



Fiber-Optic Products and Applications

SEL Fiber-Optic Transceivers Provide Simple, Reliable, and Economical Communications Solutions



Major Features and Benefits

SEL fiber-optic devices provide isolation from dangerous ground potential rise, prevent induced electrical noise, and eliminate signal ground loops. The elimination of electrical interfaces made possible by these products 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 EIA-232 transceiver into a standard 9-pin serial connector (DB-9). No special mounting is required. Plug the SEL-9220 EIA-485 adapter directly onto an SEL-300 series EIA-485 port. Mount an EIA-485 transceiver on a DIN rail, wall, or other surface.
- ▶ **Port Powered:** Each EIA-232 transceiver and the SEL-9220 receive power from the host device via the connector; they do not require a separate power supply or power wiring.
- ▶ **Improved Safety:** SEL fiber-optic products provide isolation from induced voltages resulting from ground potential rise (GPR) and electromagnetic induction commonly caused by control cables.
- ▶ **Complete Product Range:** EIA-232 transceiver models are available for applications ranging from 1 m (3.28 ft) to 110 km (68.35 mi), for use over single-mode or multimode fiber. EIA-485 transceivers are available for multimode fiber-optic links as long as 4 km (2.49 mi).

Fiber-Optic Transceivers and Applications

SEL offers several models of fiber-optic transceivers. Use *Table 1* to match an SEL transceiver to the desired application. Also use the data in *Table 1* for compatible devices in *Table 2*. For example, for SEL-2800 compatible devices, use the SEL-2800 modulation techniques.

Table 1 SEL Fiber-Optic Transceivers and Applications

	SEL-2800, SEL-2820	SEL-2810	SEL-2812 ^a , SEL-9220	SEL-2814 ^a , SEL-2824	SEL-2815	SEL-2829 ^a	SEL-2830 ^a	SEL-2831 ^a
Wavelength	650 nm	650 nm	850 nm	850 nm	850 nm	1300 nm	1300 nm	1550 nm
Optical Connector	V-pin	V-pin	ST	ST	ST	ST	ST	ST
Fiber Type	Multimode	Multimode	Multimode	Multimode	Multimode	Single mode	Single mode	Single mode
Link Budget	9 dB	9 dB	12 dB	12 dB	41 dB	20 dB	40 dB	40 dB
Typical TX Power	-24 dBm	-24 dBm	-13 dBm	-13 dBm	-10 dBm	-27 dBm	-10 dBm	-10 dBm
Max. TX Power	-10 dBm	-10 dBm	-9 dBm	-9 dBm	-3.6 dBm	-20 dBm	-3.6 dBm	-3.6 dBm
Min. TX Power	-30 dBm	-30 dBm	-15.5 dBm	-15.5 dBm	-17.6 dBm	-36 dBm	-17.6 dBm	-17.6 dBm
Min. RX Sensitivity	-39 dBm	-39 dBm	-27.5 dBm	-27.5 dBm	-50 dBm	-56 dBm	-56 dBm	-56 dBm
Fiber Size	200 μm	200 μm	50–200 μm	50–200 μm	50–200 μm	9 μm	9 μm	9 μm
Distance	1–500 m	1–500 m	1 m–4 km	1 m–4 km	2–15 km	1 m–23 km	16–80 km	16–110 km
Data Rate	0–40 kbps	0–20 kbps	0–115 kbps	0–115 kbps	0–40 kbps	0–40 kbps	0–40 kbps	0–40 kbps
Time Code + Data	None	IRIG-B	IRIG-B	None	None	None	None	None

^a The SEL-2812, SEL-2814, SEL-2829, and SEL-2830 are available with an optional conformal coating.

System Gain and Fiber Path Loss Calculations

Calculate system gain by subtracting the optical transmit power (dBm) from the receiver minimum sensitivity (dBm). The result is the link budget (dBm) or the amount of signal attenuation that can be tolerated before the system will no longer work reliably. Knowing the link budget and the installed components of the fiber-optic system allows you to calculate the maximum fiber distance at which the system can operate.

SEL fiber-optic transceivers are intended for use in two specific applications:

- To replace point-to-point EIA-485 or EIA-232 cabling between IEDs in a location (intrastation).
- To allow point-to-point EIA-485 or EIA-232 connection of IEDs in different locations (interstation).

Table 2 Transceiver and Fiber-Optic Compatibility and Typical Ranges

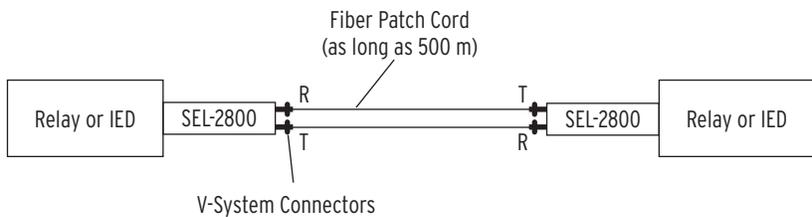
Transceiver	Single-Mode Fiber	Multimode Fiber		
	9 Micron	50 Micron	62.5 Micron	200 Micron (HCS)
SEL-2800, SEL-2810, SEL-2820	N/A	N/A	N/A	1–500 m
SEL-2812 ^a , SEL-2814	N/A	1 m–4 km	1 m–4 km	1 m–1.2 km
SEL-2824, SEL-9220	N/A	1 m–4 km	1 m–4 km	1 m–1.2 km
SEL-2815 ^b	N/A	2–15 km	2–15 km	2–6 km
SEL-2829 ^c	1 m–23 km	9 km	9 km	N/A
SEL-2830 ^c	16–80 km	0.1–30 km	0.05–30 km	N/A
SEL-2831	16–110 km	N/A	N/A	N/A

^a The SEL-2812 differs from the SEL-2814: the SEL-2812 provides IRIG-B time signals, while the SEL-2814 provides hardware flow control.

^b With attenuators in the transmit fiber path, SEL-2815 transceivers can be used for distances less than 2 km (1.24 mi).

^c The SEL-2829 and SEL-2830 are compatible when used with the 91560 attenuator, which reduces the link distance of the SEL-2830 to 23 km (14.29 mi [the link distance of the SEL-2829]).

Intrastation Fiber Optics

**Figure 1 Example of an Intrastation Application Using the SEL-2800**

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 replacing metallic cables between two EIA-232 devices.

Fiber-optic transceivers also allow application of EIA-232 connections longer than the specified 15.24 m (50 ft) limitation.

