



# SEL-2812 Fiber-Optic Transceivers With IRIG-B

## Fiber-Optic Transceivers for Serial Data and IRIG-B Time Signals



## Major Features and Benefits

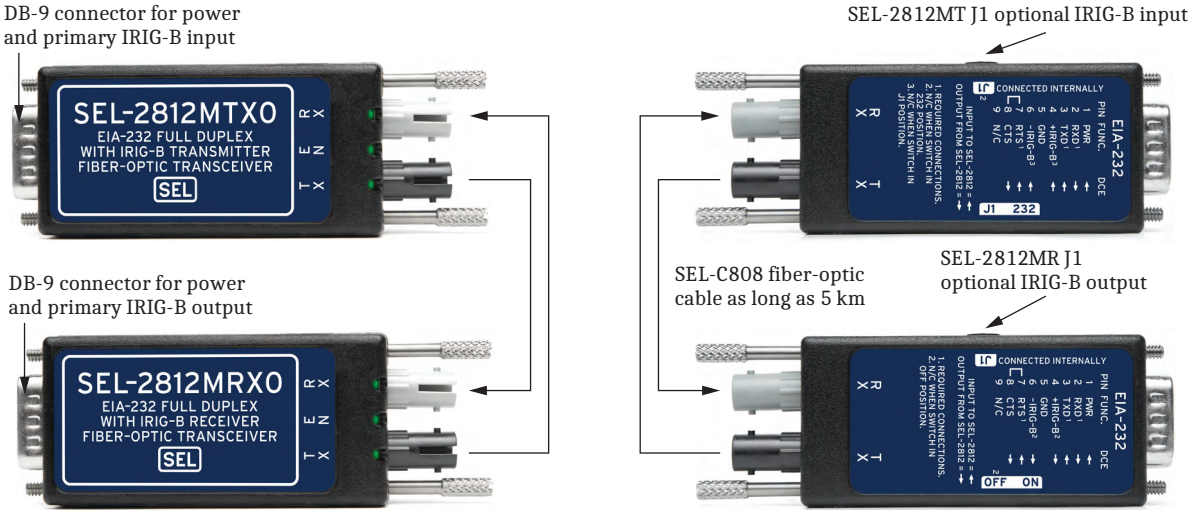
The SEL-2812 Fiber-Optic Transceivers provide isolation from dangerous ground potential rise, prevent induced electrical noise, and eliminate signal ground loops. The elimination of electrical interfaces made possible by this product increases safety, robustness, and reliability. These transceivers are suitable for use in the harsh environment of electrical substations.

- ▶ **Easy Application.** SEL fiber-optic products are simple to install. Plug an SEL-2812 Transceiver into a standard 9-pin serial connector (DB-9). No special mounting is required.
- ▶ **Port Powered.** The SEL-2812 Transceivers are powered from the host device via the connector. They do not require a separate power supply or wiring.
- ▶ **Improved Safety.** SEL fiber-optic products provide isolation from induced voltages resulting from ground potential rise and electromagnetic induction commonly caused by control cables.
- ▶ **Increased Data Transfer Reliability.** SEL-2812 Transceivers are far less susceptible than copper links to EMI/RFI and can therefore be applied in harsh electrical and physical environments.

# Product Overview

Configuring an SEL-2812 link requires a duplex fiber-optic connection between the SEL-2812T and the SEL-2812R. The transmit port, TX, of the SEL-2812T sends serial communication and IRIG-B time synchroni-

zation signals to the receive port, RX, of the SEL-2812R. The transmit port, TX, of the SEL-2812R sends serial communications to the receive port, RX, of the SEL-2812T.



**IMPORTANT:** The SEL-2812 requires the second link for proper operation and will not operate without this link.

Figure 1 SEL-2812 Product Overview

## IRIG-B Selection Switch

An IRIG-B output selection switch is available on the SEL-2812R. When the switch is in the 232 position, separate output circuits direct the IRIG-B output signal to Pins 4 and 6 of the DB-9 connector as well as the J1 output. When the switch is in the J1 position, Pins 4 and 6 of the DB-9 connector are unterminated and the IRIG-B signal is available on J1 located on the side of the transceiver. Similarly, the SEL-2812T also includes an IRIG-B input selection switch. When the switch is in the 232 position, the transceiver draws the IRIG-B input signal from Pins 4 and 6 of the DB-9 connector. When the switch is in the J1 position, the transceiver draws the IRIG-B signal from J1, located on the side of the transceiver.

