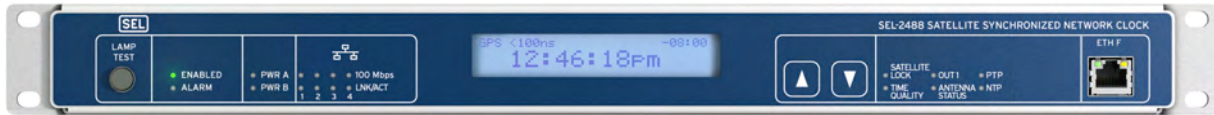




# SEL-2488 Satellite-Synchronized Network Clock

## Advanced Time Synchronization

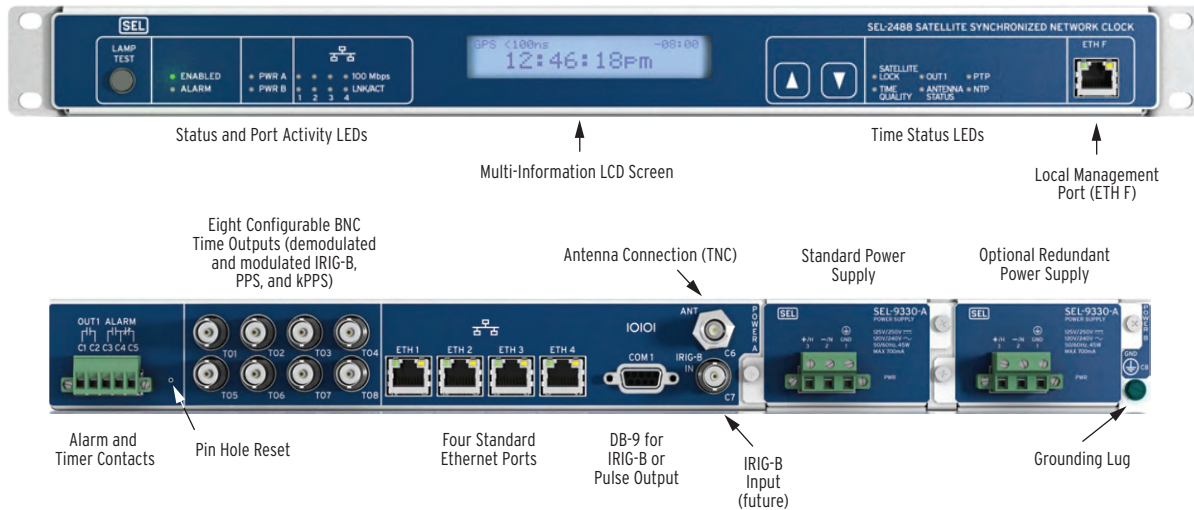


## Key Features and Benefits

The SEL-2488 Satellite-Synchronized Network Clock receives Global Navigation Satellite System (GNSS) time signals and distributes precise time via multiple output protocols, including IRIG-B, Precision Time Protocol (PTP), as defined by IEEE 1588, and Network Time Protocol (NTP). The advanced capabilities of the SEL-2488 make it well suited for demanding applications like synchrophasors and for substations with multiple time synchronization requirements.