The SEL-2800, SEL-2810, SEL-2812, SEL-2814, and SEL-9220 are simple, inexpensive solutions for these applications. Use the SEL-2800 and SEL-2814 for EIA-232 connections, the SEL-2810 and SEL-2812 for applications that require distribution of IRIG-B in addition to the serial data, and the SEL-9220 to convert SEL-300 series EIA-485 ports to SEL-2812 compatible fiber-optic ports.

To calculate the viability of the example system in *Figure 1*, perform the following steps.

Step 1. Calculate the fiber attenuation:

$$\text{SEL-C805 cable attenuation (650 nm)} = 12 \text{ dB/km}$$

$$0.5 \text{ km} \cdot 12 \text{ dB} = 6 \text{ dB}$$

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

$$9 \text{ dB (system gain)} - 6 \text{ dB (fiber loss)} = 3 \text{ dB (system margin)}$$

If the fiber loss is greater than the system gain, the system is not viable.

Interstation Fiber Optics

The SEL-2812, SEL-2814, SEL-2815, SEL-2829, SEL-2830, SEL-2831, and SEL-9220 provide two options for fiber types (62.5 μm multimode and 9 μm single-mode) and various range capabilities suitable for interstation communications.

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, as in this example, an ST connector on the other end. 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, using a fiber patch cord of suitable length.

Calculating system loss is complicated by the additional components when compared to the intrastation application. All of these extra components have additional, associated losses.

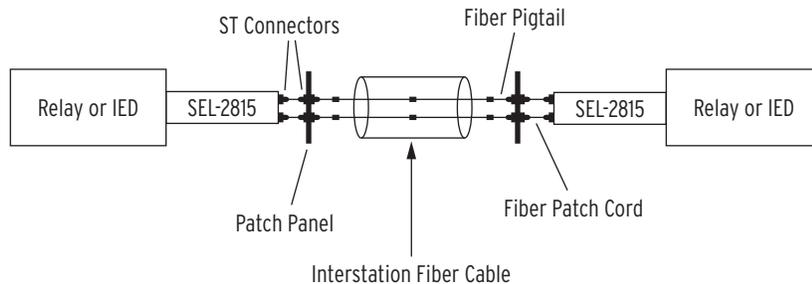


Figure 2 Example of an Interstation Application Using the SEL-2815

To calculate the viability of a system using the SEL-2815 as part of an interstation system (10 km [6.21 mi] long, configured as shown in *Figure 2*), perform the following steps.

Step 1. Calculate the fiber attenuation (refer to the typical values in *Table 3*):

$$\text{SEL-C807 cable attenuation (850 nm)} = 3.0 \text{ dB/km}$$

$$10 \text{ km} \cdot 3.0 \text{ dB} = 30 \text{ dB}$$

Step 2. Add the splice losses:

$$\text{Splice attenuation (fusion)}$$

$$3 \text{ splices} \cdot 0.2 \text{ dB} = 0.6 \text{ dB}$$

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

Connector loss: 0.75 dB/connector

2 connectors • 0.75 dB = 1.5 dB

Step 4. Sum the losses:

30 dB (fiber) + 0.6 dB (splices) + 1.5 dB (connectors) =
32.1 dB (system loss)

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

41 dB (system gain) – 32.1 dB (system loss) = 8.9 dB
(system margin), which is positive, so the system is viable.

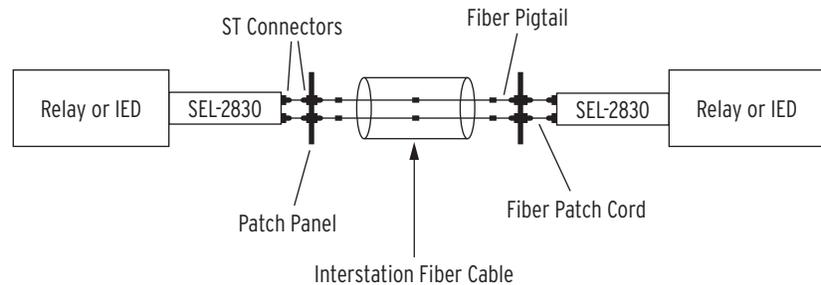


Figure 3 Example of an Interstation Application Using the SEL-2830

To calculate the viability of a system using the SEL-2830 as part of an interstation system (60 km long, configured as shown in *Figure 3*), perform the following steps.

Step 1. Calculate the fiber attenuation (refer to the typical values in *Table 3*):

SEL-C809 cable attenuation (1300 nm) = 0.4 dB/km

60 km • 0.4 dB = 24 dB

Step 2. Add the splice losses:

Splice attenuation (fusion)

10 splices • 0.2 dB = 2 dB

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

Connector loss: 0.75 dB/connector

2 connector • 0.75 dB = 1.5 dB

Step 4. Sum the losses:

24 dB (fiber) + 2 dB (splices) + 1.5 dB (connectors) =
27.5 dB (system loss)

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

41 dB (system gain) – 27.5 dB (system loss) = 13.5 dB
(system margin), which is positive, so the system is viable.

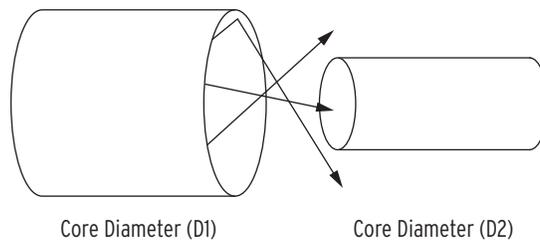
Table 3 Typical Attenuation Values^a

Type	Loss (dB) for Multimode Fiber (50 μm)	Loss (dB) for Multimode Fiber (62.5 μm)	Loss (dB) for Single-Mode Fiber (9.3 μm)
Fusion Splice	0.2	0.2	0.2
Mechanical Splice	0.4	0.4	0.4
Connector Loss	0.75	0.75	0.75
Per km @ 850 nm	3.0–4.0	2.7–4.0	N/A
Per km @ 1300 nm	1.0	1.0	0.4
Per km @ 1550 nm	1.0	1.0	0.25

^a See Table 4-Table 7 for attenuation of SEL-C805, SEL-C807, SEL-C808, and SEL-C809 fiber.

Losses Caused by Fiber Diameter Mismatch

Connecting fibers of different core sizes attenuates the signal when the transmitting fiber has a larger core size than the receiving fiber. The formula to calculate loss associated with this diameter mismatch is shown in *Figure 4*.



$$\text{dB loss} = -10 \text{LOG}_{10} \left(\frac{D1}{D2} \right)^2$$

Figure 4 Formula for Calculating Diameter Mismatch Loss

Using the mismatch formula to calculate the loss associated with connecting a 200 μm core fiber (D1) to a 50 μm core fiber (D2), the result is a 12 dB loss associated with this connection.

