



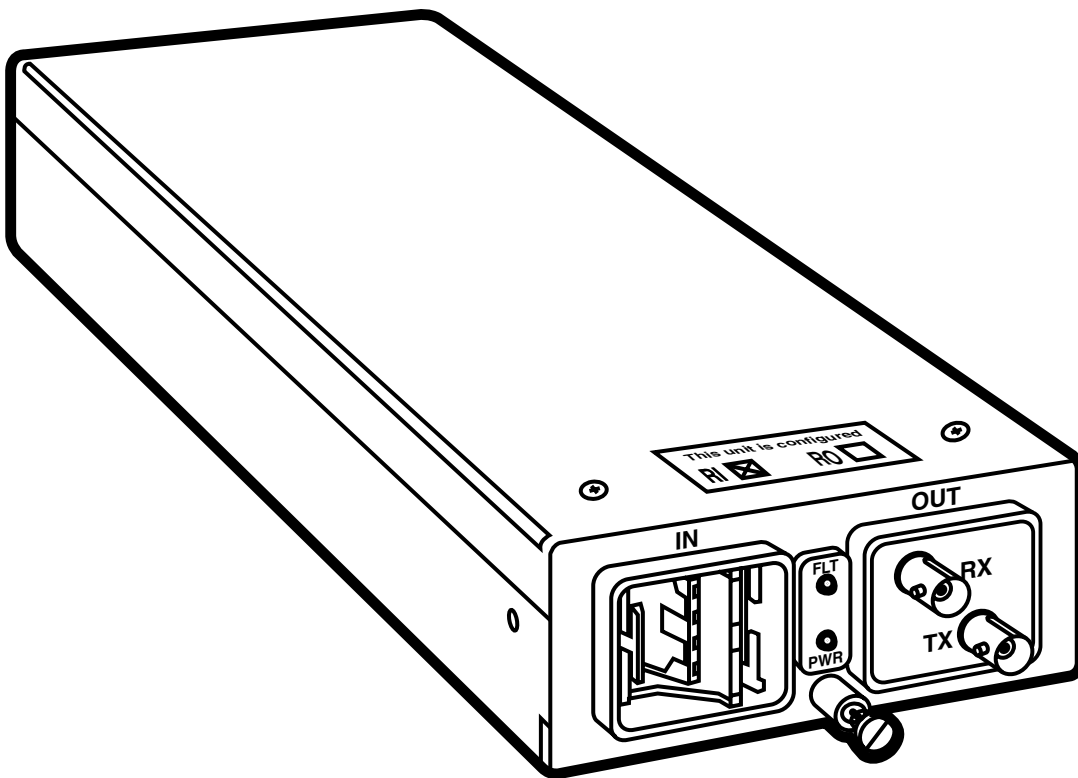
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# Fiber Optic Repeaters



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This equipment generates, uses, and can radiate radio-frequency energy, and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio communication. It has been tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart B of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when the equipment is operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be necessary to correct the interference.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

*This digital apparatus does not exceed the Class A limits for radio noise emission from digital apparatus set out in the Radio Interference Regulation of Industry Canada.*

*Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la classe A prescrites dans le Règlement sur le brouillage radioélectrique publié par Industrie Canada.*

### INSTRUCCIONES DE SEGURIDAD (Normas Oficiales Mexicanas Electrical Safety Statement)

1. Todas las instrucciones de seguridad y operación deberán ser leídas antes de que el aparato eléctrico sea operado.
2. Las instrucciones de seguridad y operación deberán ser guardadas para referencia futura.
3. Todas las advertencias en el aparato eléctrico y en sus instrucciones de operación deben ser respetadas.
4. Todas las instrucciones de operación y uso deben ser seguidas.
5. El aparato eléctrico no deberá ser usado cerca del agua—por ejemplo, cerca de la tina de baño, lavabo, sótano mojado o cerca de una alberca, etc..
6. El aparato eléctrico debe ser usado únicamente con carritos o pedestales que sean recomendados por el fabricante.
7. El aparato eléctrico debe ser montado a la pared o al techo sólo como sea recomendado por el fabricante.
8. Servicio—El usuario no debe intentar dar servicio al equipo eléctrico más allá a lo descrito en las instrucciones de operación. Todo otro servicio deberá ser referido a personal de servicio calificado.
9. El aparato eléctrico debe ser situado de tal manera que su posición no interfiera su uso. La colocación del aparato eléctrico sobre una cama, sofá, alfombra o superficie similar puede bloquea la ventilación, no se debe colocar en libreros o gabinetes que impidan el flujo de aire por los orificios de ventilación.
10. El equipo eléctrico debe ser situado fuera del alcance de fuentes de calor como radiadores, registros de calor, estufas u otros aparatos (incluyendo amplificadores) que producen calor.
11. El aparato eléctrico deberá ser conectado a una fuente de poder sólo del tipo descrito en el instructivo de operación, o como se indique en el aparato.
12. Precaución debe ser tomada de tal manera que la tierra física y la polarización del equipo no sea eliminada.
13. Los cables de la fuente de poder deben ser guiados de tal manera que no sean pisados ni pellizcados por objetos colocados sobre o contra ellos, poniendo particular atención a los contactos y receptáculos donde salen del aparato.
14. El equipo eléctrico debe ser limpiado únicamente de acuerdo a las recomendaciones del fabricante.
15. En caso de existir, una antena externa deberá ser localizada lejos de las líneas de energía.
16. El cable de corriente deberá ser desconectado del cuando el equipo no sea usado por un largo periodo de tiempo.
17. Cuidado debe ser tomado de tal manera que objetos líquidos no sean derramados sobre la cubierta u orificios de ventilación.
18. Servicio por personal calificado deberá ser provisto cuando:
  - A: El cable de poder o el contacto ha sido dañado; u
  - B: Objetos han caído o líquido ha sido derramado dentro del aparato; o
  - C: El aparato ha sido expuesto a la lluvia; o
  - D: El aparato parece no operar normalmente o muestra un cambio en su desempeño; o
  - E: El aparato ha sido tirado o su cubierta ha sido dañada.

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## SAFETY WARNING

**Always observe standard safety precautions during installation, operation, and maintenance of this product. To avoid the possibility of electrical shock, be sure to disconnect the power cord from the power source before you remove the power-supply fuse or perform any repairs. Also, do not look directly into a fiber cable or a port on the Fiber Optic Repeater — it could blind you!**

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# 1. Specifications

## Electrical Interface

Transmission Line —	4-wire (dual twisted pair)
Transmission Range —	(On IBM® Type-1 cable between the Repeater and the next active station) 2500 feet (762 meters)—4 Mbps; 1200 feet (366 meters)—16 Mbps
Data Rate —	4 or 16 Mbps
Data Format —	Balanced bipolar, differential Manchester encoding
Output Level (Nominal) —	3 to 4 V <sub>ptp</sub> (on 150 Ω)
Input Impedance —	STP: 150±15 Ω
Electrical Connector —	STP: IBM Data Connector

## Optical Interface

Interface Types —	LT0008A-ST: Multimode; LT0008A-1300: Single mode
Transmission Line —	Dual fiberoptic cable
Transmission Mode —	Full duplex
Data Rate —	4 or 16 Mbps
Wavelength —	LT0008A-ST (Multimode interface): 850 nm; LT0008A-1300 (Single-mode interface): 1300 nm
Transmission Range —	LT0008A-ST (Multimode interface): Typically up to 1.9 miles (3.1 km); LT0008A-1300 (Single-mode interface): Typically up to 12.5 miles (20.1 km)
Optical Output Power —	LT0008A-ST (Multimode): <i>50/125 micron multimode fiber</i> : -22 dBm; <i>62.5/125 micron multimode fiber</i> : -18 dBm; <i>100/140 micron multimode fiber</i> : -14 dBm; LT0008A-1300 (Single mode): <i>9/125 micron single-mode fiber</i> : -18 dBm
Fiberoptic Connector —	ST®
Receiver Sensitivity —	-32 dBm minimum
Dynamic Range —	20 dB minimum



