SEL-FLT/SEL-FLR Fault and Load Transmitter and Receiver System

Accelerate System Restoration

Key Features and Benefits

The SEL-FLT Fault and Load Transmitter and the SEL-FLR Fault and Load Receiver act in unison as a wireless line sensor system for overhead distribution circuits. The sensor system provides fault detection and accurate load data to a centralized location, such as a SCADA system or outage management system (OMS). The line sensors and concentrator communicate via a purpose-built wireless protocol optimized for fault-monitoring applications.

- **Reliability Improvement.** Turn accurate fault data into actionable information to quickly identify fault locations and restore power.
- **Load Data Monitor.** Measure load current with a typical accuracy of 1 percent in near-real time for planning and making switching decisions.
- **High-Visibility Display.** Guide line crews to fault locations with the multifunctional LED display, which is visible from greater than 50 m (164 ft) during the daytime in any direction.
- **Simple Deployment.** Reduce installation risk to personnel with the user-friendly, lightweight design of the SEL-FLT. Installation requires just a single hot stick.
- **Scalable Solution.** Expand wireless sensor deployment as needed to meet operational needs. Start with a small deployment and increase the number of SEL-FLT and SEL-FLR devices to increase system visibility.
- **Rugged Design.** Monitor load and detect faults reliably in any application or environment with the outdoor-rated SEL-FLT compliant with the IEEE 495 standard.
- **Seamless System Integration.** Integrate the DNP3 protocol output easily into a SCADA network or OMS using any existing TCP/IP backhaul, including cellular.

- **Flexible Communications.** Use an SEL-3061 Cellular Router, direct fiber, or a radio of your choice that supports DNP3 communication over Ethernet to backhaul data from SEL-FLR to SCADA.
- **Intuitive Interface.** Configure device settings and network settings through a secure web interface in the SEL-FLR.
- **Long Product Life.** Reduce ongoing maintenance with line-powering, over-the-air software updates, long product life, and a 10-year warranty.