For connecting a 200 μm core fiber (D1) to a 62.5 μm core fiber (D2), the result is a 10 dB loss.

It is important to note the large amount of attenuation these diameter mismatches introduce.

For example, if an SEL-2800 is connected to a patch panel where the fiber connected to the SEL-2800 is the required 200 μm and the fiber connected on the other side of the bulkhead connector is 62.5 μm, the resulting 10 dB loss is greater than the 9 dB system gain of the SEL-2800. As a result, this application is not feasible.

Reflection Issues When Running Short-Distance, Single-Mode Fiber

The SEL-2830, SEL-2831, SEL-2505x3, SEL-25060x3, and SEL-25060x5 all use single-mode transceivers designed for medium- to long-distance serial communications. Short-distance applications using these single-mode transceivers through patch panels can have data corruption issues because of optical signal reflections.

Figure 5 shows how the reflected waveforms are created when going through patch panels. As the transmitted data travel through the patch panels and patch cords, some of the light is reflected inside the cable. These reflected data are lower in magnitude and slightly shifted in time. When using the SEL-2830 or SEL-2831 fiber optics in applications shorter than 16 km (10 mi), the transmitted power levels are high enough that the reflected data make it back to the receiver at a valid signal level (see Figure 6). The transceivers will interpret this as valid information and add it to the original transmitted data, causing the data to appear to the receiving device to have excessive jitter.

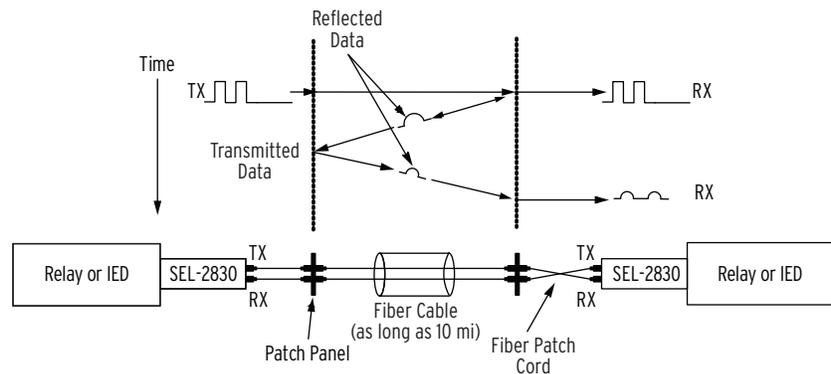


Figure 5 Data Reflected in Fiber-Optic Cables

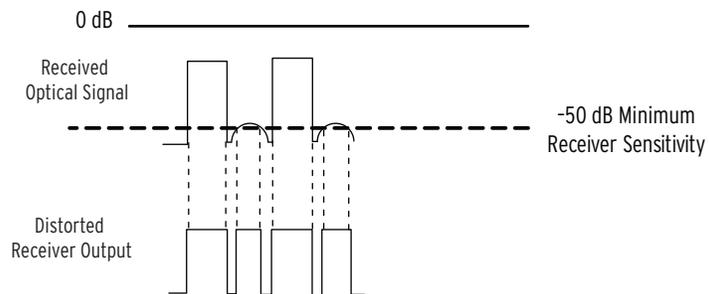


Figure 6 Effect of Reflections on Received Data

To prevent the receiver from picking up the reflected data, you must add attenuation into the system. The fiber-optic attenuator kit (SEL part number 91560) adds a spacer on the transmit side of the ST connectors. This pushes the fiber away from the transmitted light and reduces the transmit power by approximately 20 dB for a single-mode transmitter. Lowering the power by 20 dB will allow the receiver to properly filter out the reflected data (see Figure 7).

If used in a multimode application, the fiber-optic attenuator introduces 13 dB of attenuation.

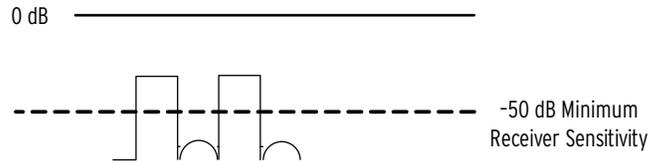


Figure 7 Reflected Signal Attenuated Below Detection Threshold

SEL Fiber-Optic Cables

NOTE: The SEL-C804 arc-flash detection fiber-optic cable and sensors are not within the scope of this data sheet.

SEL-C805, SEL-C807, SEL-C808, and SEL-C809 fiber and the connector system offer highly reliable, simple field installation, and together they make an excellent choice for utility and industrial communications applications. Connector styles offered include LC, ST, SC, and V-system configurations.

Installation takes less than three minutes per end using an easy crimp and cleave process, and is accomplished without messy epoxies, a curing oven, or the need for time-consuming polishing. *Table 4–Table 7* list the specifications for the fiber that SEL offers.

Table 4 SEL 200 μ m Core HCS Fiber-Optic Cable Specifications (SEL-C805)^a (Sheet 1 of 2)