## Power, Transmit, and Receive LED Indicators

The EN LED illuminates green when the minimum required power is applied to Pin 1 and Pin 3 or Pin 7 of the DB-9 serial port.

The TX and RX LEDs illuminate green whenever the transmit or receive signals of the SEL-2812 fiber-optic transceiver are high to help verify the function of the transceiver product.

## Application Examples

### SEL Information Processors to SEL IED Devices

Use an SEL-2812T for each IED port on an SEL information processor. Use a duplex fiber-optic cable to connect each SEL-2812T to an SEL-2812R mounted on each relay or processor. The information processor com-

municates with interleaved ASCII and binary messages over the full-duplex serial link, using the same fibers that are also synchronizing the device clocks with simplex IRIG-B signals.

If required, connect an SEL-C654 adapter cable between the IRIG-B output from the SEL-2812R to the IRIG-B BNC input of the remote device.

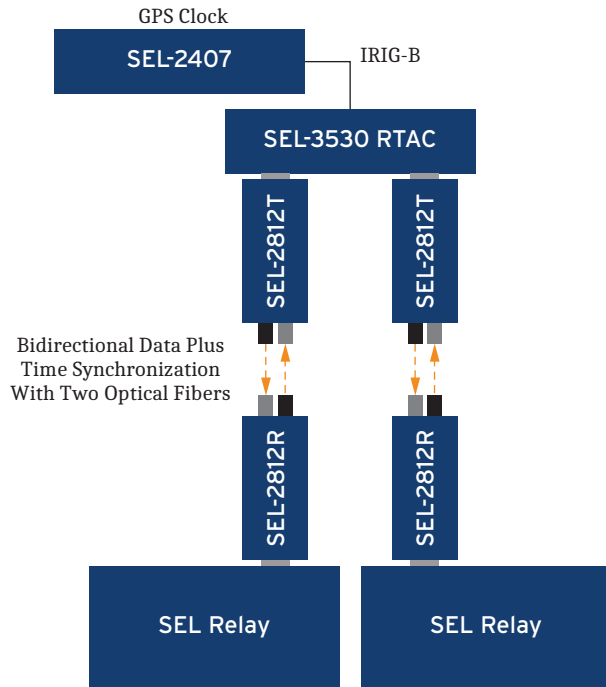


Figure 2 Information Processor to IED Device Example



Figure 3 MIRRORED BITS Communications Example

## SEL Relays and MIRRORED BITS Protection

Connect SEL-2812T Fiber-Optic Transceivers to the serial ports of a relay. Use SEL MIRRORED BITS<sup>®</sup> communications for high-speed exchange of protection information. Coordinate protection between generating plants and associated switchyards or among multiple control houses in the same station. Transfer to backup protection based on loss of potential or failures detected by diagnostic tests. Keep the dc circuits segregated between cabinets. Provide directional element-based bus protection.

## Application Information

### Determining Maximum Cable Length

The optical power budget includes transmit and receive connector coupling loss, so you can determine the maximum cable length by dividing the total optical power budget (12 dB) by the typical fiber loss/km specification (as shown in *Table 1*). To calculate the maximum cable length for your application, first ask your fiber cable supplier for fiber loss/km and connector/splice loss specifications (over the expected temperature range) based on an 850 nm wavelength optical source. Calculate the available optical power budget by subtracting the total connector/splice attenuation from the power budget specification shown in *Table 1*. Divide the available optical power budget by the fiber loss/km specification to determine the maximum cable length.

Table 1 Typical Cable Length

Fiber Diameter (μm)	Power Budget (-40° to +85°C) (dB)	Typical Fiber Loss at 25°C (dB/km)	Maximum Cable Length (km)
50	12	2.7	4.44
62.5	12	3.2	3.75
200	12	6.5	1.85

### Intrastation Example

Intrastation applications are typically very simple and consist of two fiber-optic devices connected by a patch cord. The primary benefit of an intrastation application is the replacement of metallic cables between two EIA-232 devices. Fiber-optic transceivers also allow application of EIA-232 connections longer than the specified 50-foot limitation.