Functional Overview

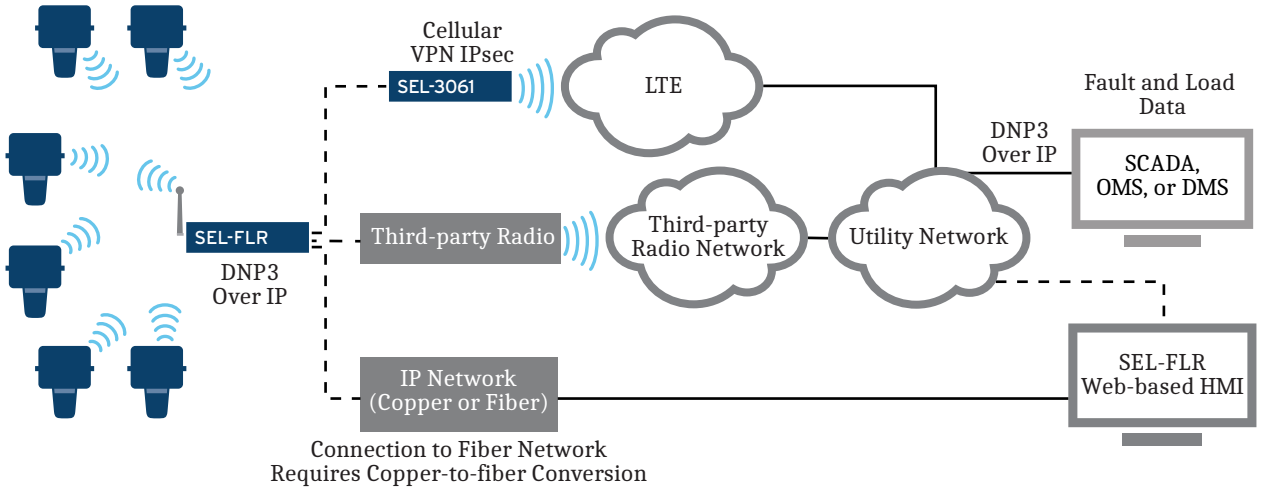


Figure 1 Functional Diagram

Device Overview

SEL-FLT

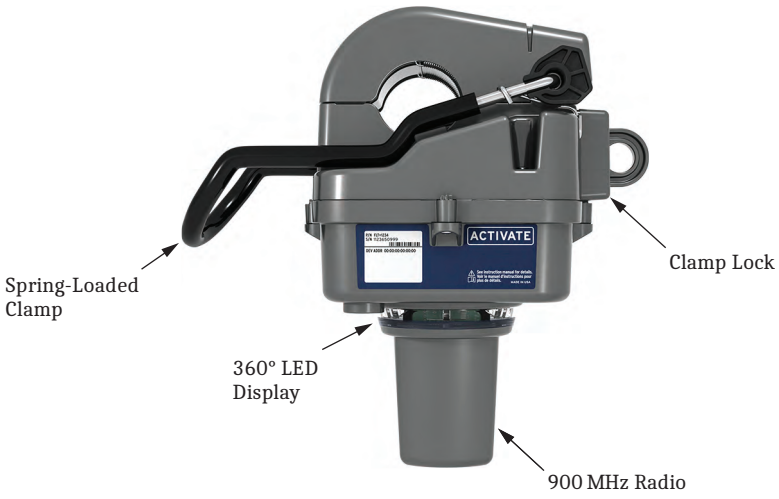


Figure 2 SEL-FLT Device Overview

SEL-FLR

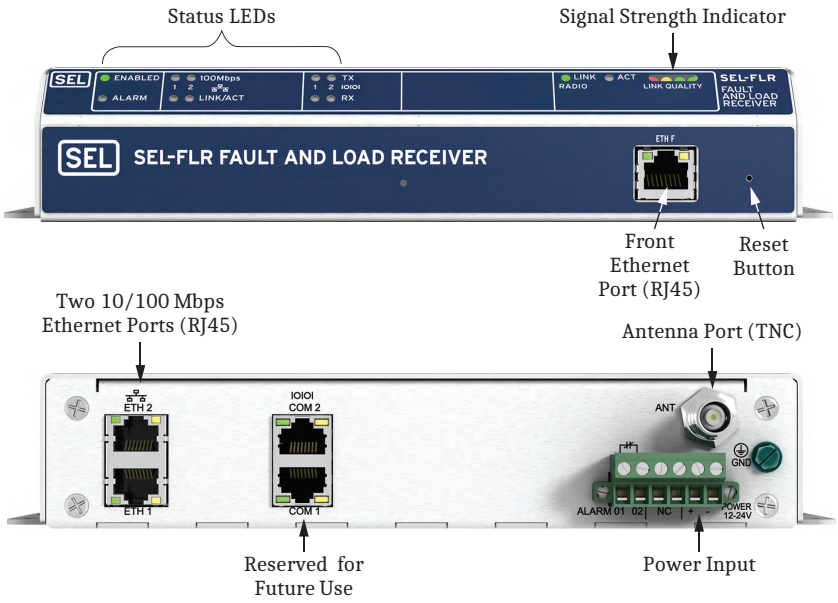


Figure 3 SEL-FLR Device Overview

System Application Overview

Wide-Area Fault Indication and Load Monitoring

The Wireless Line Sensor System collects periodic load data and fault status and sends the information to a remote SCADA system via DNP3 messages. This allows utilities to pinpoint faulted branches on distribution circuits faster and monitor load fluctuations in a distribution circuit. The SEL-FLR, typically installed in a pole-mounted enclosure, receives the fault and load status from several SEL-FLT devices. When a fault occurs, the SEL-FLT transmits a fault or outage status to the SEL-FLR. The SEL-FLR passes the sensor data through a wired or wireless network to the central SCADA master via DNP3 protocol. The SEL-FLT also reports average and peak load data as frequently as every five minutes for near-real-time load monitoring.

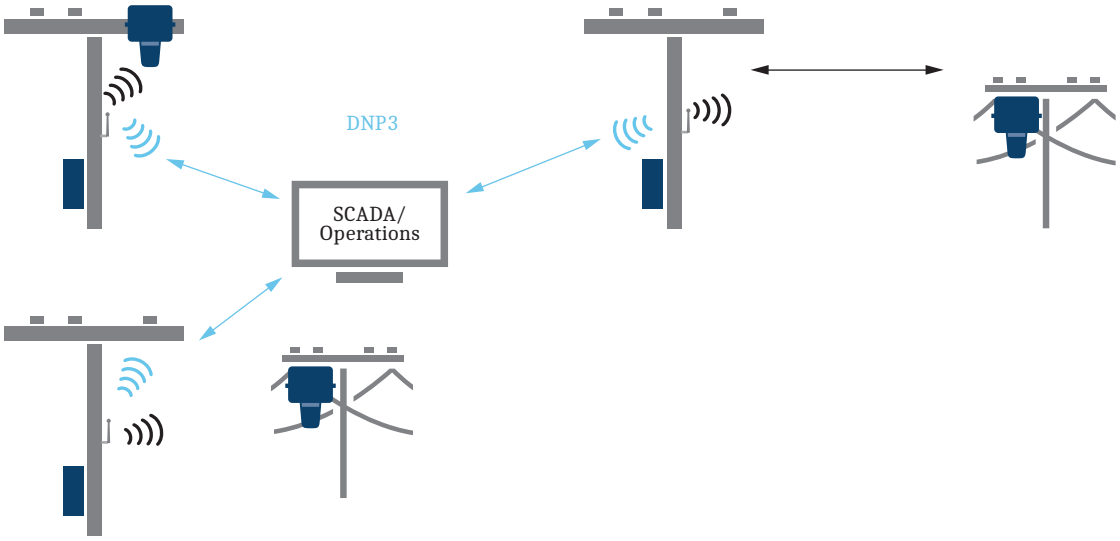
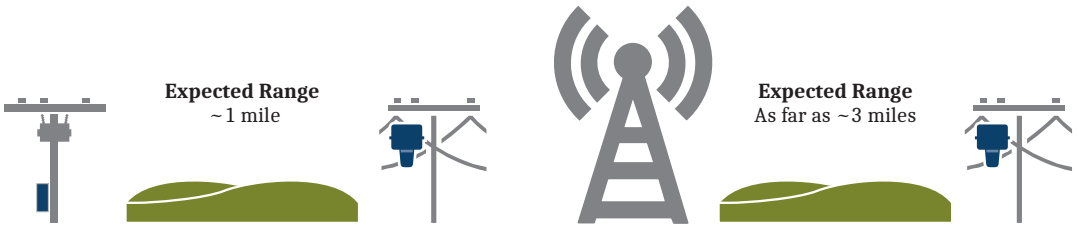


Figure 4 Network Diagram

The range of the SEL-FLT varies depending on a variety of factors including line-of-sight, sensor and antenna heights, and interference from other 900 MHz radio networks. All SEL-FLT links require onsite analysis and testing to determine with certainty if the links will be effective, but *Figure 5* shows the general effectiveness for SEL-FLR/SEL-FLR System links depending on the circumstances.



Radio maximum range with no obstructions to the Frensel zone: 10 miles

All links require direct line of sight and minimal interference to achieve stated performance.
Onsite testing is required for all SEL-FLT/SEL-FLR System links.

Figure 5 Line-of-Sight Range for Typical Wireless Applications

SEL-FLT Features

Durable, Lightweight Design

Quickly mount the SEL-FLT to overhead distribution conductors. The lightweight 3.6 lb design allows for simple installation using a single standard hot stick. The SEL-FLT clamp locks into place to ensure the sensor is securely installed.

The SEL-FLT is designed and tested to rigorous outdoor specifications of the IEEE 495-2007 standard, ensuring a long service life. The SEL-FLT is suited for a long service life and exceeds the IP-66 ingress protection rating.

Energy Harvesting

The SEL-FLT harvests required operating power from the overhead distribution line on which it is installed. With 3.5 A (rms) or greater load current, the SEL-FLT line sensor supports an operational life of greater than 15 years. In addition to energy harvesting, the SEL-FLT also has a backup battery system for power during extended outages and in low-current applications. The SEL-FLT flashes the LED display for 8 hours from harvested power during an outage before switching to the backup battery. The SEL-FLT supports greater than 1800 LED flash hours when powered by the backup battery.

LED Display

When a fault is detected and the system protection has locked out, the SEL-FLT illuminates six red and amber LEDs that rotate around the display to indicate a permanent fault.

Ultra-bright LEDs provide indications for different types of events and are visible from as far as 50 m (164 ft). The event display is configurable to display, and distinguish between, permanent faults, permanent outages, and momentary faults. The LED display automatically turns off when power is restored or after a display time-out.

