
<td>9253001</td>
</tr>
<tr>
<td>Allis-Chalmers/Howard/GE</td>
<td></td>
</tr>
</tbody>
</table>

* Use this kit for mounting in a Toshiba CR-3 voltage regulator.

* Does not include mounting hardware (hinges and latches). Includes wiring harness only. If mounting hardware is required, select appropriate kit from Table 2.

Table 2 shows the mounting hardware kits available for the SEL-2431. These kits are orderable using the part numbers shown in Table 2.

Table 2  SEL-2431 Mounting Hardware Kits

<table>
<thead>
<tr>
<th>Mounting Hardware Kit</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens/Allis-Chalmers Mounting Hardware Kit</td>
<td>9253059</td>
</tr>
<tr>
<td>Howard Mounting Hardware Kit</td>
<td>9253060</td>
</tr>
<tr>
<td>Cooper/McGraw-Edison Mounting Hardware Kit</td>
<td>9253058</td>
</tr>
<tr>
<td>GE Mounting Hardware Kit</td>
<td>9253057</td>
</tr>
</tbody>
</table>

Attach mounting hardware (hinges and latch—see Figure 4) and mount the SEL-2431 in the existing voltage regulator enclosure. Ground the SEL-2431 chassis. Connect the SEL-2431 to the voltage regulator with the wiring harness.

Figure 4  Attach Hinges and Latch and Mount the SEL-2431 in the Existing Voltage Regulator Enclosure

Traditional and New Features
Figure 6  Set Up Three Voltage-Reduction Stages for System Stability Support

Table 3  Select the Appropriate Operating Mode

<table>
<thead>
<tr>
<th>Operating Mode</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locked Forward</td>
<td>Power flow expected to always be in the forward (normal load-side) direction.</td>
</tr>
<tr>
<td>Locked Reverse</td>
<td>Power flow expected to always be in the reverse (normal source-side) direction.</td>
</tr>
<tr>
<td>Idle Reverse</td>
<td>Power flow expected to always be in the forward (normal load-side) direction, but no voltage regulation should occur if power flow is indeterminate (e.g., “no load” condition).</td>
</tr>
<tr>
<td>Bidirectional</td>
<td>Power flow varies, alternately operating in the forward and reverse directions.</td>
</tr>
<tr>
<td>Cogeneration</td>
<td>Power flow varies, alternately operating in the forward and reverse directions, and cogeneration/independent generation unit is on the normal load-side. For reverse power flow, voltage is still regulated from a forward direction perspective (at the normal load-side terminal).</td>
</tr>
</tbody>
</table>

Figure 7  Active Power Flow Regions for Different Operating Modes

Figure 8  Choose First-Tap Timer Reset Response for In-Band Voltage Excursions

Table 3 Selection of Operating Mode

- Locked Forward: Power flow expected to always be in the forward (normal load-side) direction.
- Locked Reverse: Power flow expected to always be in the reverse (normal source-side) direction.
- Idle Reverse: Power flow expected to always be in the forward (normal load-side) direction, but no voltage regulation should occur if power flow is indeterminate (e.g., “no load” condition).
- Bidirectional: Power flow varies, alternately operating in the forward and reverse directions.
- Cogeneration: Power flow varies, alternately operating in the forward and reverse directions, and cogeneration/independent generation unit is on the normal load-side. For reverse power flow, voltage is still regulated from a forward direction perspective (at the normal load-side terminal).

1. Do not interrupt timing if in-band voltage excursion is less than a settable time delay.
2. Temporarily “freeze” timing if in-band voltage excursion is less than a settable time delay.
3. Tap timer starts timing again when the in-band voltage excursion ends.

Synchrophasor Measurements

Synchrophasor Measurements

Use IEEE C37.118-2005 protocol to send synchrophasor data to SEL synchrophasor applications. Send data to SEL Phasor Data Concentrators like the SEL-3373 Station Phasor Data Concentrator (PDC), SEL-3378 Synchrophasor Vector Processor (SVP), SEL-3530 Real-Time Automation Controller (RTAC), and the SEL-5073 SYNCHROWAVE® Phasor Data Concentrator Software.

