

IBM Z

*Maintenance Information for Fiber Optic  
Links (FICON/FCP, Coupling Links, Open  
Systems Adapters, and zHyperLink  
Express)*



**Note:**

Before you use this information and the product it supports, read the information in “[Safety](#)” on page vii, [Appendix G, “Notices,”](#) on page 113, and *IBM Systems Environmental Notices and User Guide*, Z125-5823.

This edition, SY27-7696-03, applies to the IBM Z and IBM LinuxONE servers. This edition replaces SY27-7696-02.

There might be a newer version of this document in a **PDF** file available on **Resource Link**. Go to <http://www.ibm.com/servers/resourcelink> and click **Library** on the navigation bar.

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# Safety

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## Safety notices

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Safety notices may be printed throughout this guide. **DANGER** notices warn you of conditions or procedures that can result in death or severe personal injury. **CAUTION** notices warn you of conditions or procedures that can cause personal injury that is neither lethal nor extremely hazardous. **Attention** notices warn you of conditions or procedures that can cause damage to machines, equipment, or programs.

## World trade safety information

Several countries require the safety information contained in product publications to be presented in their translation. If this requirement applies to your country, a safety information booklet is included in the publications package shipped with the product. The booklet contains the translated safety information with references to the US English source. Before using a US English publication to install, operate, or service this product, you must first become familiar with the related safety information in the *Systems Safety Notices*, G229-9054. You should also refer to the booklet any time you do not clearly understand any safety information in the US English publications.

## Laser safety information

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All IBM Z® (Z) and IBM LinuxONE™ (LinuxONE) models can use I/O cards such as, ESCON, FICON®, Open Systems Adapter (OSA), InterSystem Channel-3 (ISC-3), RoCE Express, Integrated Coupling Adapter (ICA SR), IBM zHyperLink Express, or other I/O features which are fiber optic based and utilize lasers (short wavelength or long wavelength lasers).

## Laser compliance

All lasers are certified in the US to conform to the requirements of DHHS 21 CFR Subchapter J for Class 1 or Class 1M laser products. Outside the US, they are certified to be in compliance with IEC 60825 as a Class 1 or Class 1M laser product. Consult the label on each part for laser certification numbers and approval information.

**Laser Notice:** U.S. FDA CDRH NOTICE if low power lasers are utilized, integrated, or offered with end product systems as applicable. 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.

**CAUTION: Data processing environments can contain equipment transmitting on system links with laser modules that operate at greater than Class 1 power levels. For this reason, never look into the end of an optical fiber cable or open receptacle. (C027)**

**CAUTION: This product contains a Class 1M laser. Do not view directly with optical instruments. (C028)**





## About this publication

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This publication provides problem determination, verification, and repair procedures for IBM® fiber optic channel links. This designation includes:

- IBM coupling facility channels (ISC, 1x IFB, 12x IFB, x24 ICA)
- Fibre Channel Connection (FICON) including: 2G, 4G, 8G, 16G Ficon SX and 2G, 4G, 8G, 16G Ficon LX links
- Fiber optic interfaces for Open Systems Adapters (OSA), including: 1G and 10G Enet
- Fiber optic interfaces for zHyperLinks (x8 PCIe)

Although this publication covers fiber optic cable types and environments in general, the specific information includes only what is supported for IBM fiber optic channel links. Although the ANSI Fibre Channel Standard does not include the use of long wavelength (1300 nm) lasers on multi-mode fiber, IBM Z and LinuxONE does support this combination.

A technical change to the text or illustration is indicated by a vertical line to the left of the change.

**Note:** This publication, with the publication *Planning for Fiber Optic Links*, GA23-1407, replaces the publication *IBM 3044 Fiber-Optic Channel Extender Link Models C02 and D02: Fiber-Optic Cable Planning, Installation, and Maintenance Guide*, GC22-7130, and makes it obsolete.

## Who should use this publication

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This publication should be used by service representatives who need to perform problem determination on a fiber optic link.