To calculate the viability of an intrastation system that is 0.5 km (1640 ft) long and configured as shown in *Figure 4*, perform the following steps:

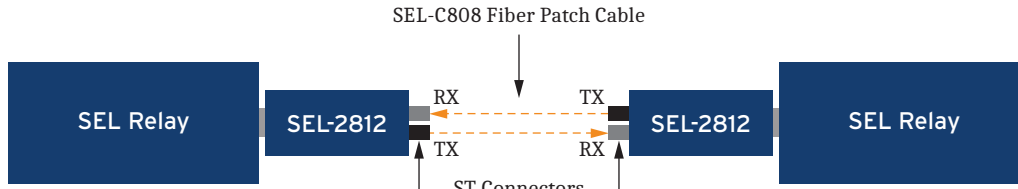
Step 1. Calculate the fiber attenuation:

$$\begin{aligned} \text{Cable attenuation for 850 nm} &= 3.0 \text{ dB/km} \\ 0.5 \text{ km} \cdot 3.2 \text{ dB} &= 1.6 \text{ dB} \end{aligned}$$

Step 2. Subtract the total losses from the system gain:

$$\begin{aligned} 12 \text{ dB} - 1.6 \text{ dB} &= 10.4 \text{ dB} \\ (\text{system gain} - \text{fiber loss} &= \text{system margin}) \end{aligned}$$

If the fiber loss adds as much as 12 dB or greater, the system is not viable.

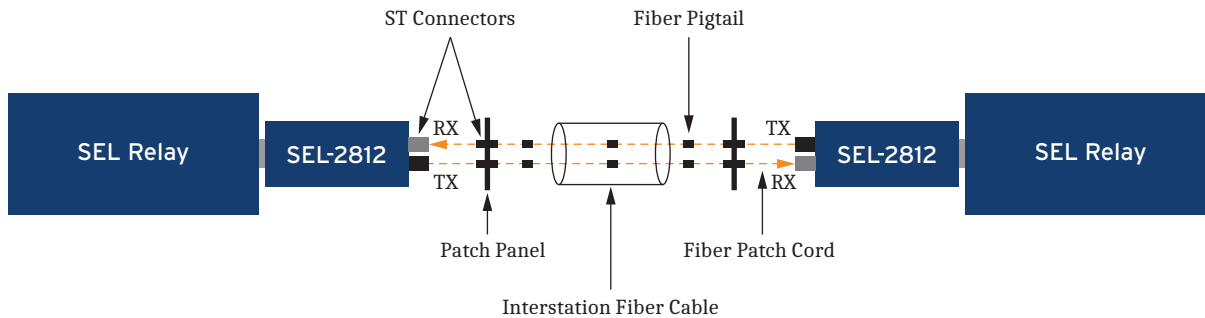


**Figure 4 Intrastation Communication Using SEL-2812 Transceivers**

## Interstation Example

Interstation configurations are more complex than those for intrastation applications. The extra equipment and cables are associated with the termination of the interstation fiber cable. These cables typically contain as many as 24 separate fibers. These separate fibers are not suitable for use as patch cords or for direct termination to the fiber transceiver. A cable termination shelf is used to splice the fibers from the cable to a fiber pigtail. A fiber pigtail is a simplex fiber with a bare fiber on one end and

a connector on the other end (the example shown in *Figure 5* uses ST connectors). The fiber pigtail connects to one side of a bulkhead connector that attaches to a patch panel or distribution panel. The SEL transceiver is terminated to the fiber cable at the patch panel through use of a fiber patch cord of suitable length. The additional components in an interstation configuration beyond what exists in an intrastation application complicate calculation of system loss. All of these extra components have additional associated losses.



**Figure 5 Interstation Communication Using SEL-2812 Transceivers**

To calculate the viability of an interstation system that is 4 km (2.5 mi) long and configured as shown in *Figure 5*, perform the following steps:

Step 1. Calculate the fiber attenuation (refer to the typical values shown in *Table 2*):

$$\begin{aligned} \text{Cable attenuation for 850 nm} &= 2.75 \text{ dB/km} \\ 3 \text{ km} \cdot 2.75 \text{ dB/km} &= 8.25 \text{ dB} \end{aligned}$$

**Table 2 Typical Attenuation Values**

Type	Loss for Multimode Fiber (50 μm)	Loss for Multimode Fiber (62.5 μm)	Loss for Multimode Fiber (200 μm)
Fusion Splice	0.2 dB	0.2 dB	0.2 dB
Mechanical Splice	0.4 dB	0.4 dB	0.4 dB
Connector Loss	0.75 dB	0.75 dB	0.75 dB
Per km @ 850 nm	2.5–3.0 dB	3.0–4.0 dB	7.4 dB