## FIBER OPTIC REPEATERS

**Optical Power Budget —** LT0008A-ST (Multimode): *50/125 micron multimode fiber*: 10 dB; *62.5/125 micron multimode fiber*: 14 dB; *100/140 micron multimode fiber*: 18 dB; LT0008A-1300 (Single mode): *9/125 micron single-mode fiber*: 14 dB

### General

**Compliance —** FCC, CE

**Cable Break Protection —** User-selectable; the main path signal appearing at the repeater output is looped to the backup path when the optical signal is lost

**Power Loss Protection —** The Fiber Optic Repeater is automatically bypassed upon loss of power

**Indicators —** (2) LEDs: (1) green PWR (On when the unit is powered); (1) red FLT (On when the optical signal is lost, and flashes when the remote optical signal is lost)

**Diagnostics —** Fault (FLT) LED shows problems on the fiber cable

**MTBF —** 1,235,369 hours

**Operating Temperature —** 32 to 122°F (0 to 50°C)

**Relative Humidity Tolerance —** 10 to 90%, noncondensing

**Power —** 115/230 VAC±10%, 47 to 63 Hz, 5 watts

**Size —** 1.75"H x 4.3"W x 9.4"D (4.5 x 10.9 x 23.9 cm)

**Weight —** 2.8 lb. (1.3 kg)

## 2. Introduction

### 2.1 Description

The Fiber Optic Repeaters are versatile fiberoptic repeaters for 16- and 4-Mbps token ring local-area networks (LAN) with user-selectable automatic cable-break protection.

The Repeaters allow the use of fiberoptic ring segments in token-ring networks, for increased range (up to 9000 ft. or 3 km per fiberoptic segment), improved performance, and better reliability. For maximum flexibility, industry-standard 50/125, 62.5/125 or 100/140 micron fibers can be used with the LT0008A-ST. The LT0008A-1300 is a single-mode interface for use with 9/125 micron fibers. The use of fiberoptic cables as the ring transmission medium reduces susceptibility to electrical noise and radio interference and increases communication security by providing immunity to tapping and eavesdropping along exposed cable segments.

The Fiber Optic Repeaters can be used both to extend the range of twisted-pair token-ring LANs and to build pure-fiber LANs.

The Repeaters come in two models:

- LT0008A-ST: A repeater for 16- or 4-Mbps token-ring LANs. It has a multimode interface and a wavelength of 850 nm, and is used with 50/125, 62.5/125, or 100/140 micron fibers.
- LT0008A-1300: A repeater for 16- or 4-Mbps token-ring LANs. It has a single-mode interface and a wavelength of 1300 nm, and is used with 9/125 micron fibers.

### 2.2 Repeaters

#### 2.2.1 GENERAL INFORMATION

Repeaters are used on token-ring LANs to increase the maximum length of the ring. In a token ring operating on twisted-pair cable (a “copper” ring), each active station participates in the transmission process by receiving the attenuated signal, regenerating it, and retransmitting it down the ring. The minimum input signal that can be reliably received by a token-ring device meeting IEEE 802.5 requirements is 0.2V peak-to-peak, and the nominal transmit level is 4V peak-to-peak. Therefore, the maximum allowable cable attenuation is 26 dB. This is a major factor limiting the maximum length of the copper ring, because at 4 Mbps the attenuation of IBM Type 1 cable is 22 dB/km (one km equals 3300 ft.), and the attenuation at 16 Mbps is about 45 dB/km. This limits the maximum recommended distance covered by any single ring segment to 375 m at 4 Mbps, or 150 m at 16 Mbps.

To increase the distance, repeaters are necessary. A repeater is similar to an active station: it regenerates the received ring signal and retransmits it down the ring at the nominal level. However, unlike an active station, the repeater is always inserted into the ring. A copper repeater nominally doubles the recommended distance covered by a ring segment. In addition, it provides a method of ensuring that large rings will continue to operate even if only one station is active on the ring. The number of repeaters that can be used on the same ring is limited by the additional jitter (random timing deviations) contributed by each repeater and workstation.

To achieve significantly greater ranges, a different transmission medium is required—fiberoptic cables. Among other advantages (bandwidth, security, etc.), fiberoptic cable has much lower attenuation—3 to 6 dB/km—and this attenuation does not increase when operating at 16 Mbps.

## FIBER OPTIC REPEATERS

### 2.2.2 FIBER OPTIC REPEATERS

The Fiber Optic Repeaters perform two functions: conversion between electrical and optical signals, and repeating. Figure 2-1 shows a basic application for the Repeater.

In the application of Figure 2-1, MAUs located at two distant sites, A and B, are interconnected by a fiberoptic segment and terminated by two Repeaters. A simplified functional diagram of the two Repeaters and the fiberoptic segment is shown in Figure 2-2:

- The Repeater connected at the RO port of the MAU at site A receives the main-path ring signal, recovers its timing, and then regenerates a clean retimed signal.

In addition, the Repeater also performs jitter attenuation. Lower jitter increases the maximum number of stations that can be connected in the ring. The regenerated signal is applied to the Repeater's fiberoptic transmitter. The transmitter converts the electrical signal to an optical signal, and sends it via the fiberoptic cable to the other site.

- The Repeater connected to the RI port of the MAU at site B receives the optical signal and reconverts it to an electrical token-ring signal with full amplitude, in effect operating as another repeater circuit in the direction of the attached MAU.
- The Repeater provides the same functions for the backup path. The repeater serving the backup path is included in the Fiber Optic Repeater connected to the RI port.

The optical section of the Fiber Optic Repeater model LT0008A-ST supports 50/125, 62.5/125 and 100/140 micron graded-index multimode fibers, and the nominal range is 3 km. Model LT0008A-1300 supports 9/125-micron single-mode fibers, with a nominal range of 20 km. **Appendix B** provides information for calculating the attenuation of fiberoptic links and evaluating the available range.

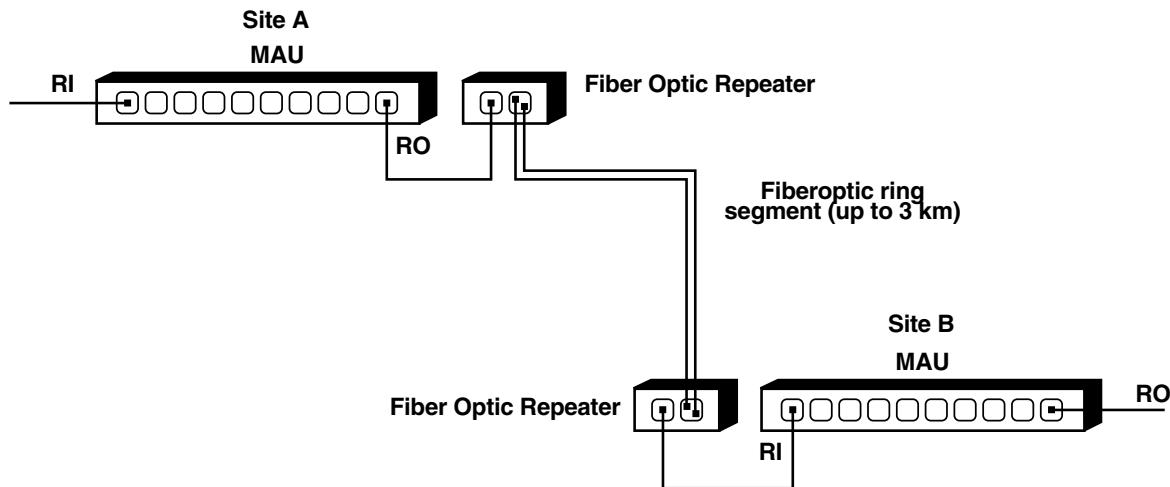


Figure 2-1. Basic Fiber Optic Repeater application.

