SEL-2824 EIA-485 Fiber-Optic ST® Transceiver Instruction Manual

Features, Benefits, and Applications

The SEL-2824 EIA-485 Fiber-Optic ST® Transceiver connects electrical EIA-485 multidrop networks or point-to-point EIA-422 links.

- **Increases Safety.** Isolate devices from ground potential rise and fault current in the communications connections by using an eye-safe, Class 1 laser product.
- **Improves Signal Integrity.** Prevent electromagnetic interference and signal ground loops by using optical connections instead of copper wires.
- **Withstands Harsh Conditions.** Increase reliability with this rugged device that operates within a temperature range of –40° to +85°C, and meets or surpasses electric utility and industrial type-test standards for instrumentation, control, and communications equipment.
- **Eases Application.** Implement fiber-optic links between two- and four-wire EIA-485 network segments. Set operating modes using control (DIP) switches. Simplify network commissioning and troubleshooting with LED traffic indicators for each port. Connect power through a terminal block or jack.

Product Overview

The SEL-2824 converts electrical signals going into and out of an asynchronous serial EIA-485/422 port into light pulses and converts light pulses sent and received via a full-duplex fiber-optic port into electrical signals. Example applications for the SEL-2824 include the following:

- Connect a distant EIA-485 device to an EIA-485 network with two SEL-2824 transceivers and optical fiber.
- Add an EIA-485 subnetwork for multiple devices, connected to a master or main network via optical fiber and two SEL-2824 transceivers.
- Use an EIA-232 port on a master computer as the master connection to a distant EIA-485 network.
- Connect an SEL-2814 Fiber-Optic Transceiver to an EIA-232 port on the master computer and connect the SEL-2814 with a fiber-optic cable to an SEL-2824 that is the master node of an EIA-485 network. Link two devices with a point-to-point fiber-optic link, via their EIA-485 or EIA-422 ports and two SEL-2824 transceivers.

Power Requirements

The SEL-2824 has two power options, the 2.5 mm power jack and the compression terminal block. Connect voltages of 5 to 30 Vdc to either the power jack or the terminal block, as shown in *Figure 1*. At most voltages, the SEL-2824 consumes less than 1.5 W. At 5 Vdc, it consumes less than 1 W.

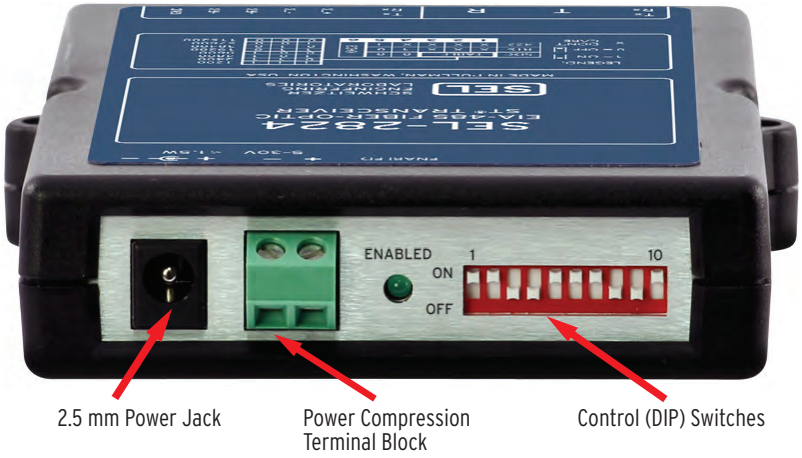


Figure 1 SEL-2824 Power Connections and Control (DIP) Switches

SEL options for providing power include the following:

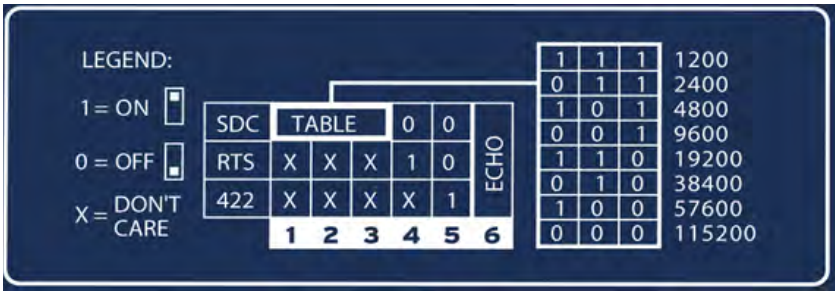
- **AC Power Adapter:** Use an SEL 230-0604 ac power adapter to provide 15 Vdc, from an input of 90 to 264 Vac.
- **SEL-9321 Low-Voltage DC Power Supply:** Use the SEL-9321 to power SEL-2824 transceivers from higher voltage power sources, including 48, 125, and 250 Vdc station batteries, and 125 and 250 Vac sources.
- **SEL-C577 Cable:** Provide power from an SEL relay or controller that has an unused EIA-232 port with pin-one 5 Vdc power. Connect the tinned leads of the SEL-C577 cable to the compression block power input, and plug the 9-pin connector into the unused EIA-232 port.

Control Switches

The SEL-2824 has several operating modes. Enable these modes using control (DIP) switches, as shown in *Figure 1*.

Table 1 Switch Functions

Switch (SW) Position	Function
1, 2, 3	Set data rate for Send Data Control (SDC), see *Table 2*
4	Transmitter controlled by RTS (on) or SDC (Off)
5	Transmitter is always enabled (EIA-422 mode) (On)
6	Receiver echo on or off (two-wire mode)
7, 8, 9, 10	Unused



Transmit Data Control (Switches 1–5)

There are several options for controlling the transmitter output.

- **EIA-422 Mode:** In the EIA-422 mode, the transmitter is always enabled. Only use this mode in a point-to-point, four-wire remote application.
- **RTS Mode:** In the RTS mode, the transmitter is enabled whenever a remote device connected to an SEL-2814 Fiber-Optic Transceiver asserts the serial port RTS line. When the RTS line is negative or is not connected, the transmitter will not enable in the RTS mode.
- **SDC Mode:** In the Send Data Control (SDC) mode, the transmitter is enabled when data are present on the serial port TX line. Apply a one-character time delay to ensure the transmitter stays enabled during low data transitions. This time delay is set using SW1–SW3. Note that these switches are only used by the SEL-2824 when SDC mode is enabled (SW4 and SW5 = 0).

Table 2 displays the interdependencies of control Switches 1–5.

Table 2 Switch Settings to Control Electrical Transmitter

SW1	SW2	SW3	SW4	SW5	Application
X[a]	X	X	X	1[b]	EIA-422 mode (TX always enabled)
X	X	X	1	0[c]	TX enabled with the remote RTS fiber-optic signal
*[d]	*	*	0	0	TX enabled by the data (SDC)

a. X = Don't care.
b. 1 = On.
c. 0 = Off.
d. * = Set per Table 3.

Table 3 Switch Settings for SDC Timing and Associated Data Rates

SW1	SW2	SW3	TX Enable Hold Time (ms/Rate)
1	1	1	11.66 ms/1200 bps
0	1	1	5.83 ms/2400 bps
1	0	1	2.91 ms/4800 bps
0	0	1	1.45 ms/9600 bps
1	1	0	0.72 ms/19200 bps
0	1	0	0.36 ms/38400 bps
1	0	0	0.24 ms/57600 bps
0	0	0	0.12 ms/115200 bps

ECHO Control (Switch 6)

When ECHO is set to On, the receiver is always enabled.

When ECHO is set to Off, the receiver is disabled while the transmitter is active. When operating in two-wire mode, turn ECHO off to prevent the transmitted data from echoing back into the receiver.

Fiber-Optic Connections

The fiber-optic port consists of two ST connectors and two traffic-indication LEDs, as shown in *Figure 2*. Data received from the EIA-485 port are sent on the transmit (T) ST connector. Data sensed from the receive (R) ST connector are transmitted to the EIA-485 port. For a link between two transceivers, connect a fiber from the T connector of each transceiver to the R connector of the other transceiver.