Step 2. Add the splice losses.

$$\begin{aligned} \text{Splice attenuation (fusion)} \\ 3 \text{ splices} \cdot 0.2 \text{ dB} &= 0.6 \text{ dB} \end{aligned}$$

Step 3. Add the connector losses (connectors on the transceiver are included in the system gain).

$$\begin{aligned} \text{Connector loss} &= 0.75 \text{ dB per connector} \\ 2 \text{ connectors} \cdot 0.75 \text{ dB} &= 1.5 \text{ dB} \end{aligned}$$

Step 4. Sum the losses.

$$\begin{aligned} 8.25 \text{ dB} + 0.6 \text{ dB} + 1.75 \text{ dB} &= 10.6 \text{ dB} \\ (\text{fiber} + \text{splices} + \text{connectors}) &= \text{system loss} \end{aligned}$$

Step 5. Subtract the total losses from the system gain.

$$\begin{aligned} 12 \text{ dB} - 10.6 \text{ dB} &= 1.4 \text{ dB} \\ (\text{system gain} - \text{system loss}) &= \text{system margin} \end{aligned}$$

The system margin is positive, so the system is viable.

## Conformal Coating Option

Order the SEL-2812 with optional conformal coating for additional protection against environmental and chemical contaminants.

## IRIG-B Adapter Cables

The SEL-2812 includes a miniature phone jack (mono jack), J1, to connect an IRIG-B signal to IEDs that do not accept the IRIG-B signal on Pins 4 and 6 of the DB-9 connector. Both the SEL-2812 IRIG-B transmitter and receiver versions include this jack. Use SEL adapter cables SEL-C654, SEL-C655, and SEL-C656 as follows when applying the SEL-2812 to IEDs that do not use Pins 4 and 6 for the IRIG-B signals.

SEL-C654: Mono plug to BNC

SEL-C655: Mono plug to DB-9 (Pins 2 and 3)

SEL-C656: Mono plug to ring terminal

## Depth-Restricted Adapter Cables

When mounting depth is an issue, such as in switchgear applications, use an SEL-C780, SEL-C641, or SEL-C641R adapter cable. The SEL-C780 is a 6-inch ribbon cable that allows for mounting of the fiber transceiver at a 90-degree angle to the mating DB-9 host connector. The SEL-C641 (shielded) and SEL-C641R

(double-shielded with metal connector housings) cables are configurable in length and allow for mounting of the SEL-2812 Transceiver as far as 1.8 m (6.0 ft) away from the DB-9 host connector.

SEL-C780: 15.24 cm (6.00 in), low-profile adapter cable, DB-9 male to DB-9 female

SEL-C641: 0.3 to 1.8 m (1.0 to 6.0 ft) shielded adapter cable, DB-9 male to DB-9 female

SEL-C641R: 0.3 to 1.8 m (1.0 to 6.0 ft) double-shielded adapter cable, DB-9 male to DB-9 female

## Transceiver Mounting Options

Use an SEL Transceiver Mounting Kit and adapter cable when connecting the SEL-2812 to IEDs with an RJ45 male serial connector or when the mounting depth is an issue (e.g., in switchgear applications). These kits provide a simple and secure way to remotely mount the transceiver away from the host connector.

915900573: Mounting kit for SEL transceiver; includes mount only

915900574: Mounting kit for SEL transceiver; includes mount and SEL-C478A cable (6 ft, DB-9 female to RJ45 male)

915900575: Mounting kit for SEL transceiver; includes mount and SEL-C641 cable (6 ft, DB-9 female to DB-9 male)



Figure 6 Transceiver Mount

# Safety Information

## ⚠ CAUTION

To ensure proper safety and operation, the equipment ratings and installation instructions must be checked before commissioning or maintenance of the equipment. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this data sheet. If misused, any safety protection provided by the equipment may be impaired.

## Fiber-Optic Port

The SEL-2812 uses an 850 nm vertical cavity surface emitting laser (VCSEL) transmitter. When working with this device, observe the following safety precautions:

- Do not look into the fiber (laser) ports/connectors.
- Do not look into the end of an optical cable connected to an optical output.
- Do not perform any procedures or adjustments that this data sheet does not describe.
- During installation, maintenance, or testing of the optical ports, use only test equipment qualified for Class 1 laser products.
- Incorporated components, such as transceivers and laser emitters, are not user serviceable. Return units to SEL for repair or replacement.