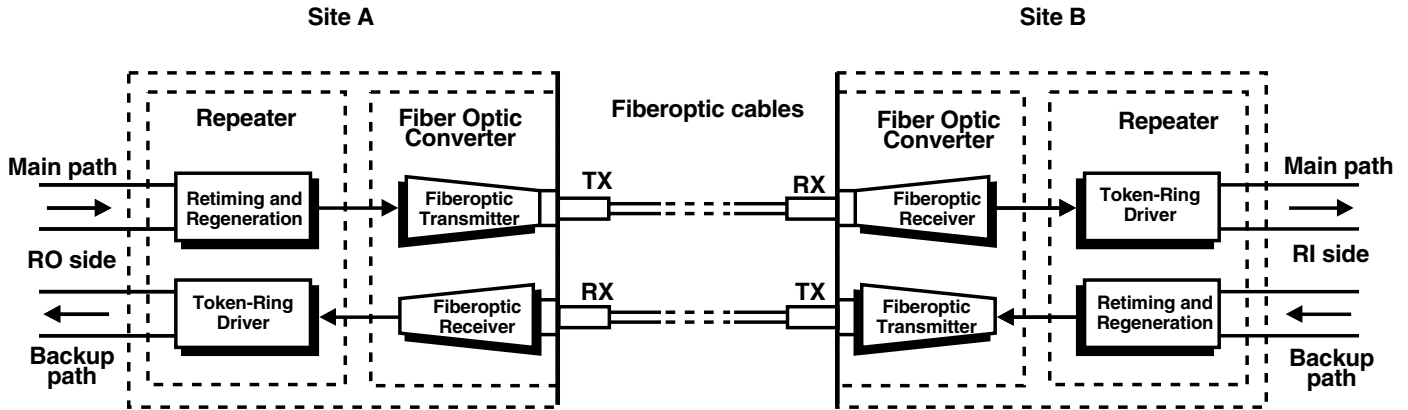


Figure 2-2. Functional diagram of the fiberoptic segment of Figure 2-1.

## 2.3 Protection

### 2.3.1 CABLE-BREAK PROTECTION

Both Repeater models include cable-break protection. A switch located on the card allows the user to disable this function when one Repeater operates in a link terminated at the other end in a fiberoptic repeater or converter using an incompatible cable-break protection method, or without cable break protection altogether.

The cable break protection function automatically detects breaks in the fiberoptic cable and loops the main path to the backup path, to maintain ring continuity. This is illustrated in Figure 2-3, which shows what happens on the fiberoptic segment of Figure 2-1 when one of the cable fibers breaks or is accidentally disconnected at an optical patch panel.

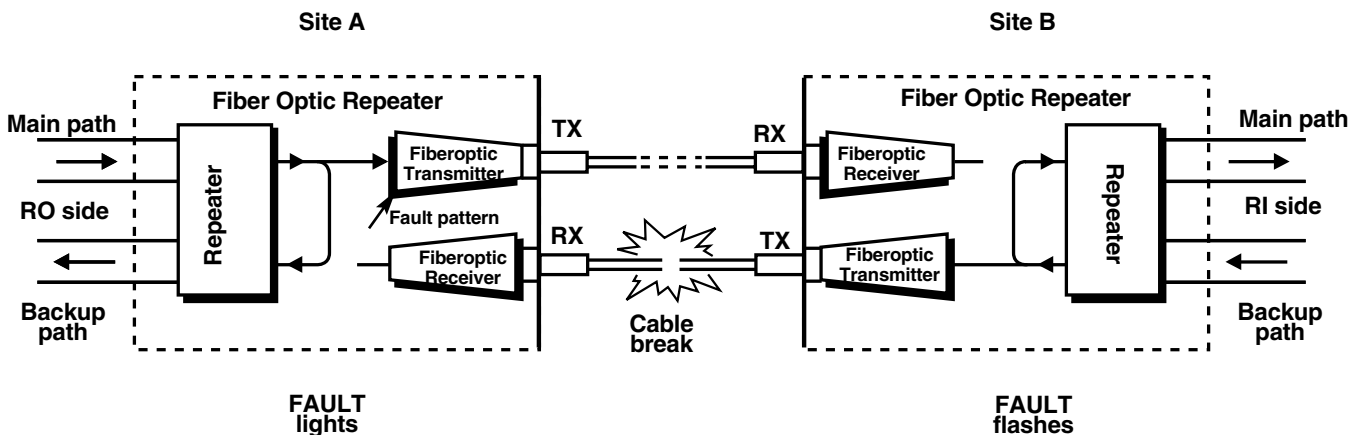


Figure 2-3. Operation of cable break protection function.

## FIBER OPTIC REPEATERS

Suppose the fiber connected to the RX connector of site A breaks. The Repeater detects the loss of the optical signal and...

1. Loops the main path to the backup path *after* passing through the repeater section. This ensures that the Repeater returns a regenerated ring signal.
2. Sends a fault pattern on the TX fiber. The Repeater at site B detects this pattern and loops the main path to the backup path (after regeneration of the signal by the repeater).

These two actions maintain ring continuity in case of a break in the fiberoptic segments.

To notify the user that a fault condition exists, the two Repeaters provide fault indications:

- At the receiving Repeater, the FLT indicator lights continuously to indicate that the receive signal is missing.
- At the other Repeater, the FLT indicator flashes, to indicate that the transmit fiber is disconnected.

The cable-break detection is also operating even when the token-ring network is inactive (for example, when all the stations are deinserted and there is no ring signal).

### 2.3.2 PROTECTION IN CASE OF POWER LOSS

In case of power loss, the Repeater automatically loops the main path to the backup, as shown in Figure 2-4. Note that in this case the repeater is not included in the ring (because it is not powered).

When the cable-break protection function is enabled and the optical input signal is lost, the Repeater at the far end will detect this condition, and will also perform looping to the backup path.

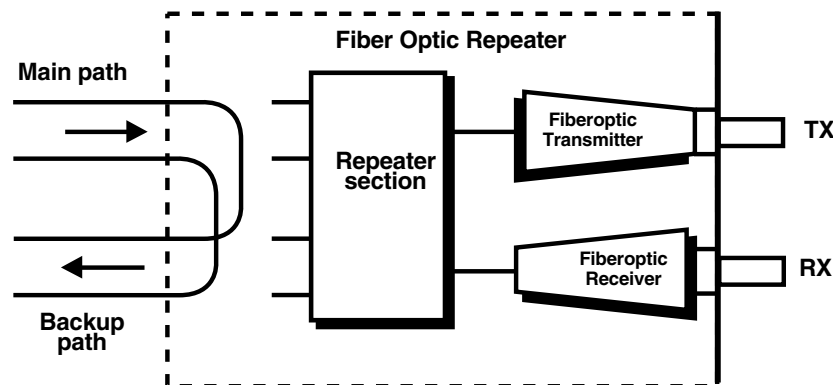


Figure 2-4. Operation of power loss protection.

### 2.3.3 COMPATIBILITY RULES FOR CABLE-BREAK PROTECTION

As explained above, both Repeater models include cable-break protection. The following compatibility rules apply:

- Always enable cable break protection at both ends of the link, unless a compatibility problem exists. This means that you should always enable cable break protection when operating two Repeaters in a link.
- Disable cable break protection when operating in the same optical link equipment with incompatible protection methods, for example, when a Fiber Optic Repeater is connected in a link to equipment from other manufacturers.

## 2.4 Systems Applications

### 2.4.1 GENERAL RECOMMENDATIONS

- Use the Repeaters on long ring segments, as a replacement for copper repeaters. You will achieve better performance and higher ring availability.
- Use the Repeaters to carry sensitive information by fiberoptic cable on exposed segments.
- Use the Repeaters to convert copper segments to fiberoptic segments where strong electrical interference (from industrial machines, nearby radar or radio transmitters) may disrupt token-ring operation, or lightning strikes or high-voltage lines present a safety hazard.

### 2.4.2 TYPICAL APPLICATIONS

#### Replacement for Copper Repeaters

Use the Fiber Optic Repeater in any installation where network calculations show that repeaters are required. See **Appendix B** for guidance.

#### Multi-story Buildings

A token-ring LAN installed in a multi-story requires a repeater in at least one segment of the ring. A practical and cost-effective solution is to use a fiberoptic vertical riser, as shown in Figure 2-5.