- ▶ **Precise Time Accuracy Meets Demanding Requirements.** Provides demodulated IRIG-B time output for protection applications, synchronizing relays, phasor measurement units (PMUs), and other intelligent electronic devices (IEDs) to within  $\pm 40$  ns average and  $\pm 100$  ns peak accuracy to coordinated universal time (UTC). The SEL-2488 can act as a stratum 1 time server with typical client synchronization accuracy on a LAN of 0.5–2 ms. With purchase of the PTP option, the SEL-2488 can act as a PTP Grandmaster Clock with Default and Power System profiles providing  $\pm 100$  ns peak time stamp accuracy to UTC.
- ▶ **Holdover Oscillator Maintains Accuracy if GPS is Unavailable.** Maintains average accuracy of 36  $\mu$ s for 24 hours at constant temperature with standard Temperature Compensated Crystal Oscillator (TCXO) holdover. With optional Oven Controlled Crystal Oscillator (OCXO) holdover, average accuracy improves to 5  $\mu$ s for 24 hours at constant or varied temperature.
- ▶ **Thirteen Standard Outputs Provide Flexible Time Distribution.** Distributes time from eight time BNC outputs plus one DB-9 output, all configurable for IRIG-B or time pulse outputs. The DB-9 port can be used with SEL-2812 Fiber-Optic Transceivers to send IRIG-B long distances over fiber-optic cable. The SEL-2488 also includes four standard Ethernet ports, which provide NTPv4. With purchase of the PTP option, the SEL-2488 can act as a PTP Grandmaster Clock with Default and Power System profiles. The SEL-2488 distributes NTP and PTP to four independent networks, and Ethernet ports are available in copper as well as single- or multimode fiber orderable in pairs.
- ▶ **Dual Power Supplies Offer Redundancy.** Provides an option for a second power supply that can receive power from a second source. SEL-9330A power supplies support 125–250 Vdc or Vac input, and SEL-9330C power supplies use 24–48 Vdc.
- ▶ **Satellite Signal Verification Provides Assurance.** Receives signals from both GPS and GLONASS satellite systems for verification to provide a level of protection from GPS spoofing attacks.
- ▶ **DHCP, LDAP, SNMP, and Syslog Support Ensure Easy and Secure Integration.** Makes commissioning, management, and monitoring faster and more secure with DHCP captive portal, LDAP authentication, SNMP read and trap support, and syslog event messaging.
- ▶ **PRP with Dual Attached Node Support Provides Network Redundancy.** Connects directly to both LANs in a PRP network without a PRP Redbox. The SEL-2488 complies with IEC 62439-3:2016 standard.
- ▶ **Ruggedness Provides Reliability in Harsh Environments.** Operates reliably between  $-40^{\circ}$  and  $+85^{\circ}$ C ( $-40^{\circ}$  to  $+185^{\circ}$ F), and complies with IEEE 1613, IEC 61850-3, and IEC 60255 standards.
- ▶ **Easy-to-Use Interface Streamlines Device Management.** The intuitive SEL-2488 HTTPS device webpage with SkyView™ simplifies configuration, management, and troubleshooting.

# Functional Overview



**Figure 1 Functional Diagram**

The SEL-2488 raises the bar for satellite-synchronized clocks by providing higher levels of accuracy, flexibility, dependability, and ease of use, all while providing advanced capabilities that make it especially well suited for critical infrastructure applications.

## Standard Features

- Average accuracy of  $\pm 40$  ns to UTC, peak accuracy of  $\pm 100$  ns to UTC for demodulated IRIG-B and pulse outputs
- Time sources used: GPS, GLONASS for satellite signal verification
- Typical NTP time-stamp accuracy  $< 100$   $\mu$ s
- Peak PTP time-stamp accuracy of  $\pm 100$  ns to UTC
- Peak accuracy of  $\pm 1$   $\mu$ s to UTC for modulated IRIG-B
- Standard TCXO holdover with 36  $\mu$ s average timing error after 24 hours at constant temperature
- Optional OCXO holdover with 5  $\mu$ s average timing error after 24 hours at constant temperature
- Eight rear BNC ports for demodulated IRIG-B, PPS, or kPPS, and as many as four ports for modulated IRIG-B
- Four Ethernet ports can serve NTPv4 and PTP to four independent networks
- One Form A solid-state contact output can provide a single contact closure or a repeating contact closure of configurable closure duration and period
- One Form C mechanical alarm contact notifies users of a major or minor event
- One standard power supply: 24–48 Vdc or 125–250 Vdc or Vac, optional second supply
- Satellite signal verification with SEL-9524B GPS/GLONASS GNSS Antenna
- LCD multi-information display plus LEDs for status
- HTTPS Web interface with SkyView, support for DHCP, LDAP, Syslog, SNMP read and traps, and ACCELERATOR QuickSet<sup>®</sup> SEL-5030 Software
- Standard SEL 10-year warranty

## Applications

### Time Synchronization of Substations

The SEL-2488 has eight BNC ports, which can be configured for demodulated IRIG-B, time pulse, or modulated IRIG-B (as many as four ports). Demodulated IRIG-B provides time output for protection applications,

synchronizing relays, phasor measurement units, and other intelligent electronic devices (IEDs) to within  $\pm 40$  ns average accuracy to UTC. Time synchronization is also essential for sequence of events recording, disturbance recording, and power system fault location.