Cable	Zipcord 2 Fibers	Heavy-Duty PVC-Jacketed 2 or 4 Fibers	Waterblocked Heavy-Duty Jacketed 2 Fibers	Waterblocked Heavy-Duty Jacketed 4 Fibers
Operating Temperature	-20° to +80°C	-20° to +80°C	-40° to +80°C	-40° to +80°C
Fiber Material	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)
Outer Cable Diameter	2.2 mm x 4.6 mm (0.087 in x 0.18 in)	7.5 mm (0.3 in)	9.5 mm (0.374 in)	8.0 mm (0.314 in)
Core Diameter	200 μ m	200 μ m	200 μ m	200 μ m
Weight/Unit Length	11.0 kg/km (7.4 lb/1000 ft)	50 kg/km (33.6 lb/1000 ft)	60 kg/km (40.3 lb/1000 ft)	50 kg/km (33.6 lb/1000 ft)
Maximum Long-Term Tension	44 N (10 lb)	200 N (45 lb)	1023 N (230 lb)	200 N (45 lb)
Maximum Cable Pull Tension	111 N (25 lb)	400 N (90 lb)	1690 N (380 lb)	400 N (90 lb)
Maximum Connector Pull Tension, V-pin	45 N (10 lb)	45 N (10 lb)	45 N (10 lb)	45 N (10 lb)
Maximum Connector Pull Tension, ST	223 N (50 lb)	223 N (50 lb)	223 N (50 lb)	223 N (50 lb)
Minimum Long-Term Bend Radius	10 mm (0.39 in)	75 mm (2.95 in)	95 mm (3.74 in)	80 mm (3.15 in)
Cable Attenuation @ 650 nm (-40° to +85°C)	12 dB/km (3.7 dB/1000 ft)	12 dB/km (3.7 dB/1000 ft)	12 dB/km (3.7 dB/1000 ft)	12 dB/km (3.7 dB/1000 ft)
Cable Attenuation @ 650 nm (0° to +70°C)	10 dB/km (3 dB/1000 ft)	10 dB/km (3 dB/1000 ft)	10 dB/km (3 dB/1000 ft)	10 dB/km (3 dB/1000 ft)
Cable Attenuation @ 650 nm (Typical)	7.4 dB/km (2.3 dB/1000 ft)	7.4 dB/km (2.3 dB/1000 ft)	7.4 dB/km (2.3 dB/1000 ft)	7.4 dB/km (2.3 dB/1000 ft)
Cable Attenuation @ 850 nm (-40° to +85°C)	10.6 dB/km (3.2 dB/1000 ft)	10.6 dB/km (3.2 dB/1000 ft)	10.6 dB/km (3.2 dB/1000 ft)	10.6 dB/km (3.2 dB/1000 ft)
Cable Attenuation @ 850 nm (0° to +70°C)	8.8 dB/km (2.7 dB/1000 ft)	8.8 dB/km (2.7 dB/1000 ft)	8.8 dB/km (2.7 dB/1000 ft)	8.8 dB/km (2.7 dB/1000 ft)

Table 4 SEL 200 μm Core HCS Fiber-Optic Cable Specifications (SEL-C805)^a (Sheet 2 of 2)

Cable	Zipcord 2 Fibers	Heavy-Duty PVC-Jacketed 2 or 4 Fibers	Waterblocked Heavy-Duty Jacketed 2 Fibers	Waterblocked Heavy-Duty Jacketed 4 Fibers
Cable Attenuation @ 850 nm (Typical)	6.5 dB/km (2 dB/1000 ft)	6.5 dB/km (2 dB/1000 ft)	6.5 dB/km (2 dB/1000 ft)	6.5 dB/km (2 dB/1000 ft)
UL Rating	Riser Rated (OFNR)	Riser Rated (OFNR)		

^a SEL-C805 finished cable and field-terminated connector options are V-pin to V-pin and ST to ST.

Table 5 SEL 62.5/200 μm Core/Cladding HCS Fiber-Optic Cable Specifications (SEL-C807)

Cable	Simplex 1 Fiber	Zipcord 2 Fibers	Waterblocked Heavy-Duty Jacketed 2 Fibers	Waterblocked Heavy-Duty Jacketed 4 Fibers
Operating Temperature	-20° to +85°C	-20° to +85°C	-40° to +85°C	-40° to +85°C
Fiber Material	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)	Hard Clad Silica (HCS)
Outer Cable Diameter	2.5 mm (0.098 in)	2.2 mm x 4.6 mm (0.087 in x 0.181 in)	8 mm (0.315 in)	8 mm (0.315 in)
Core Diameter	62.5 \pm 3 μm	62.5 \pm 3 μm	62.5 \pm 3 μm	62.5 \pm 3 μm
Cladding Diameter	200 \pm 4 μm	200 \pm 4 μm	200 \pm 4 μm	200 \pm 4 μm
Outer Jacket Material	PVC	PVC	PE	PE
Weight/Unit Length	6.5 kg/km (4.4 lb/1000 ft)	11 kg/km (7.4 lb/1000 ft)	50 kg/km (33.6 lb/1000 ft)	50 kg/km (33.6 lb/1000 ft)
Maximum Long-Term Tension	245 N (55 lb)	45 N (10 lb)	689 N (155 lb)	1179 N (265 lb)
Maximum Cable Pull Tension	489 N (110 lb)	111 N (25 lb)	1375 N (309 lb)	2358 N (530 lb)
Maximum Connector Pull Tension	223 N (50 lb)	45 N (10 lb)	223 N (50 lb)	223 N (50 lb)
Minimum Long-Term Bend Radius	25 mm (0.98 in)	25 mm (0.98 in)	80 mm (3.15 in)	80 mm (3.15 in)
Attenuation @ 850 nm	<4 dB/km	<4 dB/km	<4 dB/km	<4 dB/km
Attenuation @ 1300 nm	<2 dB/km	<2 dB/km	<2 dB/km	<2 dB/km
UL Rating	Riser Rated (OFNR)	Riser Rated (OFNR)		

Table 6 SEL 62.5/125 μm Core/Cladding Fiber-Optic Specifications (SEL-C808)^a (Sheet 1 of 2)

Cable	C808Z01 Zipcord 1 Fiber	C808Z02 Zipcord 2 Fibers	C808P01 Zipcord 1 Fiber	C808P02 Zipcord 2 Fibers	C808G02 Heavy-Duty Waterproof 2 Fibers	C808G04 Heavy-Duty Waterproof 4 Fibers
Operating Temperature	-20° to +85°C ^b	-20° to +85°C ^b	0° to +85°C ^b	0° to +85°C ^b	-40° to +85°C	-40° to +85°C
Fiber Material	Glass	Glass	Glass	Glass	Glass	Glass
Wavelength	850/1300 nm	850/1300 nm	850/1300 nm	850/1300 nm	850/1300 nm	850/1300 nm
Core/Cladding Diameters	62.5/125 μm	62.5/125 μm	62.5/125 μm	62.5/125 μm	62.5/125 μm	62.5/125 μm
Outside Cable Diameter	2.9 mm (0.11 in)	2.8 mm x 5.6 mm (0.11 in x 0.22 in)	2.9 mm (0.11 in)	2.8 mm x 5.6 mm (0.11 in x 0.22 in)	9.1 mm (0.36 in)	9.1 mm (0.36 in)
Nominal Weight	6.4 kg/km (4.3 lb/1000 ft)	12.8 kg/km (8.5 lb/1000 ft)	7.4 kg/km (5.0 lb/1000 ft)	14 kg/km (10 lb/1000 ft)	61 kg/km (41 lb/1000 ft)	61 kg/km (41 lb/1000 ft)

Table 6 SEL 62.5/125 μm Core/Cladding Fiber-Optic Specifications (SEL-C808)^a (Sheet 2 of 2)