Figure 6 LED Display

Fault Identification

Locate faults quickly in any location on overhead distribution circuits. The SEL-FLT detects low-impedance fault currents through use of the self-adjusting Auto-RANGER trip logic, which implements ten trip thresholds. The SEL-FLT continuously monitors load current and autoranges to the corresponding trip threshold (as shown in *Figure 7*). After detecting a fault, the SEL-FLT automatically determines if the event resulted in a protection operation. When protection locks out, a permanent fault event is registered and reported by exception (including the fault current magnitude up to 1600 A). Using the fault status reported by the SEL-FLT, personnel can pinpoint the fault location remotely.

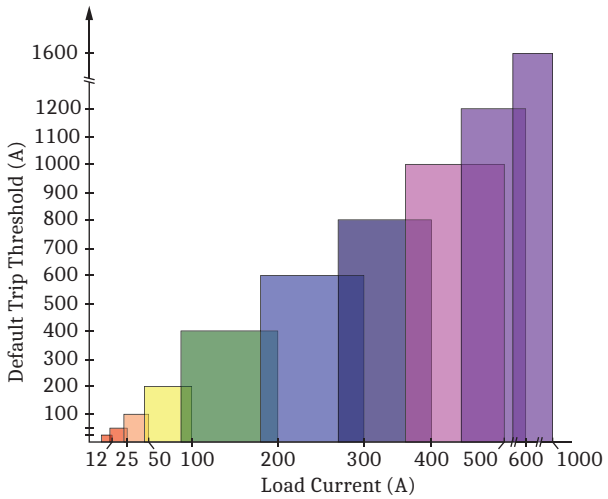


Figure 7 AutoRANGE Trip Thresholds Adjust to Any Load

Load Data

Monitor load current across an entire distribution circuit in near-real time with the SEL-FLT. The sensors continuously monitor system load current within ±(2.5 A + 2%) accuracy at every update interval. The SEL-FLT sends load data, such as average and peak rms values, to the SEL-FLR as frequently as every five minutes. The load alarms trigger alerts when the SEL-FLT measures load exceeding user-configurable thresholds.

SEL-FLR Features

Network Setup

Connect to the SEL-FLR webpage for easy network configuration. The webpage provides access to the sensors on the network, as well as settings for the sensors and the DNP3 server.

Network Statistics

Monitor all connected sensors from the SEL-FLR Dashboard webpages. Quickly view the status of connected sensors to identify faults, outages, errors, and alarm messages. Hovering over or selecting a sensor displays detailed device and radio statistics.

Over-the-Air Configuration and Updates

Upgrade deployed sensors by sending new firmware over-the-air to connected SEL-FLT sensors. You can also configure settings of in-service line sensors for specific applications without removing the sensors from the line. Users can modify specific units or make global changes to all devices connected to the network through use of the secure web interface.

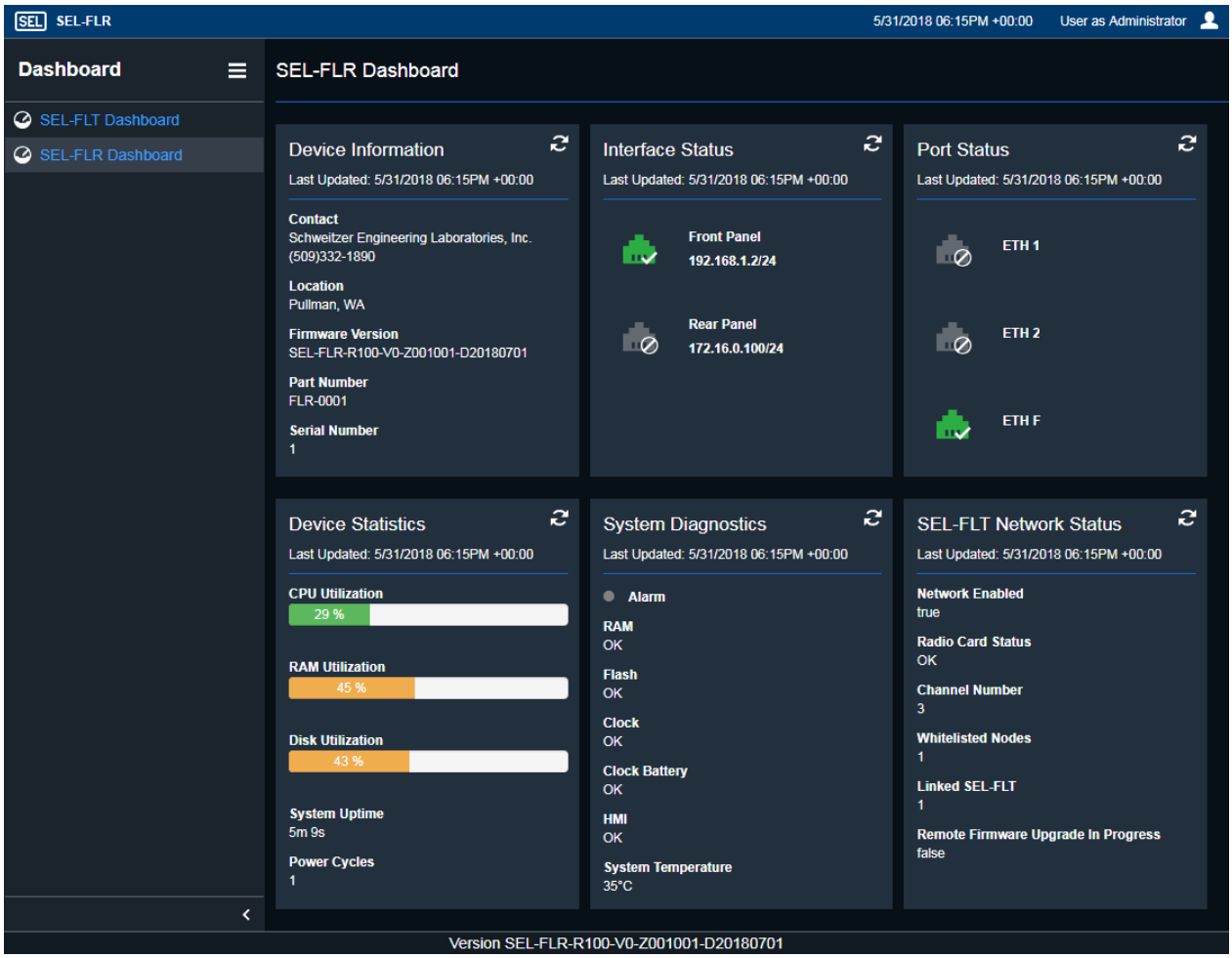


Figure 8 SEL-FLR Dashboard Provides System Overview

SEL-FLR Enclosure

SEL offers an optional pole-mounted SEL-FLR enclosure that provides a flexible, off-the-shelf solution for deploying the SEL-FLR at multiple locations throughout a power system. The enclosure includes an SEL-FLR, a power supply, and battery backup, and can come prewired with an SEL-3061 for cellular backhaul.