Modulated IRIG-B can be configured for as many as four BNC outputs for synchronizing legacy devices. The DB-9 port can be used with SEL-3405 High-Accuracy IRIG-B Fiber-Optic Transceivers to send IRIG-B long distances over fiber-optic cable.

Ethernet ports can use NTP to distribute time to devices on the substation local-area network (LAN), such as servers, computers, and other devices that set their time through NTP or the Simple Network Time Protocol (SNTP). The SEL-2488 can serve NTP to four independent networks. The SEL-2488 can act as a stratum 1 time server with typical client synchronization accuracy to the SEL-2488 NTP server on a LAN of 0.5–2 ms. With syslog support, all SEL-2488 event information, including diagnostic and status events, is available over Ethernet in a standardized format.

The SEL-2488 Ethernet ports support hardware time stamping, enabling support of the Precision Time Protocol, PTP, defined by IEEE 1588, with purchase of a firmware upgrade.

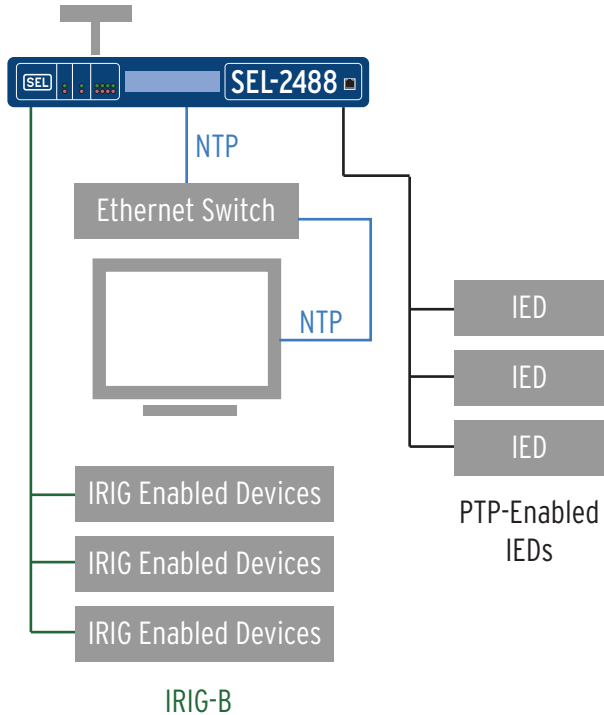


Figure 2 Functional Diagram for Utility Substation Time Synchronization

### GNSS Vulnerability Mitigation

If GNSS time signals become unavailable as a result of solar flares, jamming, or an antenna failure, the SEL-2488 clock switches its time source to the standard TCXO holdover, with 36 μs/day accuracy, or to the

optional OCXO holdover, with 5 μs/day accuracy. (Both of these holdover accuracy specifications are based on a constant temperature.) In the case of a GPS spoofing attack, in which a satellite system receiver locks to a counterfeit signal, the SEL-2488 Satellite-Synchronized Network Clock and SEL-9524B GPS/GLONASS GNSS Antenna use signals from the GLONASS Satellite constellation to validate GPS signals and identify mismatches in timing information caused by these attacks.

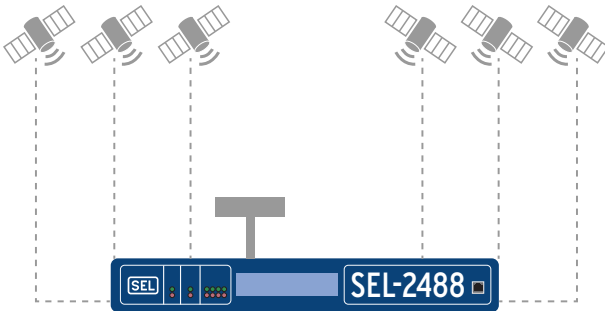


Figure 3 SEL-2488 Satellite Signal Verification

### Cable Delay Compensation

The SEL-2488 preserves accuracy by providing time-delay compensation for antenna cables and output cables on a per-port basis with demodulated IRIG-B and pulse outputs.