Cable	C808Z01 Zipcord 1 Fiber	C808Z02 Zipcord 2 Fibers	C808P01 Zipcord 1 Fiber	C808P02 Zipcord 2 Fibers	C808G02 Heavy-Duty Waterproof 2 Fibers	C808G04 Heavy-Duty Waterproof 4 Fibers
Maximum Tensile Loads Short-Term	220 N (50 lb)	220 N (50 lb)	220 N (50 lb)	220 N (50 lb)	2000 N (450 lb)	2000 N (450 lb)
Maximum Tensile Loads Long-Term	66 N (15 lb)	66 N (15 lb)	66 N (15 lb)	66 N (15 lb)	800 N (180 lb)	800 N (180 lb)
Maximum Connector Pull Tension, LC, SC, and ST	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)
Minimum Bend Radius Loaded	5.0 cm (2.0 in)	5.0 cm (2.0 in)	5.0 cm (2.0 in)	5.0 cm (2.0 in)	13 cm (5.1 in)	13 cm (5.1 in)
Minimum Bend Radius Installed	1.4 cm (0.55 in)	1.4 cm (0.55 in)	1.4 cm (0.55 in)	1.4 cm (0.55 in)	9.1 cm (3.6 in)	9.1 cm (3.6 in)
Attenuation @ 850 nm Maximum	3.5 dB/km	3.5 dB/km	3.5 dB/km	3.5 dB/km	3.5 dB/km	3.5 dB/km
Attenuation @ 1300 nm Maximum	1.5 dB/km	1.5 dB/km	1.5 dB/km	1.5 dB/km	1.5 dB/km	1.5 dB/km
UL Rated	Riser Rated (OFNR)	Riser Rated (OFNR)	Plenum Rated (OFNP)	Plenum Rated (OFNP)	Riser Rated (OFNR)	Riser Rated (OFNR)

^a SEL-C808 finished cable and field-terminated connector options are ST to ST, ST to LC, ST to SC, LC to LC, LC to SC, and SC to SC.

^b Long-term exposure above 80°C can cause the cable jacket material to become brittle.

Table 7 SEL Single-Mode Fiber-Optic Specifications (SEL-C809)^a (Sheet 1 of 2)

Cable	C809Z01 Zipcord 1 Fiber	C809Z02 Zipcord 2 Fibers	C809P01 Zipcord 1 Fiber	C809P02 Zipcord 2 Fibers	C809G02 Heavy-Duty Waterproof 2 Fibers
Operating Temperature	-20° to +85°C ^b	-20° to +85°C ^b	0° to +85°C ^b	0° to +85°C ^b	-40° to +85°C ^b
Fiber Material	Glass	Glass	Glass	Glass	Glass
Wavelength	1310/1383/1550 nm	1310/1383/1550 nm	1310/1383/1550 nm	1310/1383/1550 nm	1310/1383/1550 nm
Core/Cladding Diameters	9/125 μm	9/125 μm	9/125 μm	9/125 μm	9/125 μm
Outside Cable Diameter	2.9 mm (0.11 in)	2.8 mm x 5.6 mm (0.11 in x 0.22 in)	2.9 mm (0.11 in)	2.8 mm x 5.6 mm (0.11 in x 0.22 in)	4.2 mm x 6.5 mm (0.25 in x 0.30 in)
Nominal Weight	6.4 kg/km (4.3 lb/1000 ft)	12.8 kg/km (8.5 lb/1000 ft)	7.4 kg/km (5.0 lb/1000 ft)	14 kg/km (10 lb/1000 ft)	26 kg/km (18 lb/1000 ft)
Maximum Tensile Loads Short-Term	220 N (50 lb)	220 N (50 lb)	220 N (50 lb)	220 N (50 lb)	660 N (150 lb)
Maximum Tensile Loads Long-Term	66 N (15 lb)	66 N (15 lb)	66 N (15 lb)	66 N (15 lb)	330 N (75 lb)
Maximum Connector Pull Tension, LC, SC, and ST	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)	50 N (11 lb)
Minimum Bend Radius Loaded	5.0 cm (2.0 in)	5.0 cm (2.0 in)	5.0 cm (2.0 in)	5.0 cm (2.0 in)	11.4 cm (4.5 in)
Minimum Bend Radius Installed	1.4 cm (0.55 in)	1.4 cm (0.55 in)	1.4 cm (0.55 in)	1.4 cm (0.55 in)	7.6 cm (3.0 in)

Table 7 SEL Single-Mode Fiber-Optic Specifications (SEL-C809)^a (Sheet 2 of 2)

Cable	C809Z01 Zipcord 1 Fiber	C809Z02 Zipcord 2 Fibers	C809P01 Zipcord 1 Fiber	C809P02 Zipcord 2 Fibers	C809G02 Heavy-Duty Waterproof 2 Fibers
Maximum Attenuation @ 1310/1383/1550	0.65/0.65/ 0.50 dB/km	0.65/0.65/ 0.50 dB/km	0.65/0.65/ 0.50 dB/km	0.65/0.65/ 0.50 dB/km	0.65/0.65/ 0.50 dB/km
UL Rated	Riser Rated (OFNR)	Riser Rated (OFNR)	Plenum Rated (OFNP)	Plenum Rated (OFNP)	Riser Rated (OFNR)

^a SEL-C809 finished cable and field-terminated connector options are ST to ST, ST to LC, ST to SC, LC to LC, LC to SC, and SC to SC.

^b Long-term exposure above 80°C can cause the cable jacket material to become brittle.

Fiber Accessories

Splice Bushing (Bulkhead Connector)

Splice bushings connect the ends of two terminated fibers. The terminations need to be of the same type (ST to ST or V-pin to V-pin, for example). A connector loss of 2 dB is typical for this type of connection.

Table 8 Splice Bushings and Part Numbers

Description	SEL Part Number
V-pin splice bushing (SEL-C805)	S800 (see <i>Figure 8</i>)
ST splice bushing (SEL-C805, SEL-C807, SEL-C808, and SEL-C809)	090-5012 (see <i>Figure 9</i>)
LC splice bushing (SEL-C807, SEL-C808, and SEL-C809)	240-1810 (see <i>Figure 10</i>)
SC splice bushing (SEL-C808 and SEL-C809)	240-1811 (see <i>Figure 11</i>)

**Figure 8 V-Pin Splice Bushing (SEL S800)****Figure 9 ST Splice Bushing (SEL 090-5012)****Figure 10 LC Splice Bushing (SEL 240-1810)****Figure 11 SC Splice Bushing (SEL 240-1811)**

Fiber-Optic Attenuator Kit

This kit (SEL part number 91560) is only necessary for SEL-2830 or SEL-2831 Fiber-Optic Transceivers, and for SEL-2505 and SEL-2506 Remote I/O Modules (SEL part numbers 2505x3, 25060x3, and 25060x5) in single-mode fiber applications less than 16 km (10 mi). Additional attenuation is not required for distances greater than 16 km (10 mi). Every product shipped with the SEL-2830 and SEL-2831 comes with an attenuator kit.