# Power Requirements

## ⚠ CAUTION

SEL fiber-optic transceivers have combinations of input/output pins jumpered or shorted together. Ensure that these connections will not harm the device to which you want to attach the transceiver.

The SEL-2812 has the following power specifications:

- Operating Voltage:  $\pm 5$  to  $\pm 10$  Vdc
- Typical Current Draw:  $<15$  mA

The transceiver draws power from the EIA-232 data as shown in *Table 3*.

**Table 3 Data and Control Line Power Inputs**

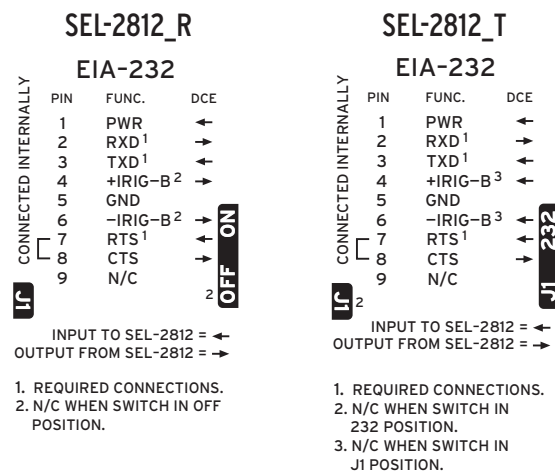
Pin	Signal
3	DCE
7	DCE

The transceiver additionally draws power per *Table 4*.

**Table 4 Other Power Input**

Pin	Voltage (Vdc)
1	+5 to +10

*Figure 7* shows the transceiver rear labels, which indicate the internally jumpered pins, pinouts, and signal names.



**Figure 7 SEL-2812\_R and SEL-2812\_T Signal Flow**

# Troubleshooting

Problem	Possible Cause	Solution
The transceiver LEDs are dark.	Input power is not present	Verify that connected IED device is powered on.
The transceiver does not communicate data.	Wiring error	Verify fiber connections. Verify connecting port is DTE-compliant.
	Reflection	If fiber length is less than 400 meters, use Attenuator Kit 91560.



# Dimensions

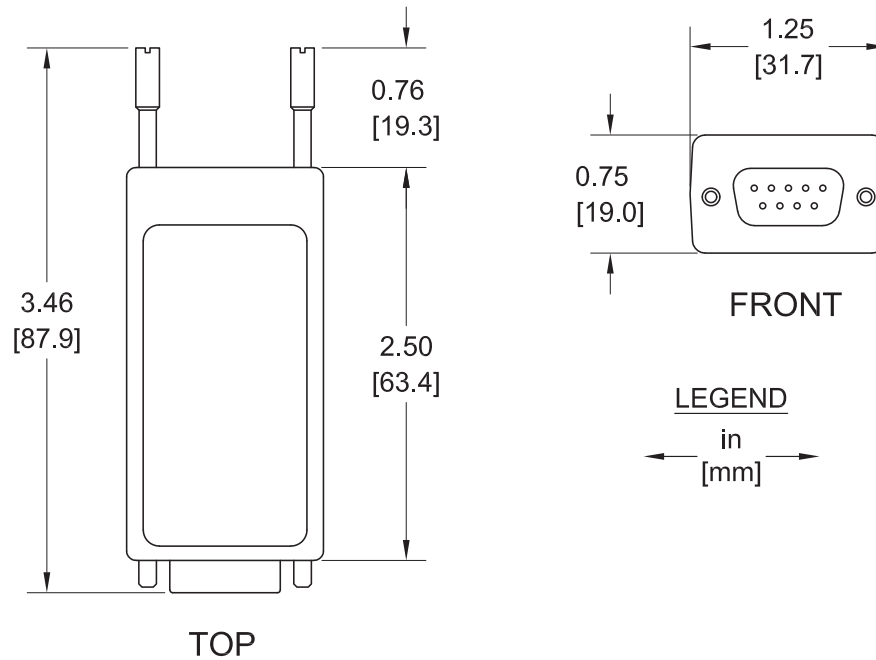


Figure 8 SEL-2812 Dimensions

# Specifications

## Compliance

Designed and manufactured under an ISO 9001 certified quality management system

CE Mark

UKCA Mark

CFR 47 Part 15 Class A

**Note:** This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operating in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may be likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Any changes or modifications not expressly approved by the manufacturer can void the user's authority to operate the equipment.