The cable delay compensation of the SEL-2488 Clock ensures high-accuracy time distribution in large facilities with dispersed IEDs or in installations where antennas must be mounted high on towers. The SEL-2488 supports as long as 500 feet of LMR-400 cable for an antenna and as long as 500 feet of RG-58 for the output cable.

Figure 4 shows an example of a clock with an antenna and two output ports. One output port is configured for 30 ns of cable delay compensation, and another is configured for 180 ns. This difference in delay compensation accounts for the 100-foot difference in output cable length.

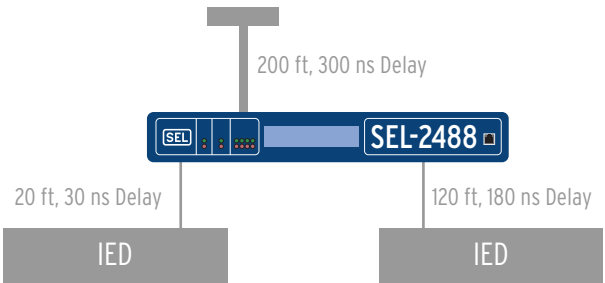


Figure 4 SEL-2488 Cable Delay Compensation

# Configuration

## HTTPS Device Webpage

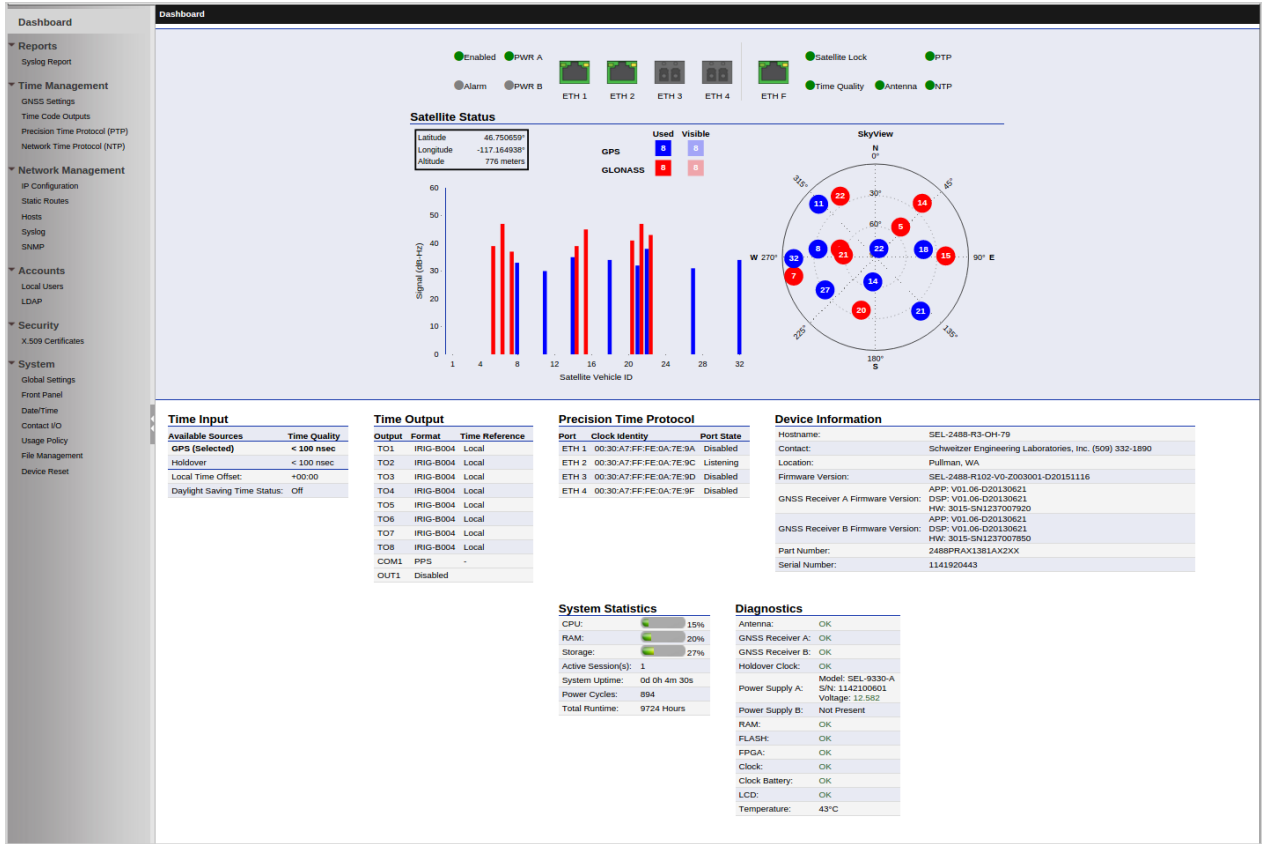


Figure 5 SEL-2488 Dashboard With SkyView