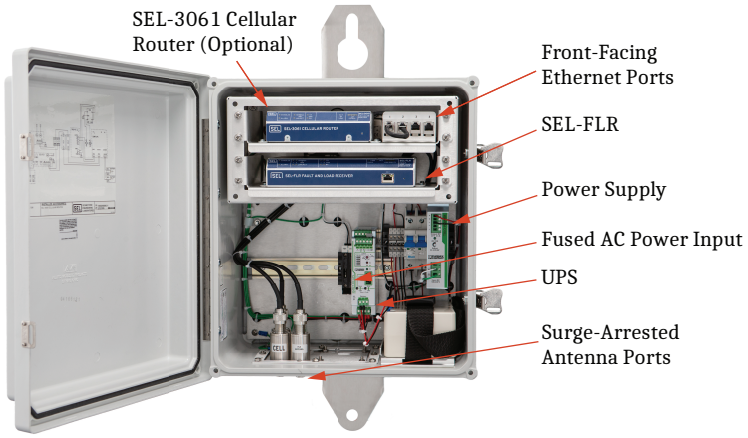


Figure 9 SEL-FLR Enclosure

Accessories

Table 1 SEL-FLT Orderable Accessories

Description	Part Number
Magnet Tool	CRSRTT
Mini Current Loop	MCL120

Table 2 SEL-FLR Orderable Accessories

Description	Part Number
Feed Line	
LMR-400 TNC Male to N Male Cable	SEL-C966
LMR-400 N Male to N Male Cable	SEL-C968
7/8" Heliax N Male to N Male Cable	SEL-C978
N Female to TNC Male Adapter	240-1809
900 MHz Pole-Top Omnidirectional Antennas[a]	
Low-Profile 3 dBi Omnidirectional, N Female Connector	235-0003
Vertical 7.15 dBi Omnidirectional, N Female Connector	235-0232
Vertical 9.15 dBi Omnidirectional, N Female Connector	235-0233
900 MHz Base Station Omnidirectional Antennas[a]	
Vertical 8.1 dBi Omnidirectional, N Female Connector	235-0234
900 MHz Yagi Directional Antennas[a]	
3-Element 8.5 dBi Yagi, N Female Connector	235-0221
5-Element 11.1 dBi Yagi, N Female Connector	235-0220
11-Element 14.1 dBi Yagi, N Female Connector	235-0222
900 MHz Indoor Antennas[a]	
Indoor 20.32 cm (8 in) Omnidirectional, TNC Male Connector	235-0108
Antenna Mounting Hardware	
Yagi Mount for 4.8 cm (1.9 in) Maximum Diameter Poles	Included With Yagi Antenna Purchase
Vertical Omnidirectional Mount for 35.56 cm (14 in) Maximum Diameter Poles	240-0103
Yagi Mount for 35.56 cm (14 in) Maximum Diameter Poles	240-0104
Mast Mount for Omnidirectional Antennas (6.35 cm [2.5 in] Maximum Diameter Mast)	240-0106
Power Supply	
15 Vdc Power Supply	SEL-9322
15 Vdc Power Supply, 120–240 Vac Input With Tinned Leads	230-0604
Surge Protection	
Radio Surge Protector With N Female Connectors	200-2004
In-Line Grounding Cable	240-0124

[a] Not certified for Brazil (model FLR-1006). Contact SEL for approved antenna models.