# FIBER OPTIC REPEATERS

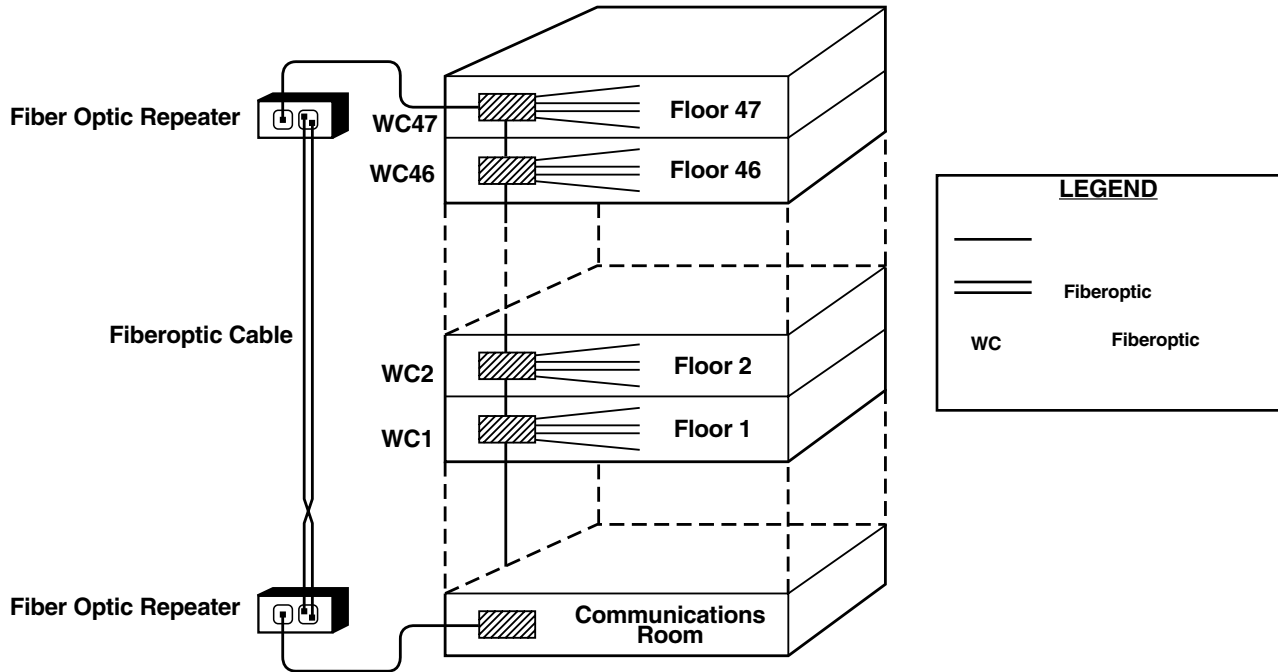


Figure 2-5. Using fiber optic riser in a multi-story building.

## Connections Between Distant Locations

When two sections of a token-ring network are located at a great distance (up to 3 km), use a fiber optic segment ending in two Fiber Optic Repeaters, to avoid the need for expensive bridges. See the example in Figure 2-6.

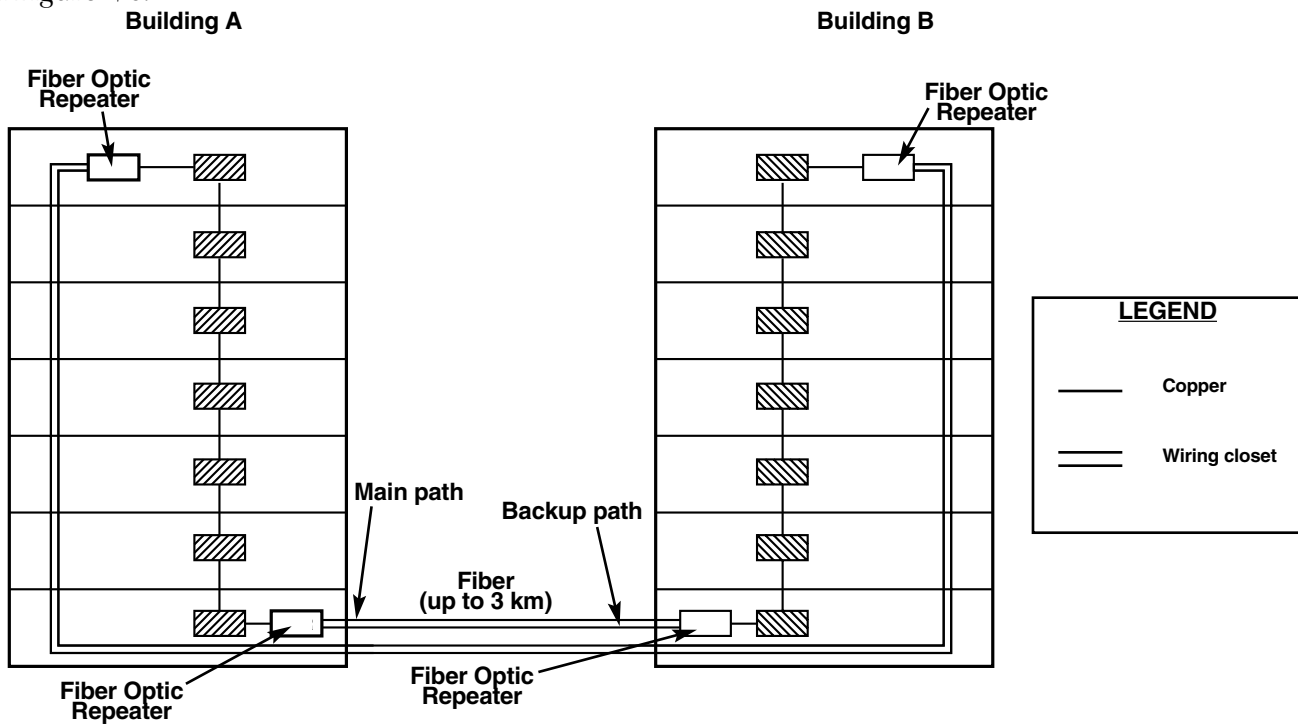


Figure 2-6. Linking distant token rings.

# 3. Installation

## 3.1 Site Requirements

### 3.1.1 POWER

The Fiber Optic Repeater is powered by 115 or 230 VAC. You'll need to install the unit within 5 feet (1.5 meters) of a grounded, easily accessible AC outlet capable of furnishing 115 or 230 V.

### CAUTION

**The Fiber Optic Repeater does not have a power switch. Operation starts when AC power is applied to the POWER connector. When applying AC power, first connect the plug of the AC cable to the POWER connector at the rear of the Repeater and then to the mains outlet.**

**Before powering the Repeater, its protective earth terminals must be connected to the protective conductor of the (mains) power cord. The mains plug should only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by use of an extension cord (power cable) without a protective conductor (grounding). Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided. Whenever it is likely that the protection offered by fuses has been impaired, the instrument must be made inoperative and secured against any unintended operation.**

### 3.1.2 GROUNDING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal can make this instrument dangerous. Intentional interruption is prohibited.

### 3.1.3 DATA CABLES CONNECTION

Patch cables are usually used to connect MAUs to the Fiber Optic Repeater within the same wiring concentrators. IBM Type-6 cables are generally used for STP patch cables within the wiring concentrator. See **Appendix A** for details on patch cables.

### 3.1.4 FIBEROPTIC CABLE CONNECTIONS

Figure 3-1 shows the connections of the fiberoptic cables to the Fiber Optic Repeater connectors. Make sure to connect each fiber between the TX connector at one end and the RX connector at the other end.