The SEL-2488 supports DHCP captive portal for an easy initial connection to the device webpage for configuration. Secure access is controlled through X.509 certificates, user-based accounts, LDAP authentication, and complex passwords. The SEL device webpage includes a dashboard display of satellite signals for both GPS and GLONASS satellites. Bar charts indicate signal strengths, and the SkyView displays the present satellite overhead positions, useful information for troubleshooting potential signal and antenna installation issues.

## ACSELERATOR QuickSet

ACSELERATOR QuickSet can be used for secure configuration of the SEL-2488. ACSELERATOR QuickSet is an easy-to-use, powerful tool with template design capabilities for consistent configuration of settings across multiple devices.

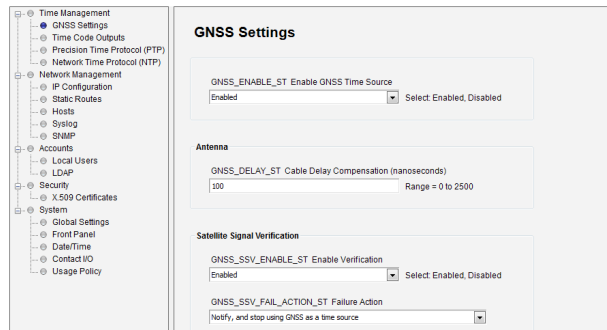
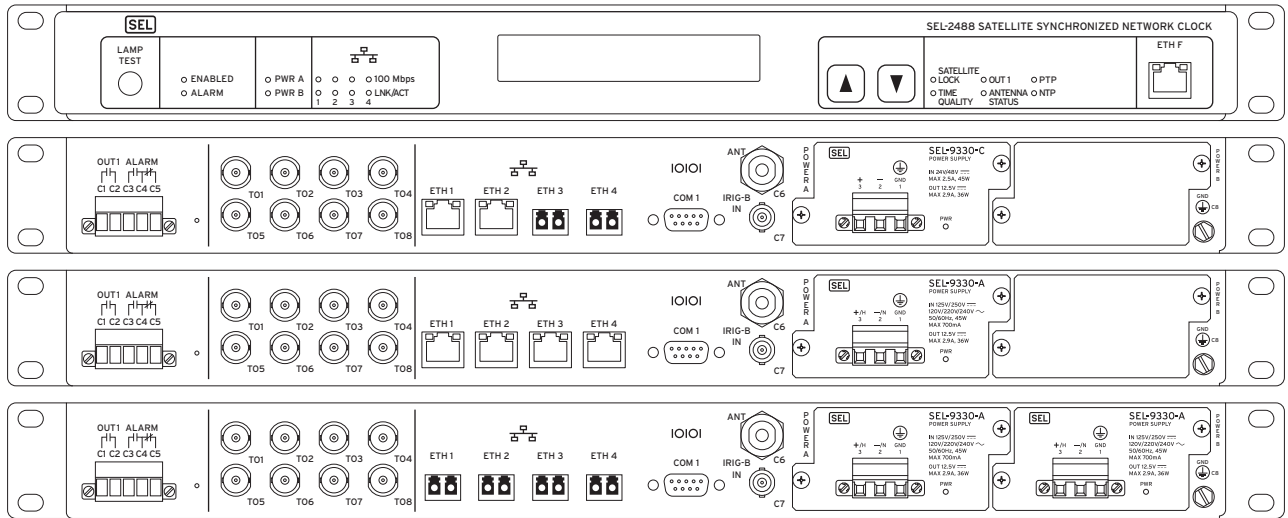