## What is included in this publication

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This publication contains the following information:

- [Chapter 1, “Introduction to fiber optic links ,” on page 1](#) provides a brief introduction to fiber optic information transfer and optical link components, and shows a typical fiber optic channel link configuration.
- [Chapter 2, “Service Strategy and Maintenance Activities ,” on page 17](#) contains a summary of the service tasks, strategy, and activities associated with fiber optic channel links. It also shows typical link configurations, describes some common link failures, and shows how to determine the direction of light propagation in an IBM jumper cable and in a fiber optic channel link. This chapter also provides a summary for the link verification procedures performed using the MAPs in Chapter 3.
- [Chapter 3, “Problem Determination Procedures ,” on page 25](#) provides information that can be used to isolate link failures between two devices. It is divided into two sections: the first section provides the maintenance analysis procedures (MAPs) used to perform step-by-step problem determination; the second section provides information for using the "fast-path" method.
- [Chapter 4, “Jumper Cable Handling and Installation Summary,” on page 51](#) provides guidance for handling fiber optic jumper cables and summarizes the tasks associated with their installation.
- [Chapter 5, “Documentation,” on page 55](#) summarizes the information used to document link installations. It provides instructions and a sample work sheet for recording link specifications and physical characteristics.
- [Appendix A, “Specifications ,” on page 61](#) lists the specifications and optical properties required for components used in a fiber optic channel link.
- [Appendix B, “Tools, Test Equipment, and Parts,” on page 67](#) lists the tools, test equipment, and parts used to perform problem determination and testing for fiber optic channel links.

- Appendix C, “Measuring Device Transmit and Receive Levels ,” on page 69 contains procedures on how to determine if the transmit and receive signals are within specification. Although these procedures are also contained in the maintenance information for each device, they are included here for convenience.
- Appendix D, “Measurement Conversion Tables ,” on page 85 contains conversion tables from English measurements to metric and from metric measurements to English.
- Appendix E, “Work Sheets,” on page 87 provides work sheets that may be reproduced and used for problem determination or to provide a permanent account record.
- Appendix F, “Fiber optic cleaning procedures,” on page 105, provides general cleaning procedures for various couplers, plugs and connectors.

## Where to find more information

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The following publications contain information related to the information in this publication:

- *Planning for Fiber Optic Links*, GA23-1408, provides information that can be used when planning for FICON, Coupling links, Open Systems Adapters, and zHyperLink Express.
- *Technical Service Letter No. 147 Fiber Optic Tools and Test Equipment* (Revised 2/19/96 or later), contains a complete list of fiber optic support tools and test equipment.
- *Maintenance Information for the 9037 Model 002 Sysplex Timer*, SY27-2641.

Coupling links are designed to be optically compatible with the F0 or physical layer industry standard *ANSI Fiber Channel Physical Interfaces (FC-PI-2)*, published by the *American National Standards Institute*, New York, NY.

The open fiber control (OFC) timing for 531 megabits per second links follows this ANSI standard. The OFC timing for 1.0625 gigabits per second links uses the same timing as specified in the ANSI standard for 266 megabits per second links, which allows longer distances for gigabit links.

## Revisions

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A technical change from the previous edition of this document is indicated by a vertical line (|) to the left of the change.

## Summary of changes

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The following information has been updated in this publication:

- Added information to Table 6 on page 71 for:
  - Single-mode FCP LX 32 Gbps 10 km (3200-SM-LC-L)
  - Multi-mode FCP SX 32 Gbps (3200-M5-SN-I, 3200-M6-SN-I)
  - Multi-mode 25 GbE SR

## How to send your comments

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## Accessibility

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Accessible publications for this product are offered in EPUB format and can be downloaded from Resource Link at <http://www.ibm.com/servers/resourcelink>.