## General

### Data Rate

As high as 115.2 kbps, full duplex, no jumpers or settings

### Link Data Delay

Serial Data: 6  $\mu$ s + 5  $\mu$ s/km of fiber

IRIG-B Time Code: 15  $\mu$ s + 5  $\mu$ s/km of fiber

**Note:** Link includes two transceivers and fibers.

### Fiber-Optic Port

Optical Interface

Connector: ST

Fiber: Multimode fiber (50 to 200  $\mu$ m)

Optical Source: 850 nm VCSEL transmitter

Maximum Output Level:	-9 dBm
Typical Transmit Level:	-13 dBm
Minimum Transmit Level:	-15.5 dBm
Minimum RX Sensitivity:	-27.5 dBm
Fiber-Optic Link Budget:	12 dB

## IRIG-B Connections

Switch selects IRIG-B connections via DB-9 connector or IRIG-B jack

### Projection From DB-9 Connector

127 mm (5 in) typical, including fiber-optic connector and minimum cable bend radius

## Power Requirements

The SEL-2812 can be powered from Pin 3 and Pin 1 or Pin 7 of its DB-9 connector.

Pin 1 Power: +5 to +10 Vdc

Pin 3, 7 Power: Parasitic power

Maximum Current Draw: 15 mA

**Note:** The SEL-2812 can accept input voltages on Pin 1 as high as 15 Vdc if the power source is current-limited to 100 mA or lower.

## Environmental

Operating Environment

Indoor Use Only

Insulation Class 3

Pollution Degree 2

Overvoltage Category 2

Operating Temperature: -40° to +85°C (-40° to +185°F)

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

Relative Humidity:	0%–95%, noncondensing
Altitude:	2000 m (6562 ft)

## Type Tests

### Electromagnetic Compatibility General

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

Radiated and Conducted Emissions:	IEC 60255-26:2013, Clause 7.1 EN 60255-26:2013, Clause 7.1 CISPR 22:2008 EN 55022:2010 CISPR 11:2009 + A1:2010 EN 55011:2009 + A1:2010 Canada ICES-001 (A) / NMB-001 (A)
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### Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-26:2013, Clause 7.2.8 EN 60255-26:2013, Clause 7.2.8 IEC 61000-4-6:2008 Severity Level: 10 V unmodulated, open circuit equivalent
Radiated RF Immunity:	IEC 60255-26:2013, Clause 7.2.4 EN 60255-26:2013, Clause 7.2.4 IEC 61000-4-3:2006 + A1:2007 + A2:2010 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 20 V/m

### Power Frequency

Magnetic Field Immunity:	EN 60255-26:2013, Clause 7.2.10 IEC 61000-4-8:2009 Severity Level 5: 100 A/m >60 seconds; 1000 A/m 1 to 3 seconds; 50/60 Hz
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### Electrostatic Discharge

Immunity:	IEC 60255-26:2013, Clause 7.2.3 EN 60255-26:2013, Clause 7.2.3 IEC 61000-4-2:2008 Discharge Severity Level: ±2, 4, 6, 8 kV contact; ±2, 4, 8, 15 kV air IEEE C37.90.3-2001 Discharge Severity Level: ±2, 4, 8 kV contact; ±4, 8, 15 kV air
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### Environmental

Cold:	IEC 60068-2-1:2007 Severity: 16 hours at –40°C
Dry Heat:	IEC 60068-2-2:2007 Severity Level: Test Bd; 16 hours at +85°C
Damp Heat, Steady State:	IEC 60068-2-78:2012 Severity Level: Test Cab; 10 days, 40°C, 93% RH
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: Test Db, Variant 2; 12 hr at 25°C + 12 hr at 55°C, 95% RH, 6 cycles

Vibration:	IEC 60255-21-1:1988 Severity Level: Class 1 Endurance; Class 2 Response
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Shock and Bump:	IEC 60255-21-2:1988 Severity Level: Class 1 Shock Withstand, Bump; Class 2 Shock Response
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Seismic:	IEC 60255-21-3:1993 Severity Level: Class 2 Quake Response
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### Safety

Measuring Relays and Protection Equipment:	IEC 60255-27:2014
Laser Safety:	21 CFR 1040.10

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