Figure 6 ACSELERATOR QuickSet Template for the SEL-2488

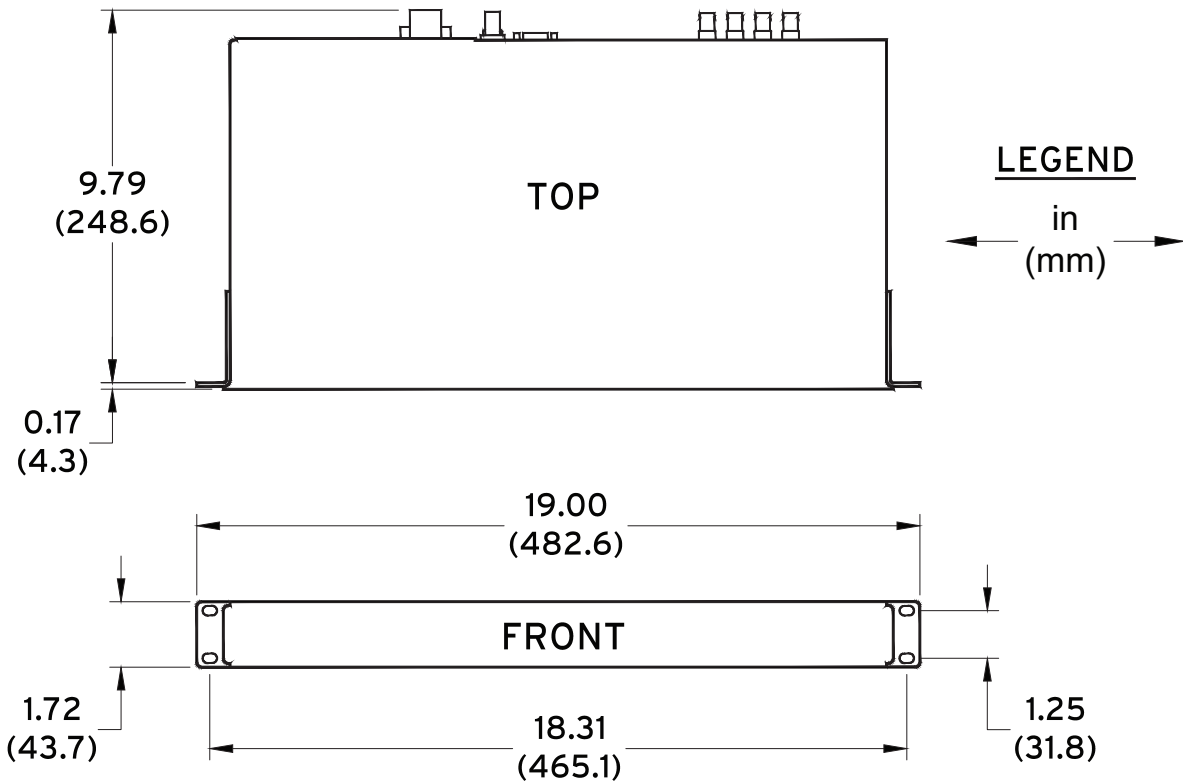
# Front- and Rear-Panel Diagrams



17114e

Figure 7 SEL-2488 Front and Rear Panels

# Dimensions



i9327a

Figure 8 SEL-2488 Dimensions (Rack-Mount Chassis)

# Specifications

## Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

UL Listed to U.S. and Canadian safety standards (File E220228; NRAQ, NRAQ7)

UL MX certified to Normas Oficiales Mexicanas (NOM)

CE Mark

## General

### Receiver

Satellite Tracking: GPS L1, C/A Code (1575.42 MHz), GLONASS L1 (1602 MHz), track as many as 16 satellites for each constellation

### Acquisition Times

Warm Start: 240 s (with saved almanac data)

Cold Start: 240 s + UTC compensation time (as many as 12.5 minutes)

### Clock Accuracy (to UTC)

1 PPS:  $\pm 40$  ns average,  $\pm 100$  ns peak

Demodulated IRIG-B:  $\pm 40$  ns average,  $\pm 100$  ns peak

Modulated IRIG-B:  $\pm 1$   $\mu$ s peak

PTP Time-Stamp Accuracy:  $\pm 100$  ns peak

NTP Time-Stamp Accuracy (Typical):  $< 100$   $\mu$ s

Typical client synchronization accuracy to the SEL-2488 NTP server on a LAN is 0.5–2 ms. Actual accuracy depends on network conditions.