The SEL-2431 phasor measurement accuracy meets the highest IEEE C37.118-2005 Level 1 requirement of one percent total vector error (TVE). This means you can use the low-cost SEL-2431 in any application that otherwise would have required purchasing a separate dedicated phasor measurement unit (PMU).
Use with the SEL communications processors, or the SEL-3530 RTAC, to change nonlinear state estimation into linear state estimation. If all necessary lines include synchrophasor measurements then state estimation is no longer necessary. The system state is directly measured.

\[
\begin{bmatrix}
V_1 \\
V_2 \\
P_{12} \\
Q_{12}
\end{bmatrix}
= h(V, \theta) + \text{error}
\]

\[
\begin{bmatrix}
\delta_1 \\
\delta_2 \\
V_1 \\
V_2
\end{bmatrix}
= h(V, \theta)
\]

**Figure 9** Synchrophasor Measurements Turn State Estimation Into State Measurement

**Improve Situational Awareness**

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

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

**Figure 10** Visualization of Phase Angle Measurements Across a Power System

**Figure 11** SEL-5078-2 SYNCHROWAVE Console Real-Time Wide-Area Visualization Tool
Flexible Communications and User Interface

Flexible Communications Options

Serial Communications Cards
- 200 μm multimode fiber with Vpin connectors
- 62.5 μm fiber with ST connectors
- 4-Wire EIA-485 with DB-9 connector
- 2-Wire EIA-485 with Euro connector
- EIA-232 with DB-9 connector

Figure 12 Serial Communications Cards

Ethernet Communications Cards
- Dual fiber Ethernet 100BASE-FX (multimode) LC connectors
- Dual copper Ethernet (10/100BASE-T) RJ45 connectors
- One copper Ethernet (10/100BASE-T) RJ45 connector and one fiber Ethernet 100BASE-FX (multimode) LC connector
- Dual fiber Ethernet 100BASE-LX10 (single-mode) LC connectors
- One copper Ethernet (10/100BASE-T) RJ45 connector, and one fiber Ethernet 100BASE-LX10 (single-mode) LC connector

Figure 13 Ethernet Communications Cards

Front-Panel Targets and Messages
Program front-panel LEDs to indicate any control element operation, and modify front-panel labeling via configurable slide-in cards. Extra cards and a Microsoft® Word template are available.

The control automatically determines the operating conditions and displays this information on the front-panel display.
- Neutral position
- Voltage reduction active
- Automatic operation inhibited
- Reverse power
- Voltage high limit
- High band
- In band
- Low band
- Voltage low limit

Simple or Advanced Settings

Easy to Use
The SEL-2431 provides two ways to get your regulator running quickly and easily. For fast, basic operation, simply enter 10–15 values of nameplate data and voltage regulation set points directly into the front panel or use Windows®-based ACSELERATOR QuickSet® SEL-5030 Software to guide you through the settings process.

Use ACSELERATOR QuickSet to Set, Monitor, and Control the SEL-2431
- Save engineering time while keeping flexibility. Communicate with the SEL-2431 through any ASCII terminal or use the ACSELERATOR QuickSet graphical user interface.
- Develop settings offline with a menu-driven interface and completely documented help screens. Speed installation by copying existing settings files and modifying application-specific items. Interface supports Windows operating systems.
- Simplify the settings procedure with rules-based architecture to automatically check interrelated settings. Out-of-range or conflicting settings are highlighted for correction.
- Transfer settings files by using a PC communications link with the SEL-2431.
Tap-Change Reporting and Troubleshooting

Event and Tap-Change Reports

The SEL-2431 captures as many as 32 30-cycle event reports and creates an event summary in response to user-programmable conditions. View the summary by using the front-panel LCD or by connecting to a computer. Event summaries contain useful data about tap changes:

- Event number, date, and time
- Magnitudes of the load current and voltage, tap position, and system frequency

Download and view full event reports by using ACSELERATOR QuickSet. Event reports contain current and voltage oscillography, and the state of the control elements. The pretrigger length is adjustable from 1–29 cycles.
Sequential Events Recorder (SER)

The SEL-2431 tracks the pickup and dropout of selectable regulator elements, control inputs, and contact outputs. The date and time of the 1000 most recent transitions are available in an SER report. This chronological report helps you determine the order and cause of events and assists in troubleshooting and root-cause analysis. Connect a USB flash drive and expand the SER report to thousands of entries, limited only by the size of the USB flash drive.