If you experience any difficulty with the accessibility of any IBM Z® and IBM LinuxONE information, go to Resource Link at <http://www.ibm.com/servers/resourcelink> and click **Feedback** from the navigation bar on the left. In the **Comments** input area, state your question or comment, the publication title and number, choose **General comment** as the category and click **Submit**. You can also send an email to [reslink@us.ibm.com](mailto:reslink@us.ibm.com) providing the same information.

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### Accessibility features

The following list includes the major accessibility features in IBM Z and IBM LinuxONE documentation, and on the Hardware Management Console and Support Element console:

- Keyboard-only operation
- Interfaces that are commonly used by screen readers
- Customizable display attributes such as color, contrast, and font size
- Communication of information independent of color
- Interfaces commonly used by screen magnifiers
- Interfaces that are free of flashing lights that could induce seizures due to photo-sensitivity.

### Keyboard navigation

This product uses standard Microsoft Windows navigation keys.

### Consult assistive technologies

Assistive technology products such as screen readers function with our publications, the Hardware Management Console, and the Support Element console. Consult the product information for the specific assistive technology product that is used to access the EPUB format publication or console.

### IBM and accessibility

See <http://www.ibm.com/able> for more information about the commitment that IBM has to accessibility.



# Chapter 1. Introduction to fiber optic links

This chapter provides a brief introduction to fiber optic information transfer, lists the components that can be included in an IBM fiber optic channel link, and shows an example of a fiber optic channel link.

## Unidirectional fiber optic information transfer

Information transfer through an optical fiber usually occurs in only one direction by using a transmitter and a receiver (Figure 1 on page 1). The transmitter accepts encoded digital information, converts it into an optical (light) signal, and sends it through the fiber. The receiver detects the optical signal, converts it into an electrical signal, and amplifies it. The decoded digital information (output) is then the same as the encoded digital information (input).

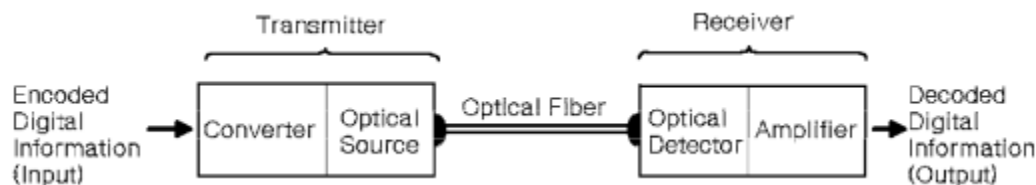


Figure 1. Unidirectional fiber optic Information transfer

## Bidirectional fiber optic information transfer

Fiber optic information transfer can also occur in two directions simultaneously (Figure 2 on page 1). This method uses 2 optical fibers contained in 1 duplex fiber optic cable and combines the transmitter, receiver, and duplex receptacle functions into 1 transmitter-receiver subassembly (TRS) in each device.

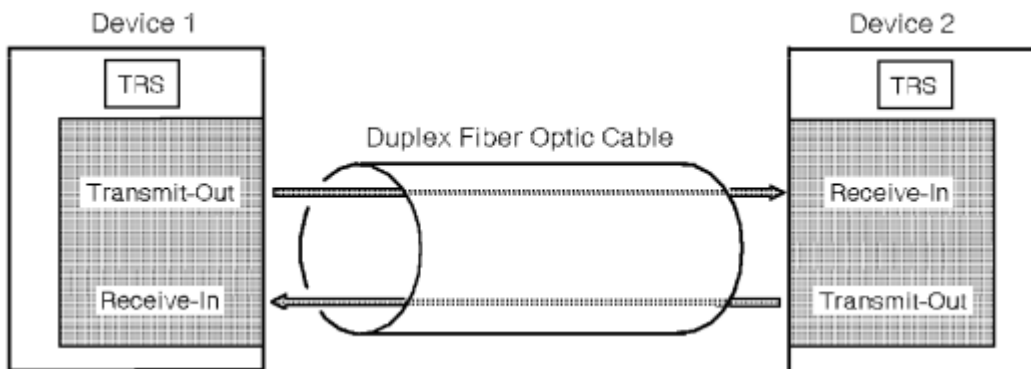


Figure 2. Bidirectional fiber optic Information transfer

## Optical fiber elements and optical cable

Note that the term *Fibre* is used in the ANSI Fibre Channel Standard documents to denote both copper and optical fiber media.