This kit includes four attenuation spacers, enough for two fiber pairs. Use one of these attenuators on the transmit ST fiber connection on each side, as shown in *Figure 12*. Be sure to fully seat the attenuator.

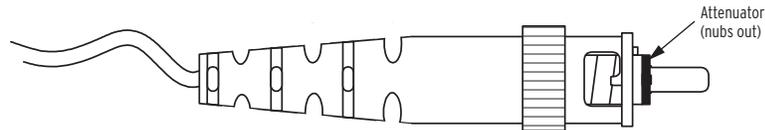


Figure 12 Attenuator Washer Attached to ST Connector

Depth-Restricted Adapter Cable

When mounting depth is an issue, such as in switchgear applications, use the adapter cable (SEL-C780). The SEL-C780 is a six-inch ribbon cable that allows the fiber transceiver to be mounted at a 90-degree angle to the mating DB-9 host connector.

IRIG-B Adapter Cables

The SEL-2810MR includes a two-pin Molex connector for IRIG-B connection to IEDs that require IRIG-B connections other than Pins 4 and 6 of the DB-9 data connector (SEL-C651 and SEL-C652). Use one of the adapter cables in *Table 9* when applying the SEL-2810MR to these types of IEDs.

The SEL-2812 includes a miniature phone jack (mono jack) to connect IRIG-B to IEDs that do not accept the IRIG-B signal on Pins 4 and 6 of the DB-9 connector. This jack is equipped on both the SEL-2812 IRIG-B transmitter and receiver versions. Use SEL adapter cables SEL-C654, SEL-C655, and SEL-C656 listed in *Table 9* when applying the SEL-2812 to these devices.

Table 9 IRIG-B Adapter Cables

Description	Product	Cable
2 Pin (Molex) to BNC	SEL-2810MR	SEL-C651
2 Pin (Molex) to DB-9	SEL-2810MR	SEL-C652
Mono Jack to BNC	SEL-2812	SEL-C654
Mono Jack to DB-9	SEL-2812	SEL-C655
Mono Jack to Ring Terminals	SEL-2812	SEL-C656
Mono Jack to Tinned Wires	SEL-2812	SEL-C657

External Power Sources

The SEL fiber-optic transceivers typically draw power from the data and control lines as shown in *Power Requirements on page 15*. When a host device is not capable of supplying the required voltage, an external power source is required. The options shown in *Table 10* and *Figure 13* are available from SEL.

Table 10 External Power Source Options

Power Supply/Source	Compatible Transceiver	Input Voltage/ Output Voltage
SEL-C643 (cable)	SEL-2800, SEL-2815, SEL-2829, SEL-2830, SEL-2831	Input: 100–250 Vac 47–63 Hz Output: 5 Vdc @ 1.6 A
230-0601 (wall plug)	SEL-2814	Input: 100–250 Vac 47–63 Hz Output: 5 Vdc @ 1.6 A
SEL-9321x2X (dc battery input)	SEL-2814	Input: 24 Vdc, 48/125 Vdc, 125 Vac, 125/250 Vac/Vdc (47–63 Hz) Output: 5 Vdc @ 1 A
SEL-9321x0X (dc battery input) and SEL-C647	SEL-2812	Input: 24 Vdc, 48/125 Vdc, 125 Vac, 125/250 Vac/Vdc (47–63 Hz) Output: 5 Vdc @ 1 A
230-0604	SEL-2820, SEL-2824	Input: 90–264 Vac 47–63 Hz Output: 15 Vdc @ 2 A
SEL-C577	SEL-2820, SEL-2824	Extracts power from unused SEL serial port Output: 5 Vdc @ 0.5 A
SEL-9321x1X	SEL-2820, SEL-2824	Input: 24 Vdc, 48/125 Vdc, 125 Vac, 125/250 Vac/Vdc (47–63 Hz) Output: 5 Vdc @ 1 A (dc battery input)

**Figure 13 SEL-C643 Cable**

Termination Kits

Termination kits include the hand tools and instructions necessary to install the connectors on zipcord or PVC-jacketed fiber-optic cable. Tools and instructions are packaged in a carrying case.



Figure 14 Termination Kit

Table 11 Termination Kits and Part Numbers

Description	SEL Part Number
200 μm (SEL-C805) V-pin connector termination kit	T800
200 μm (SEL-C805) ST connector termination kit	240-1501
62.5/200 μm (SEL-C807) ST connector termination kit	240-1499
62.5/125 μm (SEL-C808) ST, SC, and LC connector termination kit	240-1540
9/125 μm (SEL-C809) ST, SC, and LC connector termination kit	240-1540

Pulling Loop

The pulling loop option is used with the SEL-C805, SEL-C807 Heavy-Duty PVC-Jacketed or the Waterproof Heavy-Duty Jacketed, and the SEL-C808 Heavy-Duty Waterproof fiber cable. Use the pulling loop as a cable grip to pull the fiber cable through cable ducts. The pulling loop attached to a heavy-duty cable is shown in *Figure 15*.



Figure 15 Pulling Loop

V-Pin Latch Kit

In some applications there is a concern that the V-pin connector detent is not strong enough to retain the fiber connection. If this is the case, use the latch kit shown in *Figure 16* and *Figure 17* (SEL part number 9210). The latch kit provides an additional latch that connects directly to the optical components.

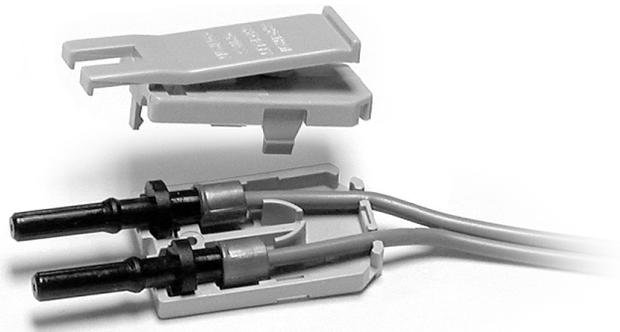


Figure 16 V-Pin Latch Kit



Figure 17 V-Pin Latch Kit Application

Transceiver Mounting Options

Use an SEL Transceiver Mounting Kit and adapter cable when connecting the transceiver 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 18 Transceiver Mount

Power Requirements

The various optical components in SEL fiber-optic transceivers cause these transceivers to have different power requirements. Additionally, the different models can use different pins/control lines as a power source.