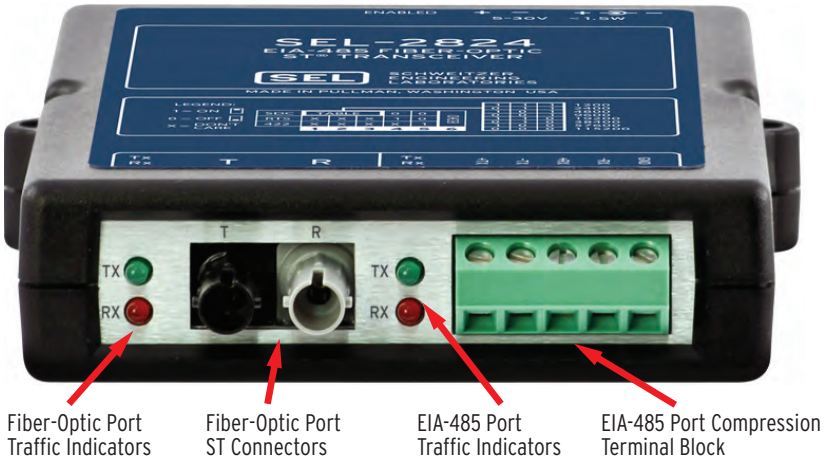


Figure 2 SEL-2824 Port Connectors and Traffic Indicators

Table 4 shows typical fiber-optic cable lengths for compatible fiber-optic cables. For the calculations to determine whether a specific fiber-optic cabling plan has sufficient optical power to reliably overcome attenuation from splices and patch panels, see *Appendix B: Determining Maximum Cable Length*.

Table 4 Typical Fiber-Optic Cable Lengths

SEL Cable	Fiber Diameter (µm)	Power Budget (dB) (-40° to +85°C)	Typical Fiber Loss (dB/km) at 25°C	Maximum Cable Length (km)
NA	50	16	2.7	5.5
SEL-C808 or SEL-C807	62.5	16	3.2	4.6
SEL-C805	200	16	6.5	2.3

EIA-485/422 Connections

The EIA-485/422 connections are made on the green five-position compression terminal block located on one end of the SEL-2824. Connection wiring will vary, based on the application. The following schematics provide wiring diagrams for each of the operating modes.

