



Attaching the PA-A1 ATM Interface Cables

To continue your PA-A1 ATM port adapter installation, you must attach the port adapter cables. The instructions that follow apply to all supported platforms. This chapter contains the following sections:

- [Connecting an Interface Cable, page 4-1](#)
- [SONET Distance Limitations, page 4-2](#)
- [Determining the Power Budget, page 4-3](#)
- [Approximating the PA-A1 ATM Power Margin, page 4-3](#)

Connecting an Interface Cable

PA-A1 ATM interfaces are full-duplex. You must use the appropriate ATM interface cable to connect the PA-A1 ATM with an external ATM network. The PA-A1 ATM cables, shown in [Figure 4-1](#) and [Figure 4-2](#), provide an interface to ATM switching fabrics for transmitting and receiving data at rates of up to 155 Mbps bidirectionally. The PA-A1 ATM connects to the SONET/SDH 155 Mbps multimode or single-mode optical fiber—STS-3 or STM-1 physical layer.

An OC-3 ATM interface cable, which is used to connect your router to an external DSU (an ATM network), is available for use with the PA-A1 ATM.

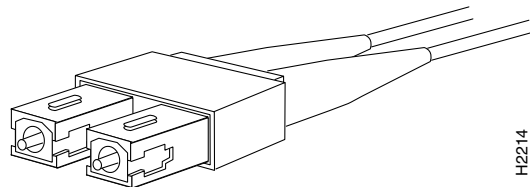


Note

The ATM port on the PA-A1 ATM is considered to be a DTE device.

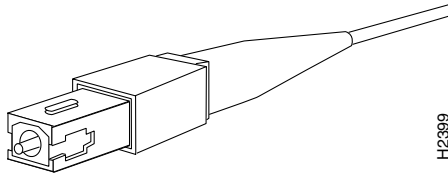
For SONET/SDH multimode and SONET/STC-3 single-mode connections, use one duplex SC connector (see [Figure 4-1](#)) or two single SC connectors (see [Figure 4-2](#)). The SONET simplex and duplex SC connectors are shipped with removable dust covers on each connector.

Figure 4-1 Duplex SC Connector



H2214

Figure 4-2 Simplex SC Connector



Single-mode and multimode cables should perform to the following specifications:

Standard	Maximum Path Length	Cabling
ISO/IEC 9314-3	2 km (all cables in a connection, end-to-end)	62.5-micron core with an optical loss of 0 to 9 dB, or 50-micron core with an optical loss of 7 dB

**Note**

A single fiber link should not mix 62.5- and 50-micron core cable.

SONET Distance Limitations

The SONET specification for fiber-optic transmission defines two types of fiber: single-mode and multimode. Modes can be thought of as bundles of light rays entering the fiber at a particular angle. Single-mode fiber allows only one mode of light to propagate through the fiber, while multimode fiber allows multiple modes of light to propagate through the fiber. Multiple modes of light propagating through the fiber travel different distances depending on the entry angles. The differing travel speeds cause the modes to arrive at the destination at different times. Single-mode fiber is capable of higher bandwidth and greater cable run distances than multimode fiber.

The typical maximum distances for single-mode and multimode transmissions, as defined by SONET, are shown in Table 4-1. If the distance between two connected stations is greater than this maximum distance, significant signal loss can result, making transmission unreliable.

Table 4-1 Maximum Fiber-Optic Power Budget and Transmission Distances

Transceiver Type	Power Budget	Transmit Power	Receive Power	Maximum Distance Between Stations ¹
Single-mode ²	13 dB ³	-15 to -8 dBm ⁴ at 1261 to 1360 nm ⁵	-28 to -8 dBm	Up to 9.3 miles (15 km)
Multimode	11 dB	-19 to -14 dBm at 1270 to 1380 nm	-30 to -14 dBm	Up to 1.2 miles (2 km)

1. Table 4-1 gives typical results. Use the power budget calculations described below to determine the actual distances.
2. Complies with Bellcore GR-253 Intermediate Reach Specification.
3. dB = decibels
4. dBm = decibels per milliwatt
5. nm = nanometers

Determining the Power Budget

To design an efficient optical data link, evaluate the power budget. The power budget is the amount of light available to overcome attenuation in the optical link and to exceed the minimum power that the receiver requires to operate within its specifications. Proper operation of an optical data link depends on modulated light reaching the receiver with enough power to be correctly demodulated.

Attenuation, caused by the passive media components (cables, cable splices, and connectors), is common to both multimode and single-mode transmission.

The following variables reduce the power of the signal (light) transmitted to the receiver in multimode transmission:

- Chromatic dispersion (spreading of the signal in time because of the different speeds of light wavelengths)
- Modal dispersion (spreading of the signal in time because of the different propagation modes in the fiber)

Attenuation is significantly lower for optical fiber than for other media. For multimode transmission, chromatic and modal dispersion reduce the available power of the system by the combined dispersion penalty (dB). The power lost over the data link is the sum of the component, dispersion, and modal losses.

Table 4-2 lists the factors of attenuation and dispersion for typical fiber-optic cable.