## FIBER OPTIC REPEATERS

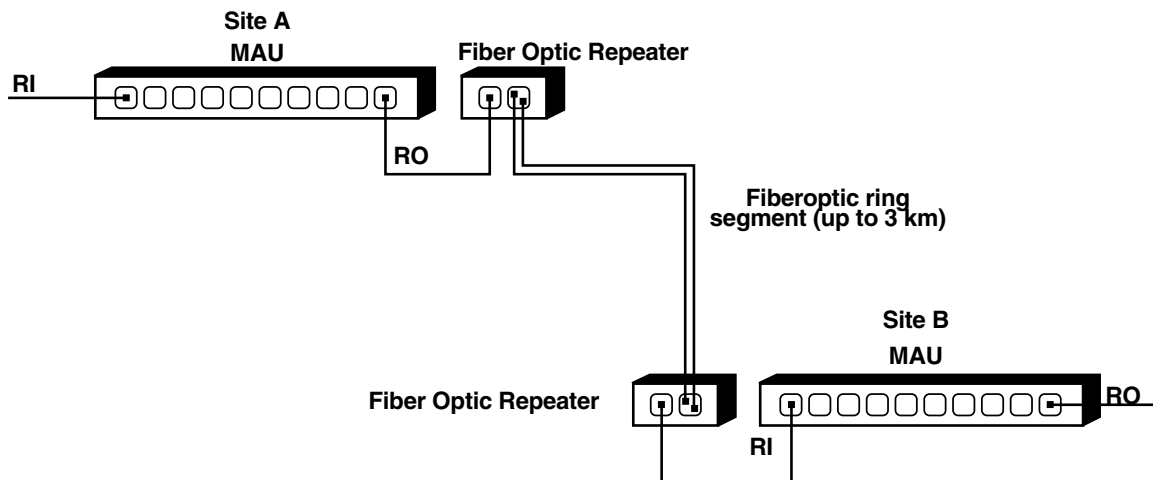


Figure 3-1. Fiber optic cable connections.

### 3.1.5 FRONT- AND REAR-PANEL CLEARANCE

When the equipment is installed in a rack, allow at least 36 inches (91.4 cm) of frontal clearance for operator access. Allow at least 4 inches (10.2 cm) clearance at the rear of the unit for power-cable connections.

### 3.1.6 PACKAGE CONTENTS

Along with the Fiber Optic Repeater, you should have received this user's manual and a power cord.

## 3.2 Reconfiguration Information

In order to configure your Fiber Optic Repeater, you'll need to follow these steps:

- Select the operating speed (4 or 16 Mbps, via the RATE switch).
- Select the repeater function (RO or RI).
- Select the cable break protection mode.
- Select the cable type as STP.

This section describes general configuration considerations, and also presents a summary of the recommended selections for typical applications.

Figure 3-2 shows the printed circuit board used by the Fiber Optic Repeater.

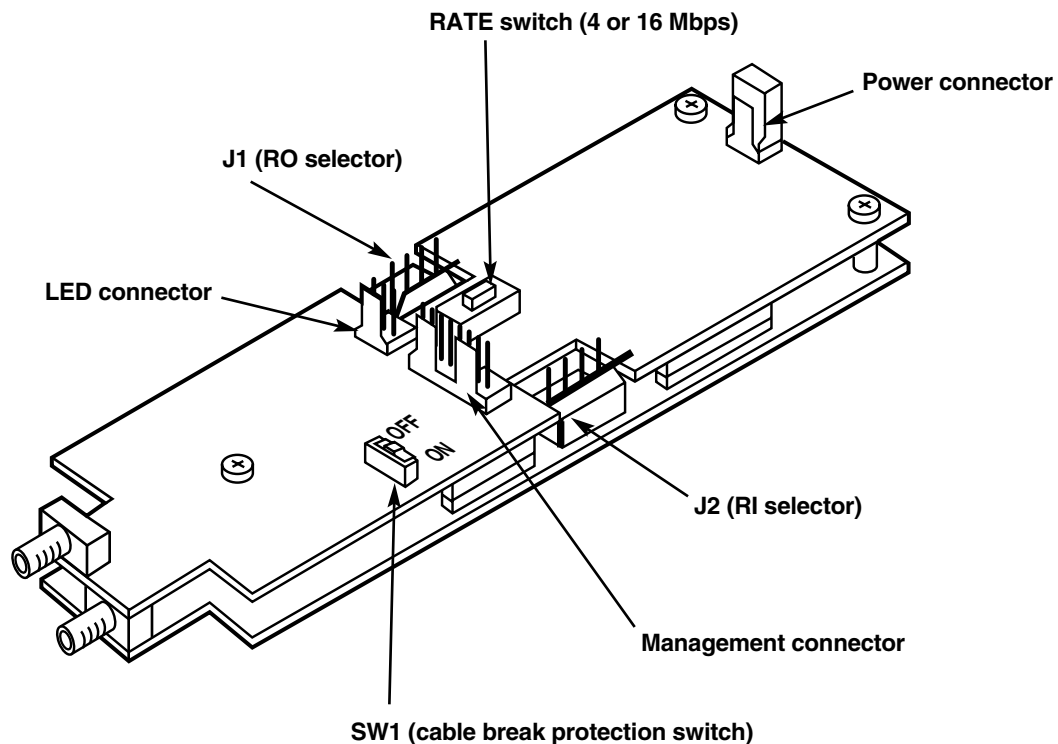


Figure 3-2. Identifying the board's components.

### 3.2.1 RO/RI SELECTION

The Fiber Optic Repeater can fulfill two functions: RO repeater or RI repeater.

The actual function depends on your system design requirements, and is selected by the internal connections made at installation time.

### 3.2.2 CABLE-BREAK PROTECTION

The Fiber Optic Repeater has an internal switch, SW1 (the ENABLE switch), which controls the cable-break protection function. The switch is located on the top card, in the position indicated in Figure 3-2.

The operation of the cable-break protection is explained in **Chapter 2**. **Chapter 2** also provides compatibility rules that are used to determine the position of the switch. For your convenience, these rules are summarized in the table on the next page.

### IMPORTANT!

Always enable cable-break protection at both ends of the link. If protection is enabled at only one end, the Fiber Optic Repeater at this end will loop the main path to the backup path. Usually this will disrupt token-ring operation.

The Fiber Optic Repeater is always delivered with cable-break protection enabled.

Fiber Optic Repeater Model	Equipment at Other End	SW1 Settings
LT0008A-ST or LT0008A-1300	LT0008A-ST or LT0008A-1300	Enable
LT0008A-ST or LT0008A-1300	From other vendors	Disable

#### 3.2.3 RATE SELECTION

The Fiber Optic Repeaters include a RATE switch (see Figure 3-2). Set the switch to the position corresponding to the token ring data rate.