### Holdover Accuracy (Typical)

TCXO: 36  $\mu$ s per day (constant temp)  
315  $\mu$ s per day ( $\pm 1^\circ\text{C}$ )

OCXO (after 24 hours of continuous operation): 5  $\mu$ s per day (constant temp)  
5  $\mu$ s per day ( $\pm 1^\circ\text{C}$ )

### Antenna Requirements

5 V,  $< 80$  mA  
 $\geq 32$  dB preamp

### Electrical Output Drive Levels

Demodulated IRIG-B/PPS, TTL (OUT1–OUT8): 5 V, 250 mA max

Modulated IRIG-B, (OUT1–OUT4): 6.2 Vpp nominal

DB-9 Port IRIG-B output, TTL (Pin 4/Pin 6): 5 Vdc, 5 mA

### Operating Environment

Pollution Degree: 2

Overvoltage Category: II

### Dimensions

1U Rack Mount

Height: 42.9 mm (1.69 inches)

Depth: 232.1 mm (9.14 inches)

Width: 482.5 mm (19.0 inches)

### Weight

1.96 kg (4.3 lb)

## Warranty

10 years

## Network Management

HTTPS Web User Interface  
ACCELERATOR QuickSet<sup>®</sup> SEL-5030 Software  
Settings Import/Export

## User-Based Accounts

Maximum Local Accounts: 256

Password Length: 1–72 characters

Password Set: All printable ASCII characters

User Roles: Administrator, Engineer, User Manager, Monitor

## Syslog

Storage for 60,000 local syslog messages

Support for three remote syslog destinations

## SNMP

Monitors diagnostics through SNMP v2c and v3 read operations

Sends notifications using SNMP v2c traps

Support for as many as three trap servers

## PRP

Operates as dual attached node device in a PRP network

Implements IEC 62439-3:2016

PTP disabled on PRP ports when PRP is enabled

## Communications Ports

### Ethernet Ports

Ports: 4 rear, 1 front

Data Rate: 10 or 100 Mb/s

Front Connector: RJ45 Female

Rear Connectors: RJ45 Female or LC Fiber (single-mode or multimode)

Standard: IEEE 802.3

### Fiber-Optic Ports

#### Multimode Option (to 2 km)

Maximum TX Power:  $-14$  dBm

Minimum TX Power:  $-20$  dBm

RX Sensitivity:  $-31$  dBm

System Gain: 11 dB

Source: LED

Wavelength: 1310 nm

Connector Type: LC (IEC 61754-20)

#### Single-Mode Option (to 15 km)

Maximum TX Power:  $-8$  dBm

Minimum TX Power:  $-15$  dBm

RX Sensitivity:  $-28$  dBm

System Gain: 13 dB

Source: Laser

Wavelength: 1310 nm

Connector Type: LC (IEC 61754-20)

## Alarm Output

Rated Operational Voltage: 24–250 Vdc

Contact Protection: 270 Vdc, MOV protected

Continuous Carry:	2 A
Pickup Time:	≤8 ms typical
Dropout Time:	≤8 ms typical

### Timing Output

Rated Operational Voltage:	12–250 Vdc
Contact Protection:	330 Vdc (250 Vac), MOV protected
Continuous Carry:	100 mA
Off Resistance:	5 MΩ
Minimum Voltage:	12 Vdc
Timing Accuracy (Closing):	±1 μs (applies only to dc voltages)

### Power Supply

#### 125/250 Volt Power Supply

Rated Supply Voltage:	125–250 Vdc; 110–240 Vac, 50/60 Hz
Input Voltage Range:	88–300 Vdc or 85–264 Vac
Power Consumption:	AC: <60 VA DC: <45 W
Input Voltage Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

#### 24/48 Volt Power Supply

Rated Supply Voltage:	24–48 Vdc (polarized)
Input Voltage Range:	19.2–57.6 Vdc
Power Consumption:	<45 W
Input Voltage Interruptions:	50 ms @ 48 Vdc