Diagrams and Dimensions

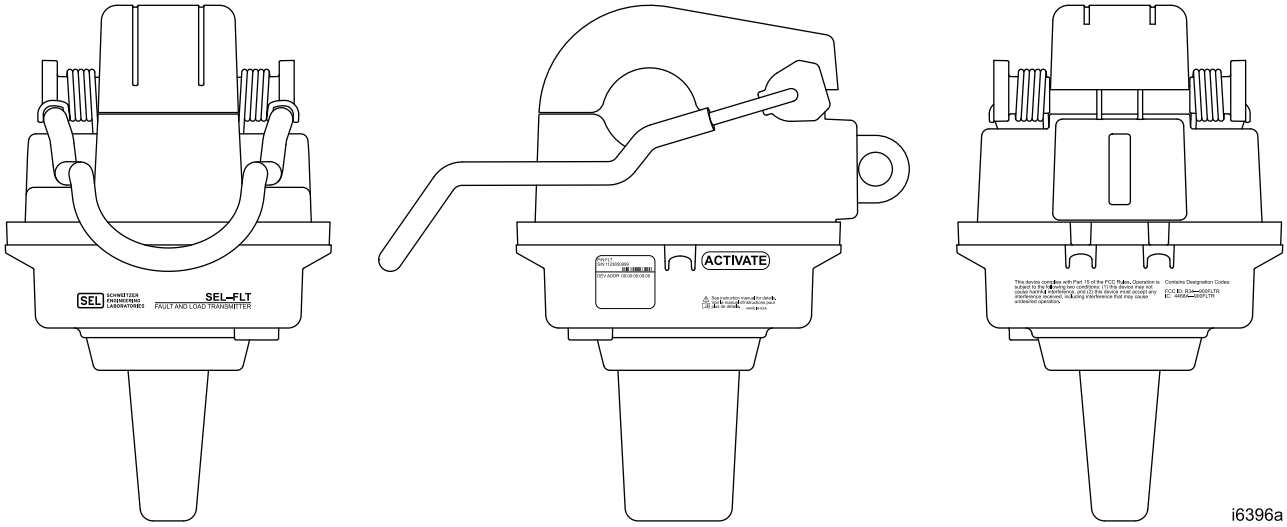


Figure 10 SEL-FLT Diagram

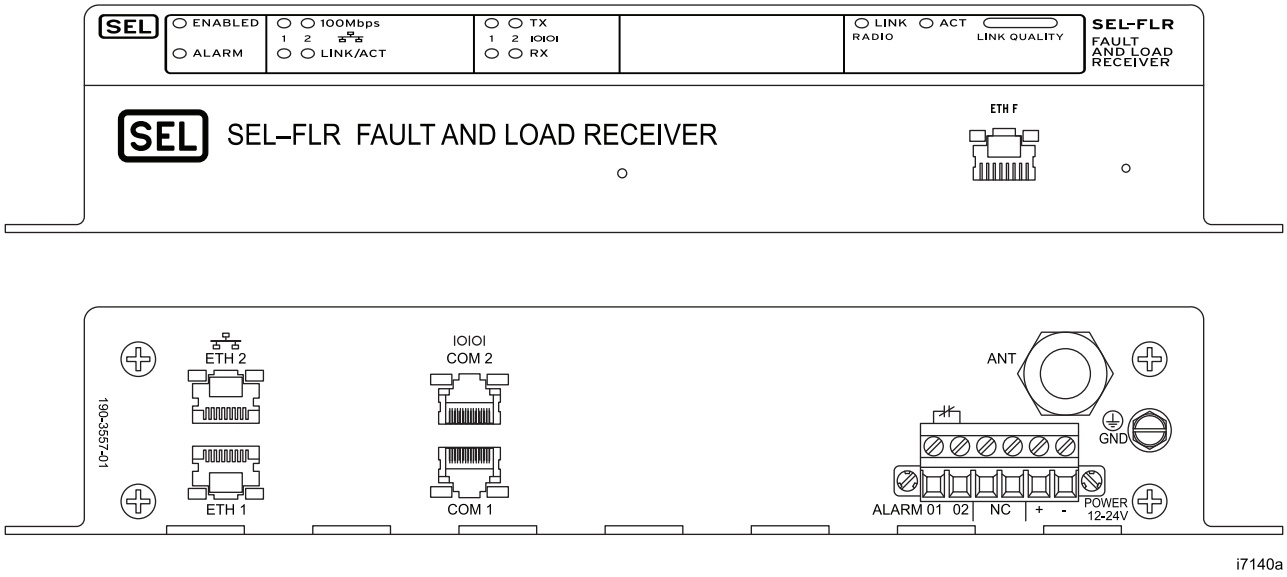


Figure 11 SEL-FLR Diagram

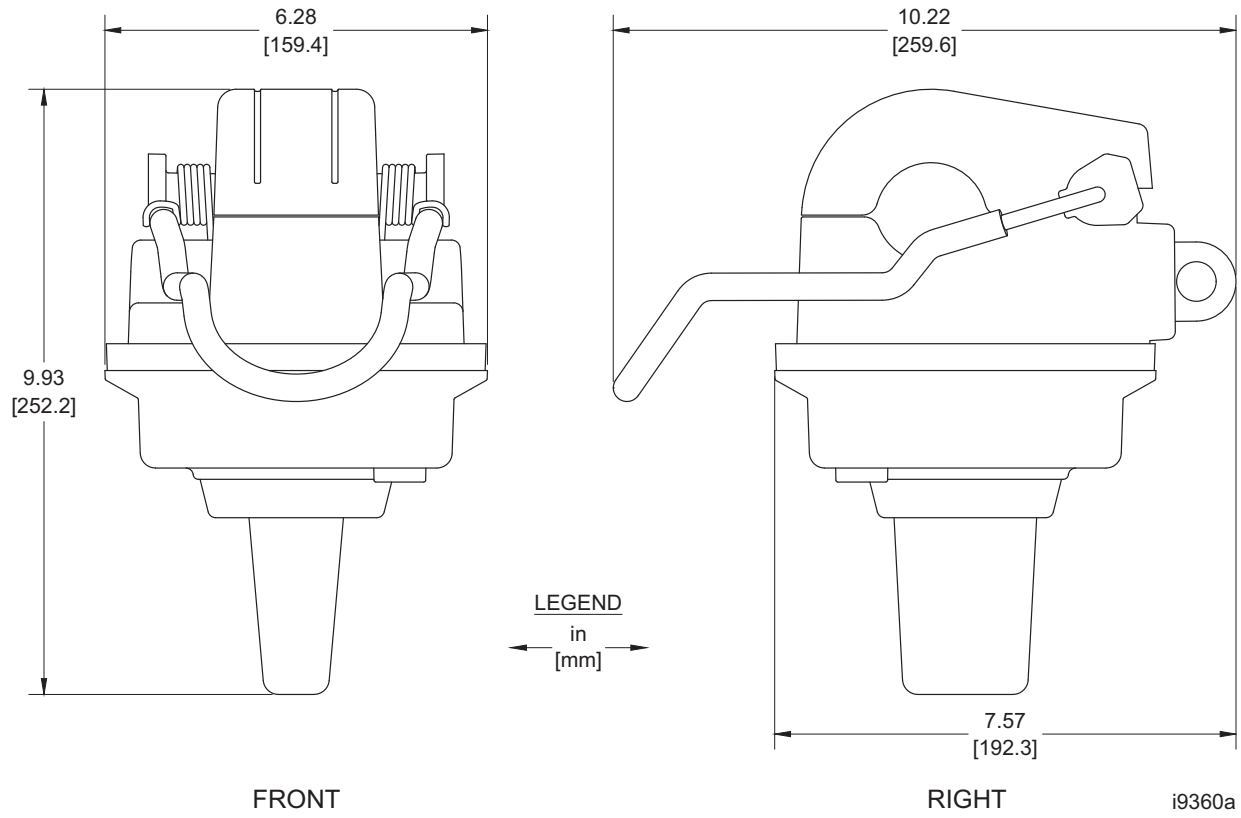


Figure 12 SEL-FLT Dimensions

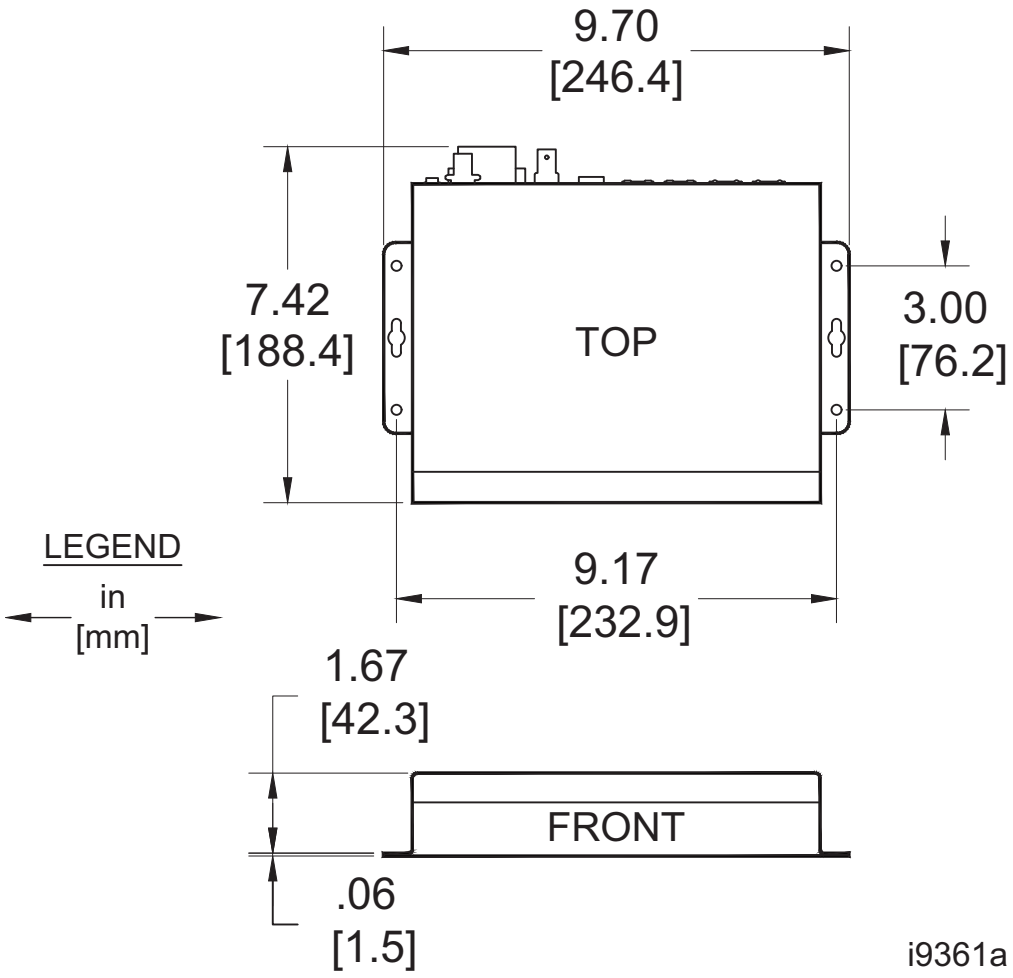


Figure 13 SEL-FLR Dimensions

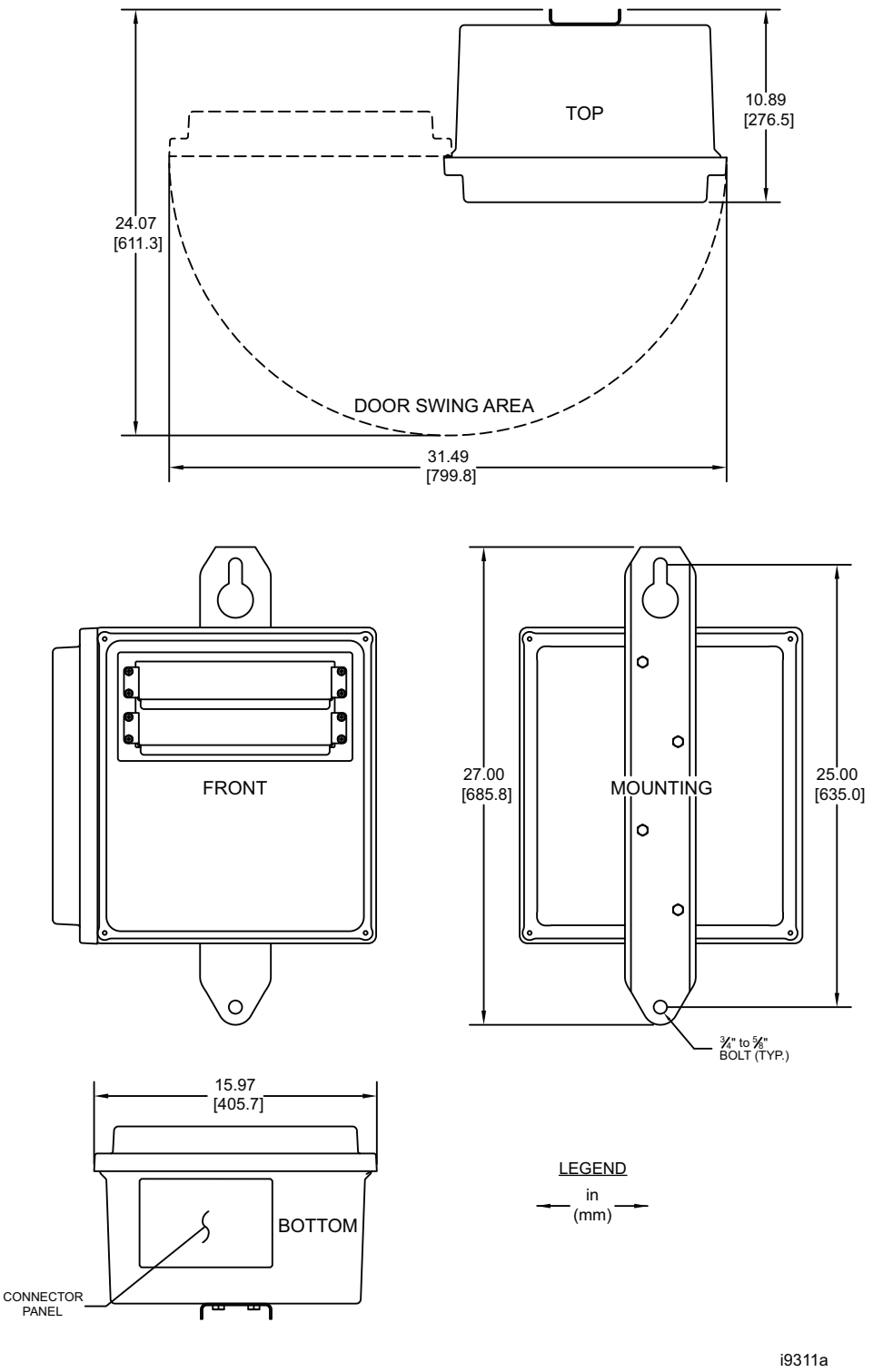


Figure 14 SEL-FLR Enclosure Dimensions

SEL-FLT Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

General

Operating Temperature Range:	–40° to +85°C (–40° to +185°F)
Storage Temperature Range:	–40° to +85°C (–40° to +185°F)
Operating Environment	
Pollution Degree:	2
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude:	2000 m (6562 ft)
Ingress Protection:	IP-66
Clamp Range:	6.4–38.1 mm (0.25–1.50 in)
Dimensions:	159 mm x 192 mm x 252 mm (6.3 in x 7.6 in x 9.9 in)
Weight:	1.6 kg (3.6 lb)