Metering

The SEL-2431 provides extensive and accurate metering capabilities, as shown in Table 4. See Specifications on page 16 for metering accuracies. THD elements for the current and voltage channels are available for harmonics-based decisions or operations.

Table 4  Available Metering Quantities (Sheet 1 of 2)

<table>
<thead>
<tr>
<th>Instantaneous Quantities</th>
<th>Fundamental Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>L—Bushing current (primary and secondary)</td>
</tr>
<tr>
<td>Voltages</td>
<td></td>
</tr>
<tr>
<td>VL</td>
<td>L—Bushing voltage</td>
</tr>
<tr>
<td>VS</td>
<td>S—Bushing voltage</td>
</tr>
<tr>
<td>VCOMP</td>
<td>Compensated voltage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Real (kW)</td>
<td>kilowatts</td>
</tr>
<tr>
<td>Reactive (kVAR)</td>
<td>kilovars</td>
</tr>
<tr>
<td>Apparent (kVA)</td>
<td>kilovolt-amperes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power Factor</th>
<th>Power factor (with leading or lagging indication)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQ</td>
<td>System frequency</td>
</tr>
<tr>
<td>TAP</td>
<td>Tap position</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Demand Quantities</th>
<th>Present and Peak, Forward and Reverse (Time-Stamped Peaks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td>IL L</td>
<td>L—Bushing current (primary)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Real (kW)</td>
<td>kilowatts</td>
</tr>
<tr>
<td>Reactive (kVAR)</td>
<td>kilovars</td>
</tr>
<tr>
<td>Apparent (kVA)</td>
<td>kilovolt-amperes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Quantities</th>
<th>Forward and Reverse (Energy Out and In)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MWh</td>
<td>megawatt hours</td>
</tr>
<tr>
<td>MVArh</td>
<td>megavar hours</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum/Minimum Quantities</th>
<th>Forward and Reverse (Time-Stamped Maximums)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td></td>
</tr>
<tr>
<td>IL L</td>
<td>L—Bushing current (primary)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltages</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VL L</td>
<td>L—Bushing voltage</td>
</tr>
<tr>
<td>VS S</td>
<td>S—Bushing voltage</td>
</tr>
<tr>
<td>VCOMP</td>
<td>Compensated voltage</td>
</tr>
</tbody>
</table>
Load Profile

The load profile recorder in the SEL-2431 is capable of recording as many as 16 selectable analog quantities at a periodic rate (5, 10, 15, 30, or 60 minutes) and storing the data in a report in nonvolatile memory. The SEL-2431 will also store the data to a connected USB flash drive if the Automatic Report Backup feature is enabled. Choose any of the analog quantities listed in Table 4 (except peak demands, 2–15 harmonic, and max/min values). At a fifteen-minute periodic recording rate and with 16 selected analog quantities, as many as 90 days of load profile data can be stored in the onboard memory. Selecting a longer recording period or fewer analog quantities increases the number of days of storage available. Enabling the Automatic Report Backup feature increases the amount of storage available based on the size of the connected USB flash drive.

Built to Relay Standards

The SEL-2431 Voltage Regulator Control is designed, built, and tested with the same practices, processes, and standards that we use for our protective relays, recloser controls, and other products. This includes compliance with IEEE and IEC standards for the following:

- Radio frequency interference
- Environmental stress
- Dielectric strength
- Impulse
- Electrostatic discharge
- Fast transients
- Surge withstand capability
- Shock and bump
- Vibration
- Object penetration

Refer to Specifications on page 16 for detailed test data.
Front- and Rear-Panel Diagrams

Figure 16  SEL-2431 Front Panels

Front Panel With Raise/Lower Toggle Switch Option

Front Panel With Raise/Lower Pushbuttons Option
Figure 17 SEL-2431 Rear Panel
Dimensions

Figure 18  SEL-2431 Dimensions

CHASSIS

LEGEND

in

(mmm)

i9135b
## Specifications

### Compliance
- ISO 9001:2008 Certified

### General

#### AC Current Input
- **0.2 A nominal:** 0.64 A continuous, 4 A for 1 s, linear to 2.18 A symmetrical. 20 A for 1 cycle.
- **Burden:** <1 VA