SEL-2800

CAUTION

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

The SEL-2800 has the following power specifications:

- The operating voltage range is 5.7–15 Vdc.
- Typical current draw is 12 mA.

The transceiver draws power from the EIA-232 data as shown in *Table 12*.

Table 12 Transmit Data Power Input

Pin	Signal
3	DCE ^a

^a Data communications equipment

The transceiver additionally draws power per *Table 13*.

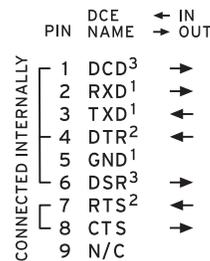
Table 13 Other Power Input

Pin	Voltage
4 ^a	±5.7 to ±15 ^b
7, 8	±5.7 to ±15 ^b

^a A positive voltage on Pin 4 will supply a DCD output on Pin 1.

^b One of the signals must be positive for proper operation.

Figure 19 shows the transceiver rear label, and indicates the internally jumpered pins, pinouts, and signal names.



1. REQUIRED CONNECTIONS.
2. DTR OR RTS MUST BE CONNECTED AND ACTIVE HIGH.
3. CURRENT LIMITED TO 4mA AT DTR=12Vdc.

R T

Figure 19 SEL-2800 Signal Flow

SEL-2810

The SEL-2810 has the following power specifications:

- The operating voltage range is 5–10 Vdc.
- Typical current draw is 12 mA.

The transceiver draws power from the EIA-232 data as shown in *Table 14*.

Table 14 Transmit Data Power Input

Pin	Signal
3	DCE

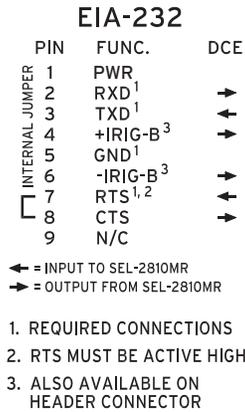
The transceiver additionally draws power per *Table 15*.

Table 15 Other Power Input

Pin	Voltage ^a
1	+5 to +10 Vdc
7, 8	±5 to ±10 Vdc

^a Voltage levels assume current-limited EIA-232 signal levels. If an external power supply is connected to Pin 1, it must be limited to 10 V.

Figure 20 shows the transceiver rear label and indicates the internally jumpered pins, pinouts, and signal names.



R T

Figure 20 SEL-2810 Signal Flow

SEL-2812

The SEL-2812 has the following power specifications:

- The operating voltage range is 5–10 Vdc.
- Typical current draw is less than 15 mA.

The transceiver draws power from the EIA-232 data as shown in Table 16.

Table 16 Data and Control Line Power Input

Pin	Signal
3	DCE
7	DCE

The transceiver additionally draws power per Table 17.

Table 17 Other Power Input

Pin	Voltage ^a
1	+5 to +10 Vdc

^a Voltage levels assume current-limited EIA-232 signal levels. If an external power supply is connected to Pin 1, it must be limited to 10 V.

Figure 21 shows the transceiver rear label and indicates the internally jumpered pins, pinouts, and signal names.

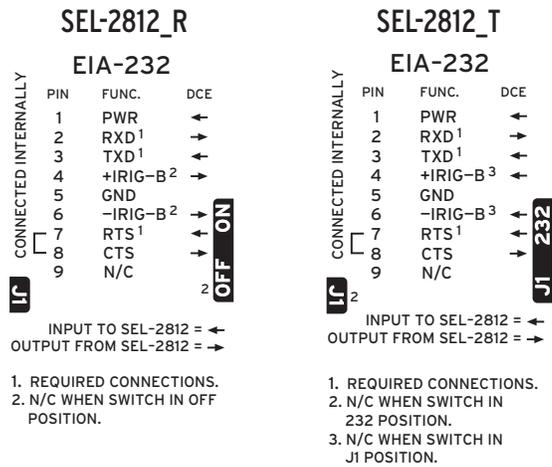


Figure 21 SEL-2812_R and SEL-2812_T Signal Flow

For the SEL-2812_R, the switch controls whether an IRIG signal is provided to EIA-232 Pins 4 and 6. The IRIG signal is always on J1, and this signal is not affected by the setting of the switch. The IRIG signal at J1 is sufficient to drive a 480 Ω load.

For the SEL-2812_T, the switch controls whether the IRIG input is taken from J1 or from EIA-232 Pins 4 and 6.

SEL-2814

The SEL-2814 has the following power specifications:

- ▶ The operating voltage range is 5–10 Vdc.
- ▶ Typical current draw is less than 15 mA.

The transceiver draws power from the EIA-232 data as shown in *Table 18*.

Table 18 Data and Control Line Power Input

Pin	Switch Position
2, 8	DTE ^a
3, 7	DCE
4 ^b , 6	DTE or DCE

^a Data terminal equipment

^b A positive voltage on Pin 4 will supply a DCD output on Pin 1.

The transceiver additionally draws power per *Table 19*.

Table 19 Other Power Input

Pin	Voltage ^a
1, J1	+5 to +10 Vdc

^a Voltage levels assume current-limited EIA-232 signal levels. If an external power supply is connected to Pin 1, it must be limited to 10 V.

Power input is also available via side-mounted jack J1. Use a 0.7 mm coaxial dc plug, with the center pin as positive. SEL provides the coaxial dc plug/cable (part number 240-1525, with a length of 1.82 m [6 ft]) to connect power jack J1 to tinned leads. You can use this cable with a low-voltage dc power supply for ac/dc and dc/dc applications.

Figure 22 shows the transceiver rear label and indicates the internally jumpered pins, pinouts, and signal names.

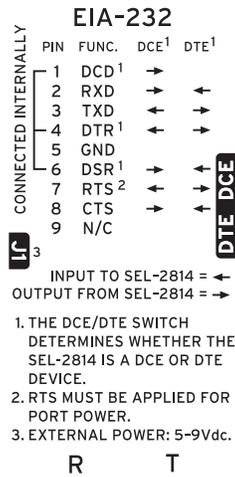


Figure 22 SEL-2814 Signal Flow

SEL-2815, SEL-2829, SEL-2830, and SEL-2831

The SEL-2815, SEL-2829, SEL-2830, and SEL-2831 have the following power specifications:

- The operating voltage range is 5–10 Vdc.
- Typical current draw is 10 mA for the SEL-2815 and 11 mA for the SEL-2829, SEL-2830, and SEL-2831.