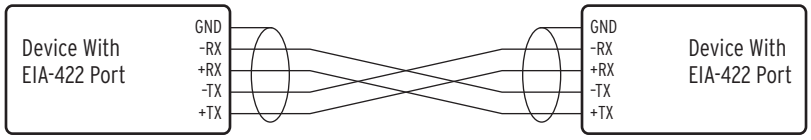


Figure 3 EIA-422 Electrical Link

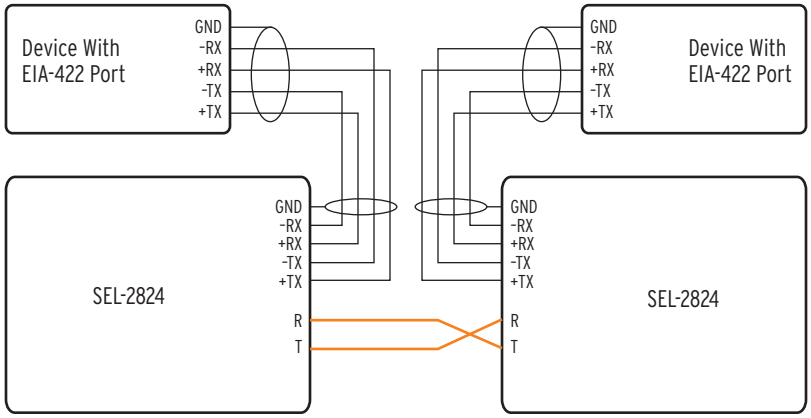


Figure 4 EIA-422 Fiber-Optic Link

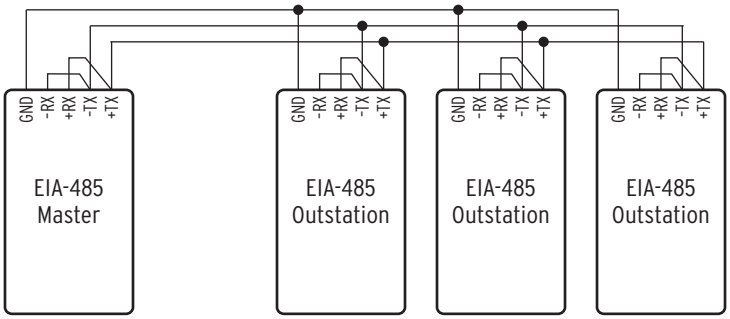


Figure 5 EIA-485 Two-Wire Multidrop

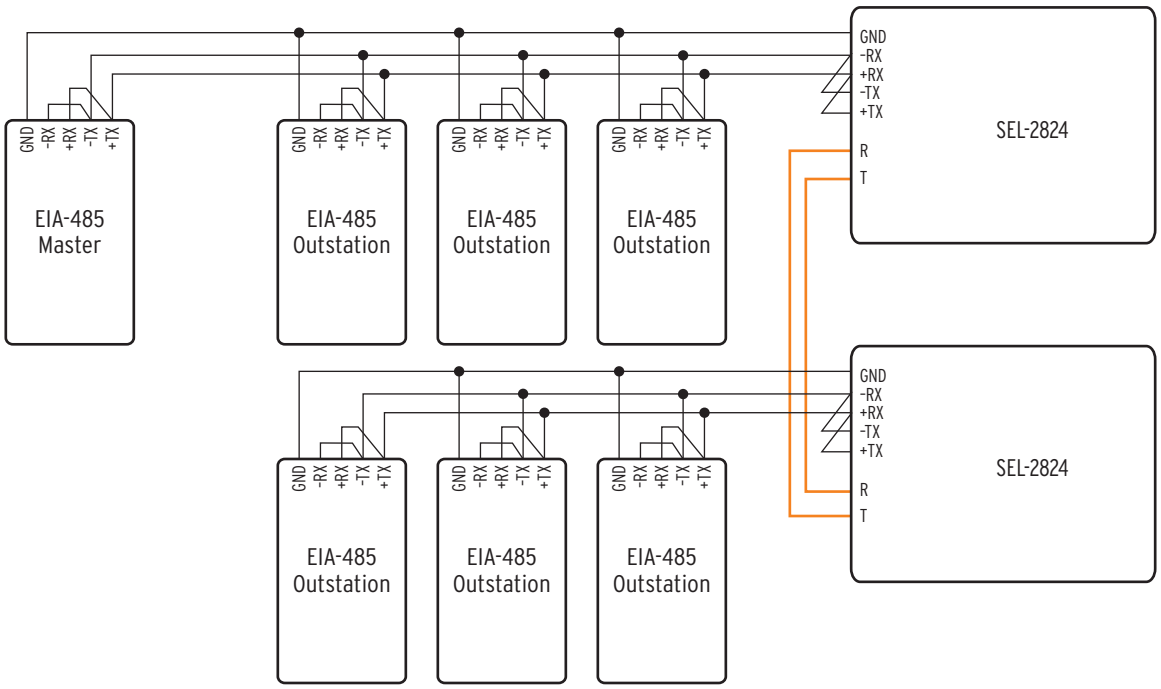


Figure 6 EIA-485 Two-Wire Multidrop With Fiber-Optic Extension

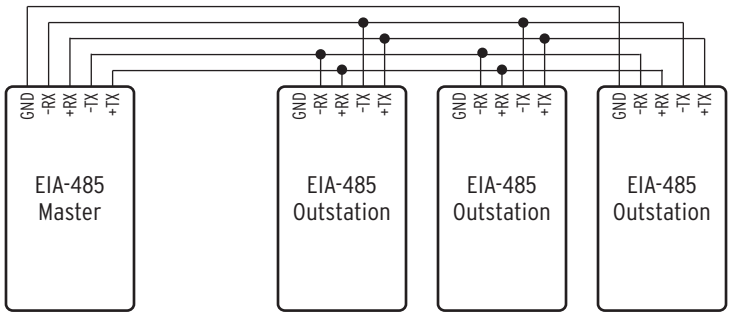


Figure 7 EIA-485 Four-Wire Multidrop

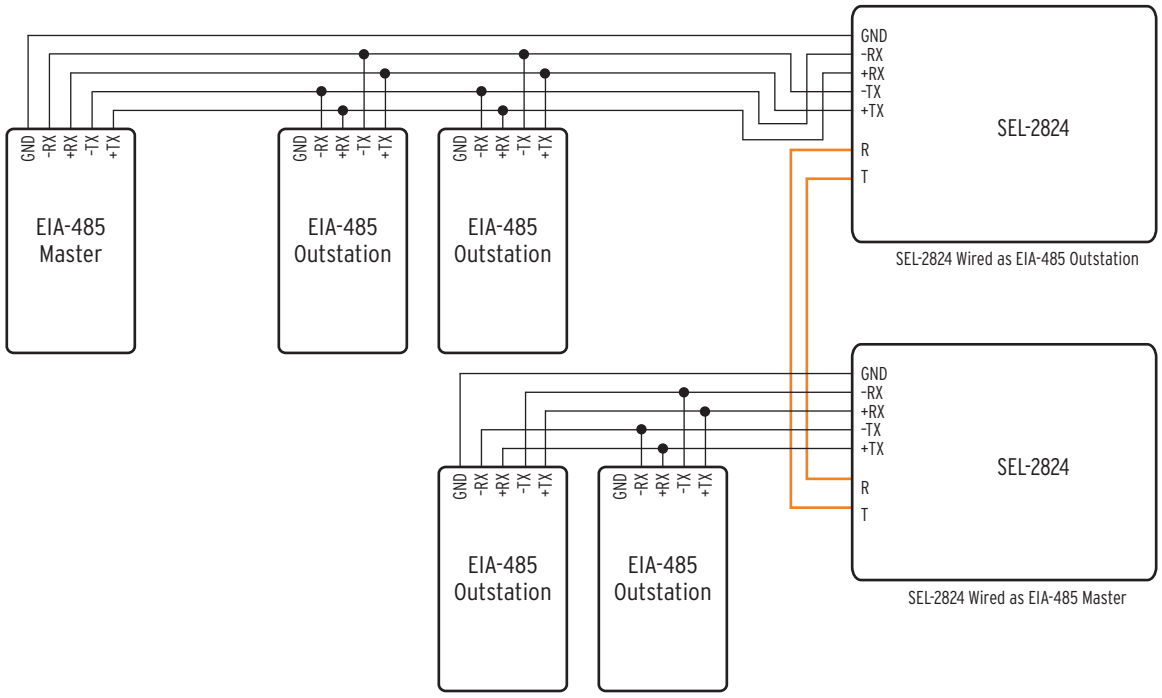


Figure 8 EIA-485 Four-Wire Multidrop With Fiber-Optic Extension

EIA-485 Terminations

EIA-485 systems operating at high speeds and long distances require termination resistors to prevent reflected signals from interfering with proper operation. Generally, the only applications of the SEL-2824 that require termination resistors are those operating at 115200 bps with wire lengths of 450 meters (1500 feet) or more.

The need for termination resistors is based on data rate and cable length. A good rule of thumb is that no termination is required when the propagation delay of the signal through the data line at the required data rate is much less than one bit time. For example, in a system operating at a data rate of 115200 bps, one bit time is approximately 8.7 µs. To determine the total round-trip signal time for an example cable length of 1500 feet, assume the signal speed in the cable to be 0.7 times the speed of light. This results in a total round trip delay for the signal of approximately 4.35 µs. Because this delay is equal to or greater than half of the bit time, we recommend termination resistors.