#### Power Supply
- **120 Vac**
  - **Range:** 88–132 Vac
  - **Burden:** ≤ 35 VA
  - **Interruption:** ≤ 50 ms at 120 Vac per IEC 60255-11

#### 120 Vac Whetting Source
- **Range:** 88–132 Vac
- **Rated current:** 6 A (motor fuse)

#### 12 Vdc Auxiliary Output Source
- **Range:** 11–14 Vdc
- **Output power:** 6 W at 12 Vdc

#### Output Contacts
- **Make:** 30 A
- **Carry:** 3 A continuous carry at 120 Vac
- **MOV Protection:** 270 Vac/360 Vdc; 40 J
- **Pickup Time:** ≤ 16 ms
- **Dropout Time:** ≤ 16 ms
- **Update Rate:** 1/16 cycle
- **Breaking Capacity (10000 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 cycle/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
- **Note:** Make per IEEE C37.90:1989; Breaking and Cyclic Capacity per IEC 60255-23 [IEC 255-23]:1994.

#### Raise/Lower Outputs
- **Carry:** 6 A continuous at 120 Vac

#### Optoisolated Inputs
- **120 Vac:** Pickup 80–145 Vac
- **12 Vdc:** Pickup 9.6–14.4 Vdc
- **Note:** 12 Vdc optoisolated inputs draw approx. 10 mA of current.

#### Frequency
- **System Frequency:** 50 or 60 Hz

### Communications Ports
- **Standard:** 1 front EIA-232 (300–38400 bps)
- **Optional:** 1 or 2 rear-mounted serial communications cards, or 1 rear-mounted serial communications card and 1 rear-mounted Ethernet communications card

#### Available Serial Communications Card Types
- EIA-232 (300–57600 bps)
- 2-Wire EIA-485 (300–57600 bps)
- 4-Wire EIA-485 (300–57600 bps)
- 200 µm multimode fiber with VPIN connector (300–38400 bps)
- 62.5 µm fiber with ST connector (300–57600 bps)

#### Available Dual Ethernet Communications Card Types
- Dual Fiber Ethernet 100BASE-FX (Multimode) LC Connectors
- Dual Copper Ethernet (10/100BASE-T) RJ45 Connectors
- One Copper Ethernet (10/100BASE-T) RJ45 Connector and One Fiber Ethernet 100BASE-FX (Multimode) LC Connector
- Dual Fiber Ethernet 100BASE-LX10 (Single-mode) LC Connectors
- One Copper Ethernet (10/100BASE-T) RJ45 Connector, and One Fiber Ethernet 100BASE-LX10 (Single-mode) LC Connector

### Operating Temperature
- –40° to +85°C (–40° to +185°F)
- **Note:** LCD contrast impaired for temperatures below –20° and above +70°C (–4° and +158°F, respectively)

### Time-Code Input
- Device accepts demodulated IRIG-B time-code input at Port 1 if Port 1 contains either an EIA-232 card, a 4-Wire EIA-485 card, or a fiber-optic serial card.

### Clock Synchronization Accuracy
- C37.118 IRIG-B: 10 μs
- IRIG-B: 5 ms
- DNP3: 2 s

### Unsynchronized Clock Drift
- **Control Powered:** 26.5 minutes per year, typical

### Routine Dielectric Strength
- **AC current inputs:** 2500 Vac for 10 s

#### Weight
- <4.5 kg (10.0 lb)

### Type Tests

#### Environmental Tests
- **Cold:** IEC 60668-2-1:2007
  - Test Ad: 16 hr at –40°C
- **Damp Heat Cyclic:** IEC 60668-2-30:2005
  - Test Db: 25° to 55°C, 6 cycles, 95% humidity
- **Dry Heat:** IEC 60668-2-2:2007
  - Test Bd: 16 hr at +85°C
Dielectric Strength and Impulse Tests

Dielectric: IEC 60255-5:2000
IEEE C37.90-2005, Section 8—Insulation Tests
3100 Vdc on general contact outputs and CT input; 2200 Vdc on EIA-485 communications port; 2000 Vdc on other connectors