The transceiver draws power from the EIA-232 data as shown in *Table 20*.

Table 20 Transmit Data Power Input

Pin	Switch Position
2	DTE
3	DCE

The transceiver additionally draws power per *Table 21*.

Table 21 Other Power Input

Pin	Voltage ^a
1	+5 to +10 Vdc
4 ^b , 6	±5 to ±10 Vdc
7, 8	±5 to ±10 Vdc

^a Voltage levels assume current-limited EIA-232 signal levels. If an external power supply is connected to Pin 1, it must be limited to 10 V.
^b A positive voltage on Pin 4 will supply a DCD output on Pin 1.

Figure 23 shows the rear labels and indicates the internally jumpered pins, pinouts, and signal names for the SEL-2815, SEL-2829, SEL-2830, and SEL-2831.

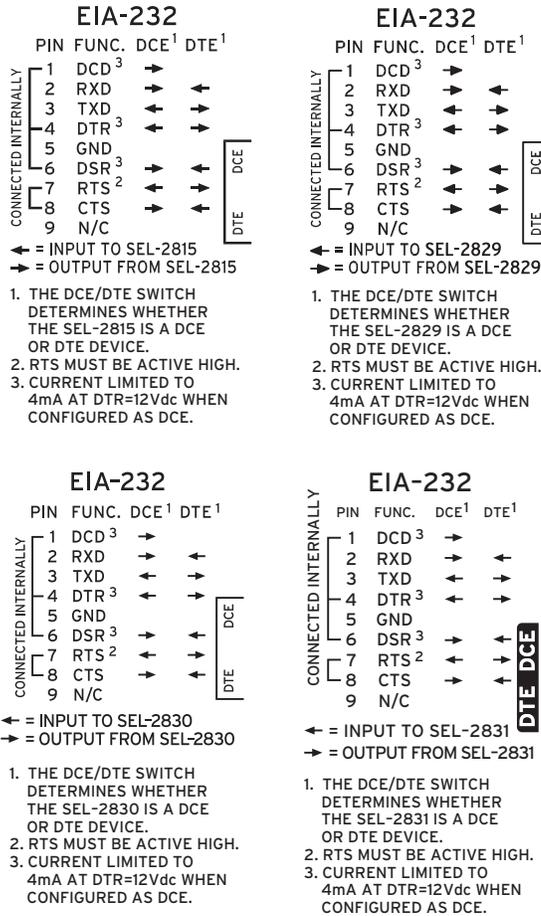


Figure 23 SEL-2815, SEL-2829, SEL-2830, and SEL-2831 Signal Flow

SEL-2820 and SEL-2824

The SEL-2820 and SEL-2824 have the following power specifications:

- The operating voltage range is 5–30 Vdc.
- At 5 Vdc, the typical power and worst-case power burden is less than 1 W. At 30 Vdc, the typical power burden is 1.35 W and the worst case is 1.5 W.

Connect the external power to either the two-position compression terminal block or the 2.5 mm jack. SEL provides the 240-1522 cable (with a length of 1.82 m [6 ft]) to connect power jack J1 to tinned leads. You can use this cable with an SEL-9321 or SEL-9322 Low-Voltage DC Power Supply for ac/dc and dc/dc applications. For ac-only input, you can use the AC Power Supply (part number 230-0604).

If an SEL device near the transceiver has an unused EIA-232 port capable of supplying 5 Vdc via a jumper to Pin 1, connect the tinned leads of an SEL-C577 cable to the transceiver before plugging the 9-pin connector into the EIA-232 serial port.

SEL-9220

The SEL-9220 converts point-to-point 4-wire EIA-485 ports to SEL-2812MRXx compatible fiber-optic ports. The SEL-9220 can either connect to another SEL-9220 or to an SEL-2812. The adapter draws power from the EIA-485 +TX and –TX connections. The operating voltage range is 3.5 to 6 Vdc, with a maximum current draw of 15 mA. *Figure 24* shows the rear label, pins, and signal names for the SEL-9220.

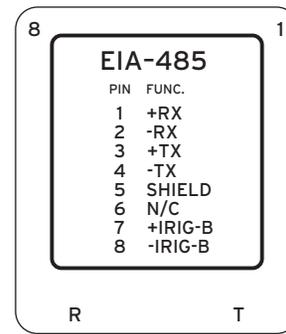


Figure 24 SEL-9220 Back Label

Adapter Cables for EIA-485 Ports

Use an adapter cable to apply an SEL-9220 to a device that does not have an 8-position EIA-485 compression block. The transmitter (TX) outputs of the device must be asserted to properly operate the SEL-9220. These cables and the SEL-9220 convert a four-wire EIA-485 port to a point-to-point fiber-optic link.

Table 22 EIA-485 Adapter Cables for the SEL-9220 to SEL Devices

Device	EIA-485 Port		Cable Data Only	Cable Data and IRIG-B (IRIG Connector if Separate)
	Port Number	Connector		
SEL-300 series, including legacy	1	8-position compression	None needed	None needed
SEL-300 series with USB and Ethernet Port	1	5-position compression	SEL-C685	SEL-C686 (BNC)
SEL-500 series	1	DB-9	SEL-C688	SEL-C689
SEL-700 series, SEL-2411, SEL-2414	4A	5-position compression	SEL-C685	SEL-C687 (2-position compression)
SEL-2431	1	DB-9	SEL-C688	SEL-C689
SEL-2431	2	DB-9	SEL-C688	N/A
SEL-2440	2	DB-9	SEL-C688	SEL-C689
SEL-2523, SEL-2533	4A	5-position compression	SEL-C685	SEL-C687 (2-position compression)

DTE/DCE Switch Selection

A DTE/DCE switch is available on the SEL-2814, SEL-2815, SEL-2829, SEL-2830, and the SEL-2831. It selects whether the transceiver is operating as DTE or as DCE. When the transceiver is connected to an SEL relay or communications processor port, the DCE position must be selected. *Table 23* lists the DB-9 connector pinouts and signal directions for DTE and DCE switch selection.

Table 23 DB-9 Connector Pinouts and Signal Directions

Function	Pin	DCE ^a	DTE ^a
DCD	1	>	
RXD	2	>	<
TXD	3	<	>
DTR	4	<	>
GND	5		
DSR	6	>	<
RTS	7	<	>
CTS	8	>	<
N/C	9		

^a < Input to transceiver
> Output from transceiver

Technical Support

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Notes

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