#### 3.2.4 CABLE TYPE SELECTION

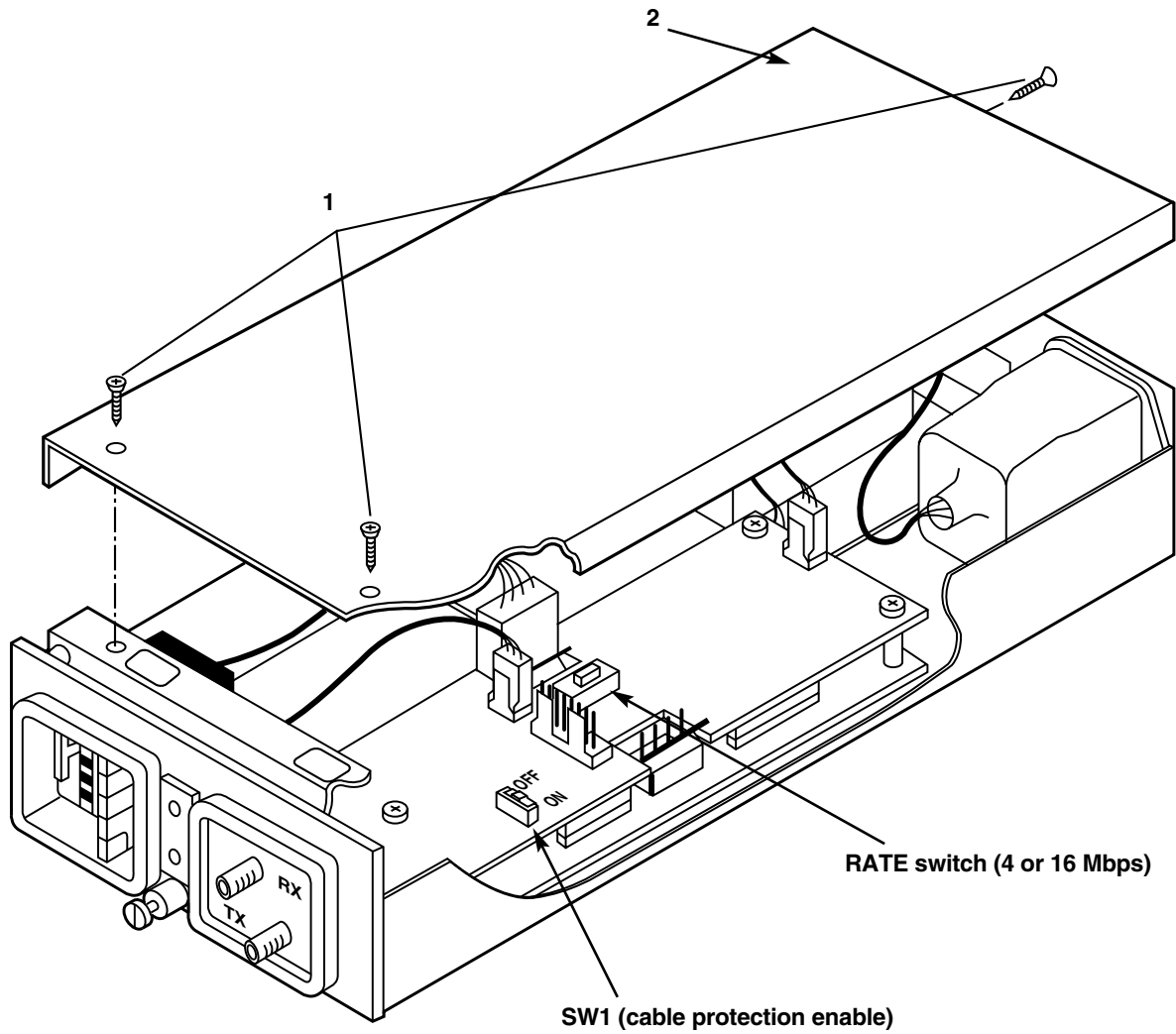
The Repeater's copper interface is an STP interface using an IDC connector. An internal switch, located on the bottom card (see Figure 3-2) is used to select accordingly the nominal impedance of the interface. The switch has two positions, and is set by the manufacturer. *Therefore, do not change its position.* It should be set for 150  $\Omega$  for proper operation with STP cable.

### 3.3 Reconfiguring and Installing the Fiber Optic Repeater

This section will tell you how to set the cable-break protection switch and change the configuration from RO to RI or vice versa.

#### NOTE

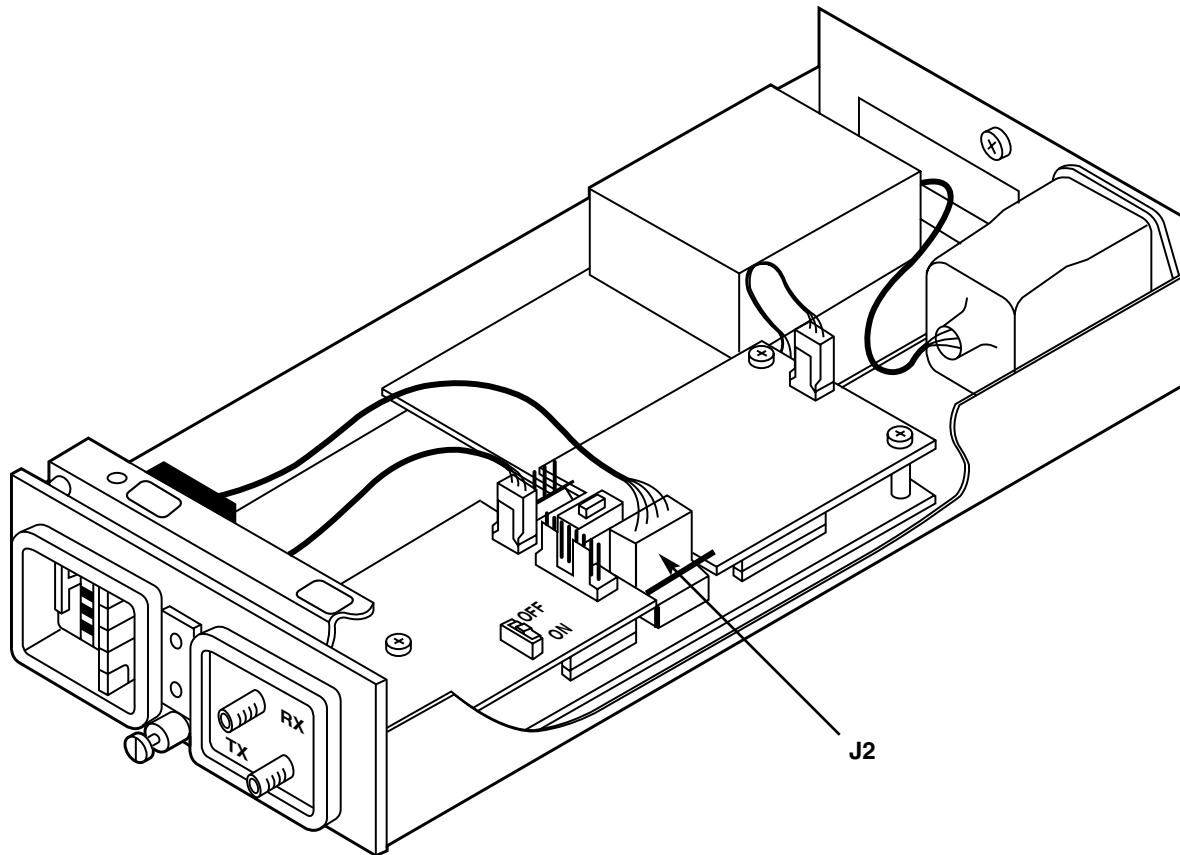
**Disconnect all power connections before attempting any installation, or before removing covers.**



**Figure 3-3. Setting the cable-break protection switch, SW1.**

To set switch SW1:

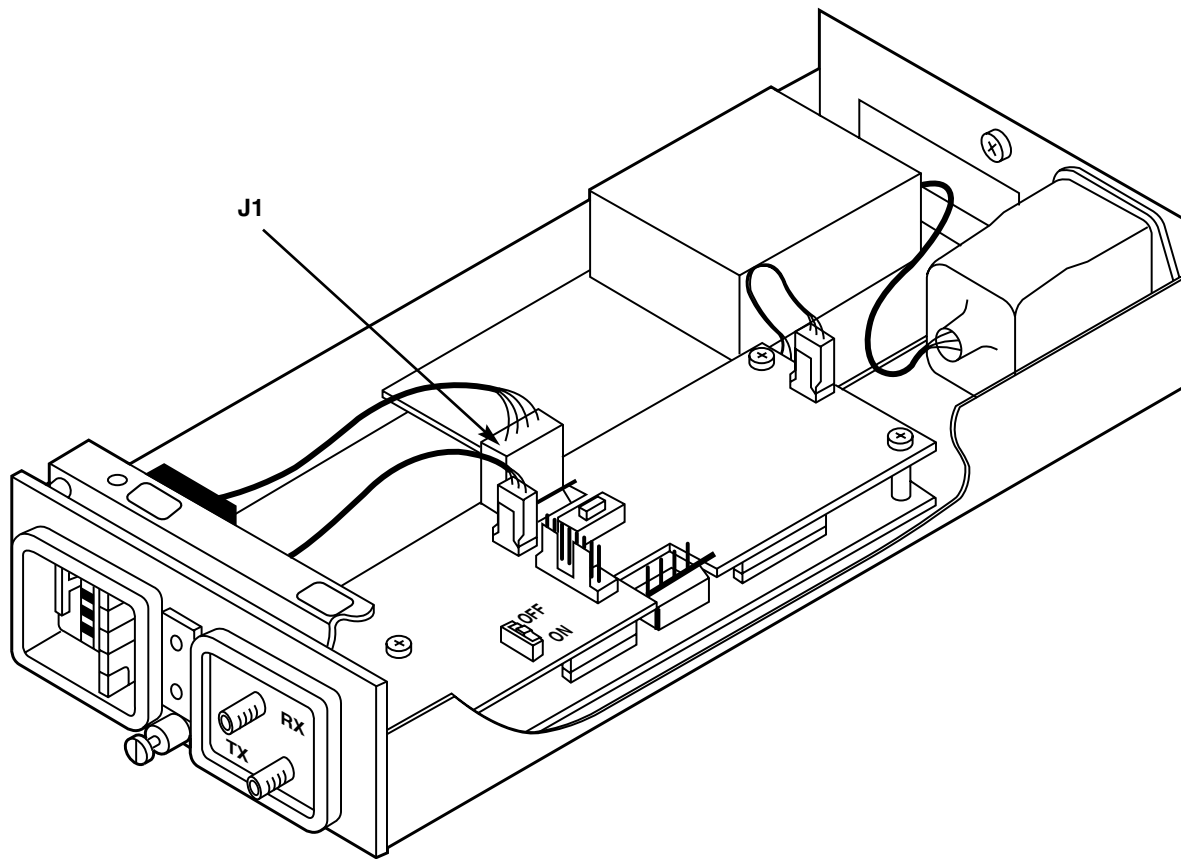
1. Remove the three screws fastening the top cover.
2. Remove the top cover.
3. Set switch SW1.
4. Reinstall the top cover and fasten with the three screws.