Impulse: IEC 60255-5:2000
IEEE 37.90-2005
0.5 J, 5000 V

Electrostatic Discharge Test
IEC 61000-4-2:2008
IEEE C37.90.3-2001
2, 4, 6, 8 kV contact discharge
2, 4, 6, 8, 15 kV air discharge

RFI and Interference Tests
IEEE 6100-4-4:2011, Class A, 4 kV
Radiated RFI: IEC 6100-4-3:2010, 10 V/m
IEC 60255-22-3:2007, 10 V/m
IEEE 37.90.2:2004, 35 V/m
Radiated Radio Frequency (1.89 GHz): ENV 50204:1995, 10 V/m
Surge Withstand: IEEE C37.90.1-2002
2.5 kV oscillatory, 4 kV fast transient
IEC 60255-22-1:2007
2.5 kV peak common mode, 1.0 kV peak differential mode
Surge Immunity: IEC 61000-4-5:2005
IEC 60255-22-5:2008
1 kV line-to-line, 2 kV line-to-earth
Conducted Immunity: IEEE 61000-4-6:2008
IEC 60255-22-6:2001
10 V/m
100 A/m (60 sec), 1000 A/m (3 sec)
Installed RF Ferrite Choke (Fair Rite part #0443164151) on copper Ethernet cables. Contact the SEL factory for this complimentary part if needed.

Power Frequency Magnetic Field Immunity: IEC 61000-4-8:2009
100 A/m (60 sec), 1000 A/m (3 sec)
100 A/m
Pulse Magnetic Field Immunity: IEC 61000-4-9:2001
1000 A/m
Damped Oscillatory Magnetic Field Immunity: IEC 61000-4-10:2001
100 A/m
IEC 61000-4-11:2004
IEC 61000-4-17:2002
IEC 61000-4-29:2000

Vibration and Shock Tests
Class 1: Shock Withstand, Bump
Class 2: Shock Response
IEC 60255-21-3:1993 Class 2
Sinusoidal Vibration: IEC 60255-21-1:1988
Class 1: Endurance
Class 2: Response

Object Penetration
Object Penetration: IEC 60529:2001 IP 20, excluding terminal blocks

Processing Specifications
Analog Data Acquisition: 32 samples per power system cycle, frequency tracking
Control Processing Rate: Once per power system cycle, frequency tracking
Data Filtering: Full-cycle cosine filter after low-pass analog filtering
Filtered Data Averaging (voltage and currents): 10 cycles (except for fault overcurrent element)

Control Accuracies
Voltage Control Accuracy—Steady State (V secondary)
Measured Channels: ±0.3% (~40° to +85°C, 108–132 Vac) (IEEE C57.15-1999)
Calculated Values: ±1.0% (~40° to +85°C, 108–132 Vac)
Overcurrent Accuracy—Steady State (A secondary)
General Overcurrent Elements: ±0.3% ± 500 μA (0.002–0.700 A)
Fault Overcurrent Element: ±0.3% ± 500 μA (0.4–2.0 A)
Overcurrent Element Response (Applied Current > 2x Pickup Setting)
General Overcurrent Elements: <10 cycles
Fault Overcurrent Element: <3 cycles

Metering Accuracy
Load Current: ±0.3% ±500 μA (0.001–2.000 A) and ±0.5° (0.02–2.000 A)
Harmonics (2nd–15th): Current: ±5% of fundamental (0.02–0.64 A)
Voltages: ±0.3% and ±0.5° (80–145 Vac)

Synchronphasor Accuracy
Maximum Data Rate in Messages per Second
IEEE C37.118 Protocol: 60 (nominal 60 Hz system)
50 (nominal 50 Hz system)
IEEE C37.118 Accuracy: Level 1 at maximum message rate when frequency-based phasor compensation is enabled (PHCOMP = Y)
PMDOK bit will deassert due to inclusion of out-of-band interfering signal.
Nominal Current: 450 mA
Current Range: 45 mA to 540 mA
Frequency Range: ±5 Hz of nominal (50 to 60 Hz)
Voltage Range: 80 V to 145 V (Voltage range is limited by power supply ratings)
Phase Angle Range: –180° to +180°