System

Frequency Range:	50–60 Hz
Current Range:	3–600 A
Maximum Voltage:	69 kV (line-to-line)

Fault Detection

Trip Threshold Range:	25–1600 A
Fault Detection Accuracy:	±(2 A + 4%)
Maximum Fault Current:	25 kA for 10 cycles
Trip Response Time:	24 ms at 60 Hz (default)

Load Measurement

Current Range:	3–600 A
Measurement Accuracy:	±(0.25 A + 1%) from 5–600 A (typical) ±(2.5 A + 2%) from 5–600 A (maximum) ±3 A from 3–5 A (maximum)

Power

Minimum Continuous Operating Current:	3.5 A (AutoRange) 4 A (Fixed Trip)
Battery Capacity:	19 Ah
Battery Shelf-Life:	20 years

Flash Hours

Harvested Power Flash Time:	8 hours (per outage)
Battery Flash Time:	1800 hours

Radio

Frequency Band	
FLT-1000 (U.S.A., Canada, Mexico, Panama):	902–928 MHz ISM, 25 non-overlapping channels
FLT-1003 (Peru):	916–928 MHz, 11 non-overlapping channels
FLT-1006 (Brazil):	902–907 MHz and 915–928 MHz, 16 non-overlapping channels
FLT-1007 (Costa Rica):	921–928 MHz, 6 non-overlapping channels
FLT-1008 (Argentina):	902–928 MHz ISM, 25 non-overlapping channels
FLT-1009 (Ecuador):	915–928 MHz, 12 non-overlapping channels
Occupied Bandwidth:	850 kHz
Modulation:	Digital modulation 2-FSK
Operating Mode:	Point-to-multipoint
Power Output:	0.4 W (26 dBm)
Sensitivity:	–102 dBm ± 2 dB at 5% PER
Fixed Antenna Gain:	–4 dBi
Polarization:	Vertical
Link Data Rate:	62.5 kbps
Typical Effective Line-of-Sight Range	
Receiver Antenna Mounted on a Distribution Pole:	Approximately 1 mile[a]
Receiver Antenna Mounted on a 75 ft Communications Tower:	Approximately 3 miles[a]
Radio Maximum Range With No Obstructions:	Up to 10 miles

[a] Requires flat terrain with clear line of sight and no RF interference—see *SEL-FLT/SEL-FLR System Deployment Guide* for details.

Error Detection:	16-bit CRC
Encryption:	AES 128-bit

Type Tests

Environmental Tests

Temperature Cycling:	IEEE 495-2007 Test 4.4.1; 2 hours at –40°, +20°, and +85°C, 5 cycles
Trip Current:	IEEE 495-2007 Test 4.4.9; –30°, +20°, and +70°C
Reset:	IEEE 495-2007 Test 4.4.10; –30°, +20°, and +70°C
Short-Time Current:	IEEE 495-2007 Test 4.4.7; 25 kA for 10 cycles
Adjacent Phase Immunity:	IEEE 495-2007 Test 4.4.8; 25 kA at 18 inches
Time Current:	IEEE 495-2007 Test 4.4.11; <1 ms
Vibration Resistance:	IEC 60255-21-1:1988 Class 2 Endurance Class 2 Response IEEE 495-2007 Test 4.4.6
Shock and Bump Resistance:	IEC 60255-21-2:1988 Class 1 Shock Withstand Class 1 Bump Class 2 Shock Response IEEE 495-2007 Test 4.4.6
Seismic Resistance:	IEC 60255-21-3:1993 Class 2 (Quake Response) IEEE 495-2007 Test 4.4.6
Salt Spray:	IEEE 495-2007 Test 4.4.4 MIL-STD-810G: Method 509.5
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours

Dry Heat:	IEC 60068-2-2:2007 +85°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25°C to 55°C, 6 cycles, 93% relative humidity
Damp Heat, Steady State:	IEC 60068-2-78: 2012 +40°C, 93% relative humidity
Outdoor Weathering:	IEEE 495-2007 Test 4.4.3 ASTM G154-16
Ingress Protection:	IP-66
Rain:	MIL-STD-810G: Method 506.5 Procedure 1 Rain and Blowing Rain
Ice Build-Up:	MIL-STD-810G: Method 521.4 Procedure 1

Electromagnetic Compatibility Immunity

Electrostatic Discharge Immunity:	IEC 60255-26:2013 Severity Level 4 8 kV contact discharge 15 kV air discharge IEC 61000-4-2:2009 Severity Level 4 8 kV contact discharge 15 kV air discharge IEEE C37.90.3-2001 Severity Level 3 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	EN 60255-26:2013 10 V/m EN 61000-4-3:2006+A1:2008+A2:2010 10 V/m IEEE C37.90.2-2004 35 V/m
Power Frequency Magnetic Field Immunity:	IEC 60255-26:2013 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-8:2009 1000 A/m for 3 seconds 100 A/m for 1 minute
Pulse Magnetic Field Immunity:	IEC 61000-4-9:2016 1000 A/m
Damped Oscillatory Magnetic Field Immunity:	IEC 61000-4-10:2016 100 A/m

Electromagnetic Compatibility Emissions

Radiated RF Emissions:	IEC 60255-26:2013 FCC Part 15.247; ICES-001; RSS-210

Certifications

Table 3 SEL-FLT Certifications by Country

Country	SEL-FLT Model Number	Authority	Reference
U.S.A.	FLT-1000	FCC	R34-900FLTR
Canada	FLT-1000	IC	4468A-900FLTR
Mexico	FLT-1000	IFETEL	RCPSCSE20-0664
Panama	FLT-1000	ASEP	6857
Peru	FLT-1003	MTC	TRSS43952
Brazil	FLT-1006	Anatel	05384-20-12987
Costa Rica	FLT-1007	SUTEL	
Argentina	FLT-1008	ENACOM	C-27030

SEL-FLR Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

General

SEL-FLR

Temperature Range:	–40° to +85°C (–40° to +185°F) per IEC 60068-2-1 and 60068-2-2

SEL-FLR Enclosure

With SEL-3061:	–25° to +50°C (–13° to +122°F)
Max. Loading (SEL-3061 and <10 W of Accessories):	–25° to +40°C (–13° to +104°F)
Without Direct Sunlight:	Increase max. temperatures by 15°C (27°F)