**Figure 3-4. Changing the configuration, RI side.**

To change the Repeater's configuration, RI side:

1. Remove the three screws fastening the top cover.
2. Remove the top cover.
3. Connect the cable from the IN connector to connector J2.
4. Set switch SW1 on the top circuit board as required.
5. Replace the cover and fasten the three screws in place.



**Figure 3-5. Changing the configuration, RO side.**

To change the Repeater's configuration, RO side:

1. Remove the three screws fastening the top cover.
2. Remove the top cover.
3. Connect the cable from the IN connector to connector J1.
4. Set switch SW1 on the top circuit board as required.
5. Replace the cover and fasten the three screws in place.

## 4. Operation

### 4.1 Front-Panel Indicators

The Fiber Optic Repeater LED panel provides configuration (RI or RO) information, and power and fault indications.

- FLT (Fault) indicates a cable fault:
  - FLT lights steadily when the receive signal is missing (fault on fiber connected to local RX connector).
  - When the cable-break protection ENABLE switch is set to ON at both ends of the cable, FLT flashes when the remote Fiber Optic Repeater does not receive a signal (fault on fiber connected to local TX connector).
- PWR (Power) lights when the Fiber Optic Repeater is powered.

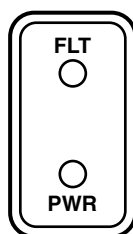


Figure 4-1. Front-panel indicators.

### 4.2 Fiber Optic Repeater Operation

#### 4.2.1 GENERAL

After being prepared for operation, the Fiber Optic Repeater normally operates unattended. Operator intervention is required only when a cable fault exists, or when the power supply has failed.

#### 4.2.2 CABLE-BREAK PROTECTION OPERATION

When the cable break protection is enabled and the ring segment (fiberoptic cable) connecting a pair of Fiber Optic Repeaters fails, the ring continues to function because the data is automatically routed into the backup ring path by the Fiber Optic Repeaters. Nevertheless, the faulty ring segment should be repaired as soon as possible to ensure reliable ring operation and to avoid ring segmentation if more segments of the ring fail.

### NOTE

If only one fiber of the dual fiberoptic cable fails, the FLT indicator of one Fiber Optic Repeater will flash, while the FLT indicator of the other Fiber Optic Repeater will light steadily, as explained in *Section 4.1*.

## 4.3 What to Do in Case of Malfunctions

### IMPORTANT!

**Disconnect all power connectors before attempting any installation, or before removing covers.**

#### 4.3.1 LOCAL FLT LED LIGHTS STEADILY

- Check that the fibers of the optical cable are correctly connected (from the TX connector of the local Fiber Optic Repeater to the RX connector of the remote Fiber Optic Repeater and vice versa).

You can check that this problem is *not caused* by incorrect fiber connection by interchanging between the fibers connected to the local TX and RX connectors. *If the problem is not corrected, immediately return the connections to their previous positions.*

- Check that the Fiber Optic Repeater at the other end of the ring segment receives power (its PWR LED must light).

If the PWR LED does not light, check that the Fiber Optic Repeater is receiving power and that its fuse is not blown. The fuse is located in the rear AC power connector. If it is blown, replace it with a fuse of the correct rating as marked on the case.

- Connect a short fiberoptic cable between the local TX and RX connectors. The FLT indicator must turn off; if not, replace the local Fiber Optic Repeater.
- Using an optical power meter, measure the optical power received from the remote Fiber Optic Repeater: it must be at least -40 dBm. If sufficient power is received, replace the local Fiber Optic Repeater. If the power is too low or no power is received, check and replace if necessary the remote Fiber Optic Repeater.
- If the problem is not corrected after the remote Fiber Optic Repeater is replaced, the problem is with the fiberoptic cable (on the fiber connected to the local RX connectors).

#### 4.3.2 LOCAL FLT LED FLASHES

Connect a power meter to the TX connector of the local Fiber Optic Repeater and check the output power. If it is too low, replace the local Fiber Optic Repeater.

### NOTE

**If you cannot measure optical power, connect a short fiber between the TX and RX connectors of the local Fiber Optic Repeater. If the local FLT LED lights up, replace the local Fiber Optic Repeater.**



### 4.4 Calling Your Supplier

If you determine that your Fiber Optic Repeater is malfunctioning, do not attempt to alter or repair the unit. It contains no user-serviceable parts. Contact Black Box at 724-746-5500.

Before you do, make a record of the history of the problem. Your supplier will be able to provide more efficient and accurate assistance if you have a complete description, including:

- the nature and duration of the problem.
- when the problem occurs.
- the components involved in the problem.
- any particular application that, when used, appears to create the problem or make it worse.

### 4.5 Shipping and Packaging

If you need to transport or ship your Repeater:

- Package it carefully. We recommend that you use the original container.
- If you are shipping the Repeater for repair, make sure you include everything that came in the original package. Before you ship, contact your supplier to get a Return Authorization (RA) number.

# Appendix A: Patch Cables

STP patch cables are usually made of IBM Type-6 cable terminated in IDC connectors. Two lengths are most common:

- *Short*: 8 feet (2.4 meters), for use within a rack.
- *Long*: 30 feet (10 meters) for use between racks.

Typical STP patch cables and their wiring diagrams are shown below.

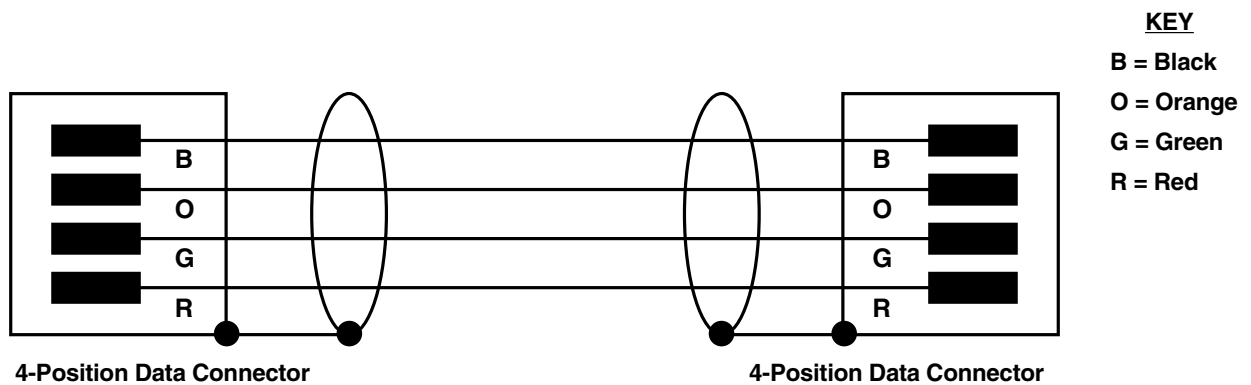


Figure A-1. STP patch cable (see the notes below).

## NOTES

1. Use IBM Type-6 cable.
2. The “G” and “R” lines are used for the main ring path.
3. The “O” and “B” lines are used for the backup ring path.