Table 4-2 Typical Fiber-Optic Link Attenuation and Dispersion Limits

Limits	Single-mode	Multimode
Attenuation	0.5 dB	1.0 dB/km
Dispersion	No limit	500 MHz/km ¹

1. The product of bandwidth and distance must be less than 500 MHz/km.

Approximating the PA-A1 ATM Power Margin

The LED used for a multimode transmission light source creates multiple propagation paths of light, each with a different path length and time requirement to cross the optical fiber, causing signal dispersion (smear). Higher order mode loss (HOL) results when light from the LED enters the fiber and radiates into the fiber cladding. A worst case estimate of power margin (PM) for multimode transmissions assumes minimum transmitter power (PT), maximum link loss (LL), and minimum receiver sensitivity (PR). The worst case analysis provides a margin of error; not all of the parts of an actual system will operate at the worst case levels.

The power budget (PB) is the maximum possible amount of power transmitted. The following equation lists the calculation of the power budget:

$$PB = PT - PR$$

$$PB = -20 \text{ decibels per meter (dBm)} - (-30 \text{ dBm})$$

$$PB = 10 \text{ dB}$$

The power margin calculation is derived from the power budget and subtracts the link loss:

$$PM = PB - LL$$

If the power margin is positive, the link usually will work.

Table 4-3 lists the factors that contribute to link loss and the estimate of the link loss value attributable to those factors.

Table 4-3 Link Loss Factors and Values

Link Loss Factor	Estimate of Link Loss Value
Higher order mode losses	0.5 dB
Clock recovery module	1 dB
Modal and chromatic dispersion	Dependent on fiber and wavelength used
Connector	0.5 dB
Splice	0.5 dB
Fiber attenuation	1 dB/km for multimode (0 dB/km for single-mode)

After calculating the power budget minus the data link loss, the result should be greater than zero. Circuits whose results are less than zero may have insufficient power to operate the receiver.

The SONET specification requires that the signal must meet the worst case parameters listed in Table 4-4.

Table 4-4 ATM Port Adapter SONET Signal Requirements

	Single-mode	Multimode
PT	-15 dBm	-20 dBm
PR	-31 dBm	-30 dBm
PB	13 dB	11 dB

Multimode Power Budget Example with Sufficient Power for Transmission

The following is an example of multimode power budget calculated based on the following variables:

- Length of multimode link = 3 kilometers (km)
- 4 connectors
- 3 splices
- Higher order loss (HOL)
- Clock recovery module (CRM)

Estimate the power budget as follows:

$$PB = 11 \text{ dB} - 3 \text{ km} (1.0 \text{ dB/km}) - 4 (0.5 \text{ dB}) - 3 (0.5 \text{ dB}) - 0.5 \text{ dB (HOL)} - 1 \text{ dB (CRM)}$$

$$PB = 11 \text{ dB} - 3 \text{ dB} - 2 \text{ dB} - 1.5 \text{ dB} - 0.5 \text{ dB} - 1 \text{ dB}$$

$$PB = 3 \text{ dB}$$

The positive value of 3 dB indicates that this link would have sufficient power for transmission.

Multimode Power Budget Example of Dispersion Limit

The following example has the same parameters as the previous example, but with a multimode link distance of 4 km:

$$PB = 11 \text{ dB} - 4 \text{ km} (1.0 \text{ dB/km}) - 4 (0.5 \text{ dB}) - 3 (0.5 \text{ dB}) - 0.5 \text{ dB (HOL)} - 1 \text{ dB (CRM)}$$

$$PB = 11 \text{ dB} - 4 \text{ dB} - 2 \text{ dB} - 1.5 \text{ dB} - 0.5 \text{ dB} - 1 \text{ dB}$$

$$PB = 2 \text{ dB}$$

The value of 2 dB indicates that this link would have sufficient power for transmission. But, because of the dispersion limit on the link (4 km x 155.52 MHz > 500 MHz/km), this link would not work with multimode fiber. In this case, single-mode fiber would be the better choice.

Single-Mode Transmission

The single-mode signal source is an injection laser diode. Single-mode transmission is useful for longer distances, because there is a single transmission path within the fiber and smear does not occur. In addition, chromatic dispersion is also reduced because laser light is essentially monochromatic.

The maximum overload specification on the single-mode receiver is -14 dBm. The single-mode receiver can be overloaded when using short lengths of fiber because the transmitter can transmit up to -8 dB, but no damage to the receiver will result.



Caution

To prevent overloading the receiver that is connecting short fiber links, insert a 5 to 10 dB attenuator on the link between any single-mode SONET transmitter and the receiver.

SONET Single-Mode Power Budget Example

The following example of a single-mode power budget assumes two buildings, 8 kilometers apart, are connected through a patch panel in an intervening building with a total of 12 connectors:

- Length of single-mode link = 8 km
- 12 connectors

Estimate the power margin as follows:

$$PM = PB - LL$$

$$PM = 13 \text{ dB} - 8 \text{ km} (0.5 \text{ dB/km}) - 12 (0.5 \text{ dB})$$

$$PM = 13 \text{ dB} - 4 \text{ dB} - 6 \text{ dB}$$

$$PM = 3 \text{ dB}$$

The value of 3 dB indicates that this link would have sufficient power for transmission and is not in excess of the maximum receiver input power.

Using Statistics to Estimate the Power Budget

Statistical models more accurately determine the power budget than the worst case method. Determining the link loss with statistical methods requires accurate knowledge of variations in the data-link components. Statistical power budget analysis is beyond the scope of this document. For further information, refer to UNI Forum specifications, ITU-T standards, and your equipment specifications.