Operating Environment

Pollution Degree:	2
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude:	2000 m (6562 ft)
SEL- FLR Dimensions:	216 mm x 165.1 mm x 44.5 mm (8.5 in x 6.5 in x 1.75 in)
SEL-FLR Enclosure Dimensions:	685.8 mm x 405.7 mm x 276.5 mm (27.0 in x 15.97 in x 10.89 in)
SEL-FLR Weight:	1 kg (2.2 lb)
SEL-FLR Enclosure Weight (Without Batteries):	13.3 kg (29.5 lb)
RF Connector:	TNC
Supported Web Browser:	Google Chrome

Communications (Ethernet)

Ports:	2 rear, 1 front
Data Rate:	10/100 Mbps
Rear Connectors:	RJ45
Standard:	IEEE 802.3

Power Supply

SEL-FLR

Input Voltage Range:	9–30 Vdc
Power Consumption:	<10 W

SEL-FLR Enclosure

Input Voltage:	120 Vac nominal
AC Power Consumption:	<39 W
Usable DC Load:	<25 W

Radio

Frequency Band

FLR-1000 (U.S.A., Canada, Mexico, Panama):	902–928 MHz ISM, 25 non-overlapping channels
FLR-1003 (Peru):	916–928 MHz, 11 non-overlapping channels
FLR-1006 (Brazil):	902–907 MHz and 915–928 MHz, 16 non-overlapping channels
FLR-1007 (Costa Rica):	921–928 MHz, 6 non-overlapping channels
FLR-1008 (Argentina):	902–928 MHz ISM, 25 non-overlapping channels
FLR-1009 (Ecuador):	915–928 MHz, 12 non-overlapping channels
Occupied Bandwidth:	850 kHz
Modulation:	Digital modulation 2-FSK
Operating Mode:	Point-to-multipoint
Power Output:	0.4 W (26 dBm)
Sensitivity:	–102 dBm ± 2 dB at 5% PER
Polarization:	Vertical
Link Data Rate:	62.5 kbps

Typical Effective Line-of-Sight Range

Receiver Antenna Mounted on a Distribution Pole:	Approximately 1 mile[a]
Receiver Antenna Mounted on a 75 ft Communications Tower:	Approximately 3 miles[a]
Radio Maximum Range With No Obstructions:	Up to 10 miles

[a] Requires flat terrain with clear line of sight and no RF interference—see *SEL-FLT/SEL-FLR System Deployment Guide* for details.

Error Detection:	16-bit CRC
Encryption:	AES 128-bit

Alarm Output

Rated Operational Voltage:	24–250 Vdc
Contact Protection:	300 Vdc, MOV-protected
Continuous Carry:	2 A
Pickup Time:	≤8 ms typical
Dropout Time:	≤8 ms typical

Type Tests

Communications Equipment Tests

Communications for Substation Equipment:	IEEE 1613-2009 Class 1
Power Frequency Disturbances:	IEC 61850-3:2002

Environmental Tests

Vibration Resistance:	IEC 60255-21-1:1988 Class 2 Endurance Class 2 Response
Shock and Bump Resistance:	IEC 60255-21-2:1988 Class 1 Shock Withstand Class 1 Bump Class 2 Shock Response
Seismic Resistance:	IEC 60255-21-3:1993 Class 2 (Quake Response)
Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25° to 55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 +85°C, 16 hours

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 60255-27:2013
IEEE C37.90-2005
Dielectric (HiPot) Severity Level:
Power Supply: 3100 Vdc
Alarm Contact: 2500 Vac
Impulse Severity Level:
5 J; ±5 kV, 1.2/50 ms
2.4 kV on Ethernet Port
IEEE 802.3-2012
Ethernet ports comply with Environment A requirements

Electromagnetic Compatibility Immunity Tests

Electrostatic Discharge Immunity:
IEC 60255-26:2013
Severity Level 4
8 kV contact discharge
15 kV air discharge
IEC 61000-4-2:2009
Severity Level 4
8 kV contact discharge
15 kV air discharge
IEEE C37.90.3-2001
Severity Level 3
8 kV contact discharge
15 kV air discharge

Conducted RF Immunity:
IEC 60255-26-6:2013
10 Vrms
IEC 61000-4-6:2008
10 Vrms

Radiated RF Immunity:
EN 60255-26:2013
10 V/m
EN 61000-4-3:2006+A1:2008+A2:2010
10 V/m
IEEE C37.90.2-2004
35 V/m

Electrical Fast Transient Burst Immunity:
IEC 60255-26:2013
4 kV @ 5.0 kHz for power port
2 kV @ 5.0 kHz for communications ports
IEC 61000-4-4:2012
4 kV @ 5.0 kHz for power port
2 kV @ 5.0 kHz for communications ports

Power Frequency Magnetic Field Immunity:
IEC 60255-26:2013
1000 A/m for 3 seconds
100 A/m for 1 minute
IEC 61000-4-8:2009
1000 A/m for 3 seconds
100 A/m for 1 minute

Power Supply Immunity:
IEC 60255-11:2008
IEC 61000-4-11:2004
IEC 61000-4-17:1999+A1:2001 +A2:2008
IEC 61000-4-9:2000

Surge Withstand Capability Immunity:
IEC 60255-26:2013
2.5 kV common mode
1 kV differential mode
IEC 61000-4-18:2006+A1:2010
2.5 kV common mode
1 kV differential mode
IEEE C37.90.1-2012
2.5 kV oscillatory
4 kV fast transient

Electromagnetic Compatibility Emissions

SEL-FLR Radiated RF Emissions:
IEC 60255-26:2013
FCC Part 15.247; ICES-001; RSS-210

SEL-FLR Enclosure Radiated RF Emissions:
FCC Part 15.107, 15.109; ICES-001, Issue 5

Certifications

Table 4 SEL-FLR Certifications by Country

Country	SEL-FLR Model Number	Authority	Reference
U.S.A.	FLR-1000	FCC	R34-900FLTR
Canada	FLR-1000	IC	4468A-900FLTR
Mexico	FLR-1000	IFETEL	RCPSCSE20-0664
Panama	FLR-1000	ASEP	6859
Peru	FLR-1003	MTC	TRSS48383
Brazil	FLR-1006	Anatel	05385-20-12987
Costa Rica	FLR-1007	SUTEL	
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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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PDSFLT-FLR-01