When termination resistors are required, apply one termination resistor across the EIA-485 wire-pair on each of the extreme ends of the circuit (two total). The value of the resistors should match the characteristic impedance of the twisted-pair line. If this impedance is not known, use 120-ohm resistors as a reasonable approximation.

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

Data Rate

Up to 115200 bps, full-duplex

Data Delay

5 µs plus 5 µs/km of fiber

Operating Temperature

–40° to +85°C (–40° to +185°F)

Power Requirements

5–30 Vdc 5% tolerance, <1.5 W

Fiber-Optic Port

Connectors:	Two ST female
Wavelength:	850 nm
Typical Tx Power:	–13 dBm
Min Rx Sensitivity:	–29 dBm
Optical Budget:	16 dB
Compatible Optical Fiber:	50, 62.5, or 200 µm core diameter

Electrical Port

Connector:	5 position compression terminal block
Connections:	4-wire full-duplex or 2-wire half-duplex
Operation:	EIA-485 multidrop or EIA-422 point-to-point

LED Indicators

Enable:	Powered and operating
Fiber Tx:	Data sent to T fiber
Fiber Rx:	Data received from R fiber
EIA-485 Tx:	Data send to EIA-485 network
EIA-485 Rx:	Data received from EIA-485 network

Dimensions

Height (Without DIN Mount):	25.4 mm (1.0 in)
Width:	93.35 mm (3.675 in)
Depth:	121.9 mm (4.8 in)

Type Tests

Communication Product Testing

Substation Products: IEEE 1613

Note: The SEL-2824 is compliant to a performance class of Class 1 of IEEE Standard 1613-2003, Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.