The fiber element within an optical cable usually consists of a core and a cladding (Figure 3 on page 2). The core provides the light path, the cladding surrounds the core, and the optical properties of the core and cladding junction cause the light to remain within the core.

Although the core and the cladding diameters, expressed in micrometers ( $\mu\text{m}$ ), are often used to describe an optical cable, they actually indicate the physical size of the fiber element. For example, a fiber element having a core diameter of  $62.5 \mu\text{m}$  and a cladding diameter of  $125 \mu\text{m}$  is called  $62.5/125 \mu\text{m}$  fiber.

In an optical cable, the core and cladding are typically surrounded by other layers (such as a primary and secondary buffer), a strength member, and an outer jacket (Figure 3 on page 2) that provide strength and environmental protection.

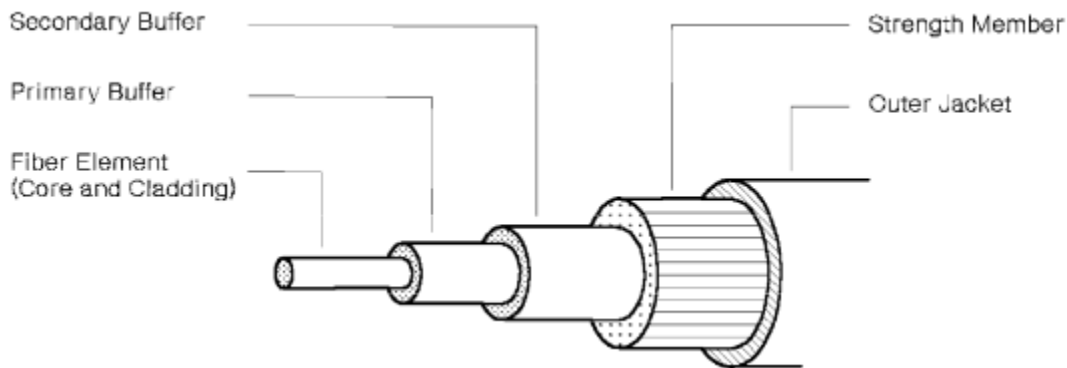


Figure 3. Typical optical cable elements

Because information transfer usually occurs in only one direction through an optical fiber, various fiber types have been developed for different applications. The properties and specifications of an optical fiber determine many characteristics. For example, **single-mode** fiber (nominally about 9.0  $\mu\text{m}$ ) provides a single high-bandwidth information "path". Single-mode fiber is normally used to transfer information over greater distances compared to **multi-mode** fiber (62.5  $\mu\text{m}$ , for example), which provides multiple paths and has a lower bandwidth. The terms single-mode and multi-mode are often used interchangeably to describe both the optical fiber and the cable types.

Generally, laser diodes use single-mode fiber to transmit information while light-emitting diodes (LEDs) use multi-mode fiber. An exception is the multi-mode coupling link, which uses a laser source and 50 micron multi-mode fiber. In a data processing environment using optical fiber, product, distance, and right-of-way considerations usually determine if single-mode or multi-mode fiber is used.

## Optical cable connectors

Optical cable connectors allow manual coupling and uncoupling of the fibers but contribute to link attenuation (loss). Although several connector types have been developed to minimize this loss, all connectors can be classified as either physical-contact or nonphysical-contact connectors.