# Appendix B: Fiberoptic Budget Calculations

Fiberoptic ring segments must be analyzed to ensure that their attenuation is not excessive. The maximum allowable attenuation of a fiberoptic link is determined as a function of the optical power budget. See **Section B.2**.

**Section B.1** gives you a few definitions that will help clarify the calculation method.

**Section B.3** analyzes another aspect of fiberoptic links: the minimum attenuation required to prevent saturation of the optical receiver on very short links.

## B.1 Definitions and Background Information

### OPTICAL POWER UNITS

Optical power is expressed in watts. However, the common unit of power measure is the dBm, defined by means of the following equation:

$$\text{Power (dBm)} = 10 \log \frac{\text{Power (mW)}}{1 \text{ mW}}$$

Examples:

0 dBm =	1 milliwatt
-10 dBm =	100 microwatts
-20 dBm =	10 microwatts
-30 dBm =	1 microwatt

### POWER COUPLED INTO A FIBER

For short-distance links, the preferred light source is an LED. The LED radiates a wide cone of light. As shown in Figure B-1, the optical fiber has a much smaller diameter, and the result is that a large part of LED light energy is lost. In fact, the larger the fiber diameter, the more power is coupled into it.

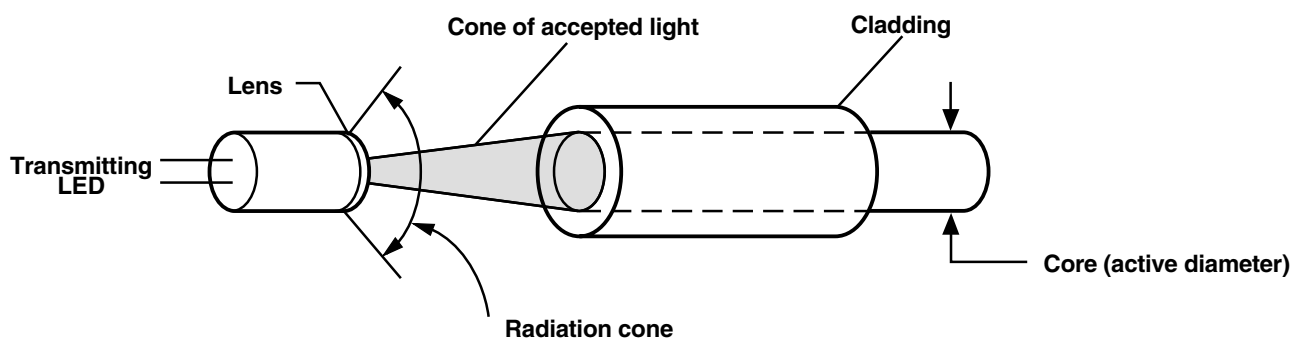


Figure B-1. Geometry of light coupling into optical fiber.

The most common fiber diameters are 50/125, 62.5/125, and 100/140 microns. The first digits (50, 62.5, and 100) indicate core diameter (the active part), and the second group of digits indicate external fiber diameter (including the fiber cladding).

For example, compare the ratio of energy coupled into a 100/140 micron fiber to that coupled into a 50/125 micron fiber. Since the LED is assumed to radiate uniformly within the angles of interest, the power ratio is directly proportional to the area ratio, which is  $(100/50)^2 = 4$ .

In dB, this means that 6 dB more power ( $10 \log 4 = 6$ ) is coupled into the 100/140 micron fiber. In practice, the ratio is even higher (close to 7 dB).

For the same reasons, the power coupled into a 100/140 micron fiber is 4 dB higher than the energy coupled into a 62.5/125 micron fiber.

## NOTE

**The Fiber Optic Repeaters can operate with all the common core diameters: 50/125, 62.5/125, and 100/140 microns.**

### LOSSES IN OPTICAL FIBERS

Losses are expressed in dB.

$$\text{Losses (dB)} = 10 \log \frac{P_{\text{in}}}{P_{\text{out}}}$$

where  $P_{\text{in}}$  is the power coupled into the fiber, and  $P_{\text{out}}$  is the power reaching the other end of the fiber.

Examples:

$$P_{\text{in}} = 1.0 \mu\text{W} \text{ (-30 dBm)}$$

$$P_{\text{out}} = 0.5 \mu\text{W} \text{ (-33 dBm)}$$

$$\text{Losses (dB)} = 10 \log \frac{1.0}{0.5} = 3 \text{ dB}$$

Note that  $-30 \text{ dBm} - (-33 \text{ dBm}) = 3 \text{ dBm}$

Typical losses of graded-index fibers at a wavelength of 820 nm (the common LED wavelength) are as follows:

50/125 micron: 3.0–3.5 dB/km

62.5/125 micron: 3.5–4.0 dB/km

100/140 micron: 4.5–5.0 dB/km

## B.2 Calculation of Optical Link Budgets

The maximum link attenuation (optical “link budget”) equals the power coupled into the fiber at transmitter side minus receiver sensitivity.

### TYPICAL VALUES OF LINK BUDGETS

Fiber Type	Multimode Fibers			Single-Mode Fiber
	50/125 micron	62.5/125 micron	100/140 micron	9/120 micron
Output Power	-22 dBm	-18 dBm	-14 dBm	-18 dBm
Sensitivity	-32 dBm	-32 dBm	-32 dBm	-32 dBm
Link Budget	10 dB	14 dB	18 dB	14 dB

### LOSSES IN OPTICAL FIBERS

Typical losses that must be considered when calculating losses in an actual fiberoptic link are as follows:

- Cable Losses ..... 3–5 dB/km
- Connector Losses ..... 1–2 dB/connector
- Splice Losses ..... 0.1–0.3 dB/splice
- Aging, Temperature ..... 3 dB

### NOTE

1. The values given above are given for guidance only. Always use cable and connector losses specified by their manufacturer.
2. Connectors are the weakest point. The “cost” of a “bad” connector may be as high as 1 km of fiber.

*Do not design in too many connectors!*

3. Connector losses decrease as fiber diameter increases.

**CALCULATION EXAMPLE FOR OPTICAL LINK**

The following example will calculate the maximum range for various types of fibers, assuming typical Fiber Optic Repeaters. Calculation results are given in the following table.

Fiber Type	Multimode Fibers			Single-Mode Fiber
	50/125 micron	62.5/125 micron	100/140 micron	9/120 micron
Power Coupled into Fiber	-22 dBm	-18 dBm	-14 dBm	-18 dBm
Sensitivity	-32 dBm	-32 dBm	-32 dBm	-33 dBm
Link Budget	10 dB	14 dB	18 dB	15 dB
Connector Loss	0.8 dB	0.8 dB	0.5 dB	1.0 dB
Splice Loss	0.4 dB	0.4 dB	0.4 dB	0.4 dB
Link Margin (aging, etc.)	2.0 dB	2.0 dB	2.0 dB	2.0 dB
Allowed Link Attenuation	6.8 dB	10.8 dB	15.1 dB	11.6 dB
Typical Cable Attenuation	3.0 dB/km	3.5 dB/km	4.0 dB/km	0.7 dB/km
Maximum Range	2.3 km	3.1 km	3.7 km	16.5 km

The link margin indicates the reserve for unexpected increases in link attenuation, such as splices, increased attenuation due to fiber aging, or decreased transmit power due to component aging.

**B.3 Preventing Saturation of Optical Receivers**

Optical receivers are optimized for operation at low optical power levels (long cable runs). When the optical input power reaching the receiver is too high, the receiver may be saturated. Saturation causes very high bit error rate, high enough to disrupt data transmission. Therefore, it's essential to prevent receiver saturation.

The dynamic range of the optical receivers used by the Fiber Optic Repeaters is 20 dB, and their sensitivity is -32 dBm. Therefore, the maximum optical input power before saturation occurs is:  $-32 \text{ dBm} + 20 \text{ dB} = -12 \text{ dBm}$ .

The saturation power is high enough to ensure that the Fiber Optic Repeater will never be saturated when receiving the signal generated by another Fiber Optic Repeater, even when operating with short 100/140-micron cable having a very low attenuation.