Electromagnetic Compatibility Emissions

Generic Emissions: CFR 47 Part 15
Severity Level: Class B

Product-Specific Emissions: IEC 60255-25:2000
FCC CFR 47 Part 15 Class B
This Class B device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
Canada ICES-001(A) / NMB-001(A)

Electromagnetic Compatibility Immunity

Conducted RF Immunity: IEC 60255-22-6:2001
Severity Level: 10 V/m
IEC 61000-4-6:2008
Severity Level: 10 V/m

Radiated RF Immunity: IEC 60255-22-3:2007
Severity Level: 10 V/m
IEC 61000-4-3:2010
Severity Level: 10 V/m
ENV 50204-1995
Severity Level: 10 V/m at 900 MHz and 1.89 GHz
IEEE C37.90.2-2004
Severity Level: 35 V/m

Electrostatic Discharge Immunity: IEC 60255-22-2:2008
Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air
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, 8 kV contact; 4, 8, 15 kV air

Fast Transient/ Burst Immunity: IEC 60255-22-4:2008
Severity Level: Class A: 4 kV at 5 kHz, 2 kV at 5 kHz on comm ports
IEC 61000-4-4:2011
Severity Level: 4 kV, 5 kHz

Surge Withstand Capability Immunity: 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 oscillatory, 4 kV fast transient waveform

Power Supply Immunity: IEC 60255-11:2008
IEC 61000-4-29:2000
IEC 61000-4-11:2004
IEC 61000-4-17:2002

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°C to 55°C, 6 cycles, Relative Humidity: 95%

Dry Heat: IEC 60068-2-2:2007
Severity Level: 16 hours at +85°C

Vibration: IEC 60255-21-3:1993
Severity Level: Class 2 (Quake Response)
IEC 60255-21-1:1988
Severity Level: Class 1 Endurance, Class 2 Response
IEC 60255-21-2:1988
Severity Level:
Class 1—Shock withstand, Bump, and
Class 2—Shock Response

Safety

Laser Safety:	Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.

Safety Notes: Although Class 1 lasers are considered to be eye safe, avoid staring into the transmitter or fiber-end infrared radiation. The lasers are not user serviceable. Return to the factory for repair or replacement.

Caution: Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

Appendix A: Manual Versions

Determining the Manual Version

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table 5 lists the product manual release dates and a description of modifications. The most recent product manual revisions are listed at the top.

Table 5 Manual Revision History

Revision Date	Summary of Revisions
20241216	Updated *Specifications*.
20210715	Updated *Specifications*.
20120629	Initial version.

Appendix B: Determining Maximum Cable Length

The optical power budget of 15 dB includes transmit and receive connector coupling loss; therefore, the maximum cable length is determined by dividing the total optical power budget by the typical fiber loss/km specification.

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 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 the table below. Divide the available optical power budget by the fiber loss/km specification to determine the maximum cable length.

Table 6 Example Calculation for SEL-C808 Fiber-Optic Cable

Value	Variable or Calculation
Fiber Type	62.5 µm
Splice Loss (fusion)	0.2 dB/splice
Fiber Loss @ 850 nm	3.2 dB/km
SEL-2824 Optical Budget	16 dB
Less Splice Loss (1 • 0.2 dB)	0.2 dB
Available Power	15.8 dB
Maximum Cable Length	15.8 dB ÷ 3.2 dB/km = 4.9 km

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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Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

⚠CAUTION
Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

⚠CAUTION
Class 1 LASER Product. This product uses visible or invisible LASERs based on model option. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

⚠WARNING
Operator safety may be impaired if the devices is used in a manner not specified by SEL.

⚠DANGER
Contact with instrument terminals can cause electrical shock that can result in injury or death.

⚠ATTENTION
L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.

⚠ATTENTION
Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

⚠ATTENTION
Produit LASER de Classe 1. Ce produit utilise des LASERS visibles ou invisibles dépendant des options du modèle. Regarder vers les connecteurs optiques, les extrémités des fibres ou les connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.

⚠AVERTISSEMENT
La sécurité de l'opérateur peut être compromise si l'appareil est utilisé d'une façon non indiquée par SEL.

⚠DANGER
Tout contact avec les bornes de raccordement de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

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