#### External Overcurrent Protection

Breaker Type:	Standard
Breaker Rating:	20 A at 250 Vdc
Current Breaking Capacity:	10 kA
Grounded Neutral Systems:	Device in series with the HOT or energized conductor
DC and Isolated Systems:	Device in series with both conductors

## Environmental

### Temperature

Operating:	–40° to +85°C (–40° to +185°F)
Non-operating:	–40° to +85°C (–40° to +185°F)

### Relative Humidity

0 to 95% noncondensing

### Altitude

2000 m

## Type Tests

### Communication Product Testing

Communications for Substation Equipment:	IEEE 1613-2009 Class 2
Power Frequency Disturbances:	IEC 61850-3:2002; Section 5.7.3

### Electromagnetic Compatibility General

Measuring Relays and Protection Equipment:	IEC 60255-26:2013
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### Electromagnetic Compatibility Emissions

Radiated RF Emissions:	IEC 60255-25:2000 FCC 15.109:2014 FCC 15.109(g):2014; CISPR 22:2008 Severity Level: Class A
Conducted RF Emissions:	IEC 60255-25:2000 FCC 15.107:2014 Severity Level: Class A
Telecom Conducted RF Emissions:	EN 55022:2010 Severity Level: Class A

### Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-22-6:2001 IEC 61000-4-6:2008 Severity Level: 10 Vrms
Radiated RF Immunity:	IEC 60255-22-3:2007 IEC 61000-4-3:2008 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 35 V/m
Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 IEC 61000-4-2:2008 Severity Level: ±2, 4, 6, 8 kV contact; ±2, 4, 8, 15 kV air IEEE C37.90.3-2001 Severity Level: ±2, 4, and 8 kV contact; ±4, 8, and 15 kV air
Surge Withstand Capability:	IEC 60255-22-1:2007 Severity Level: ±2.5 kV peak common mode; ±1.0 kV peak differential mode IEEE C37.90.1-2002 Severity Level: ±2.5 kV, 1 MHz oscillatory; ±4 kV, 2.5 kHz fast transient
Fast Transient/Burst Immunity:	IEC 60255-22-4:2008 IEC 61000-4-4:2011 Severity Level: ±4 kV, 5 kHz; ±2 kV, 5 kHz on communications ports
Surge Immunity:	IEC 60255-22-5:2008 IEC 61000-4-5:2005 Severity Level: ±0.5 kV, 1 kV line-to-line; ±0.5 kV, 1 kV, 2 kV line-to-earth; ±0.5 kV, 1 kV line-to-earth on communications ports
Power Frequency Magnetic Field Immunity:	IEC 61000-4-8:2009 Severity Level: 1000 A/m for 3 seconds; 100 A/m for 1 minute
Pulse Magnetic Field Immunity:	IEC 61000-4-9:2001 Severity Level: 1000 A/m
Damped Oscillatory Magnetic Field Immunity:	IEC 61000-4-10:2001 Severity Level: 100 A/m (at 1 kHz and 1 MHz)
Power Supply Immunity:	IEC 60255-11:2008 IEC 61000-4-11:2004 IEC 61000-4-17:2002 IEC 61000-4-29:2000

**Environmental**

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at -40°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 25° to 55°C, 6 cycles, relative humidity: 95%
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C
Free Fall:	IEEE 1613-2009 Severity Level: 100 mm
Vibration:	IEC 60255-21-1:1988 Severity Level: Class 2 Endurance Class 2 Response
Shock & Bump:	IEC 60255-21-2:1988 Severity Level: Class 1 Shock Withstand Class 1 Bump Class 2 Shock Response
Seismic:	IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response)

**Safety**

Measuring Relays and Protection Equipment:	IEC 60255-27:2013
Protection IP Code:	IEC 60529:2001 IP Code: IP3X for category 2 equipment
Insulation Coordination:	IEC 60255-5:2000 IEEE C37.90-2005 Dielectric (HiPot) Severity Level: Power Supply: 3100 Vdc Alarm Contact: 2500 Vac IRIG-B Input: 2100 Vdc Ethernet Ports: 1500 Vac Timer Contact (OUT1): 3500 Vdc Impulse Severity Level: 5 J; ±5 kV, 1.2/50 µs

## Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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