### Physical-contact connectors

Physical-contact connectors, sometimes referred to as butt-coupled connectors, have a polished end-face surface with a slight outward (convex) curvature. When inserted into the receptacle, the fibers are precisely aligned and touch each other, thereby allowing maximum light transfer and minimum return loss. The IBM duplex connector (Figure 4 on page 3), the ST connector (Figure 6 on page 3), the Fiber Channel Connection (FICON) SC-duplex connector (Figure 7 on page 4), the FC connector (Figure 8 on page 4), the IBM FDDI connector, also known as a Media Interface Connector (MIC) (Figure 11 on page 5), the MT-RJ connector (Figure 12 on page 5) and the LC connector (Figure 13 on page 6) are types of physical-contact connectors.

IBM duplex connectors, which combine the transmit and receive signals in one housing, provide high reliability and have low loss characteristics. They are keyed to provide correct orientation and use release tabs to prevent accidental removal.

Some IBM duplex connectors and receptacles used for single-mode fiber have additional keying. This prevents the plugging of multi-mode IBM duplex connectors into IBM products having single-mode receptacles.

The Fiber Channel Connection (FICON) SC-duplex connector is another type of connector which may be keyed to prevent accidental plugging of a multi-mode fiber into a single-mode receptacle, and to provide

correct orientation to the TRS. The FDDI MIC connector uses special keys to provide correct orientation (Figure 11 on page 5).

The MT-RJ connector has distinct male ends (with metal guide pins) and female ends (with guide holes). Only male to female connections will transmit optical signals. Since all MT-RJ transceivers have a male interface, only female jumper cables are required for most installations.

For single-mode ESCON links, the SC-duplex connector may be used on both the transceiver receptacle and the fiber optic cable as an alternative to the single-mode ESCON connector and receptacle. The SC-duplex connector and receptacle are defined as part of the ANSI Fiber Channel Standard Physical and Signaling Interface (FC-PH) ref. X3T9.3/755D. The connector is shown in Figure 7 on page 4; it is the same connector which has been adopted for other industry standard data links including FICON, ATM, and low cost (LC) FDDI. For single-mode ESCON links, the transceiver receptacle and connector is gray and the optical fiber cable is yellow, conforming to the established color coding for single-mode ESCON channels. The SC-duplex receptacle and connector are keyed to prevent accidental plugging of a multi-mode fiber into a single-mode receptacle. All of the physical layer characteristics for the single-mode ESCON interface must still be maintained by transceivers and cables using this alternative interface.

### Nonphysical-contact connectors

Nonphysical-contact connectors do not allow the fiber end-faces to touch. Because an air gap exists, these connectors typically have a higher interface loss compared to physical-contact connectors. The biconic connector used by IBM (Figure 9 on page 4), which is equivalent to AT&T part number 1006A, is an example of a nonphysical-contact connector.

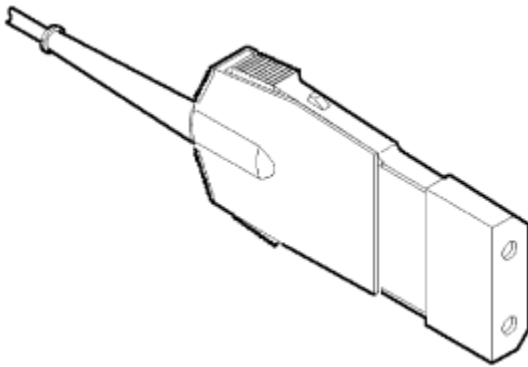


Figure 4. ESCON Duplex multi-mode Connector

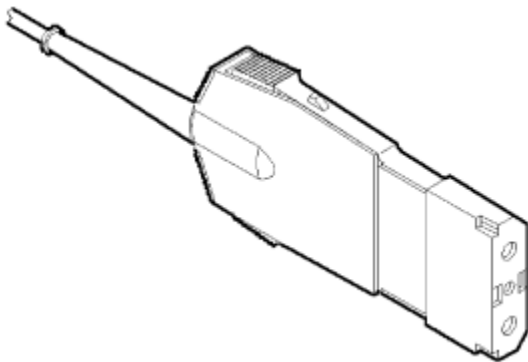


Figure 5. ESCON Duplex Single-mode Connector

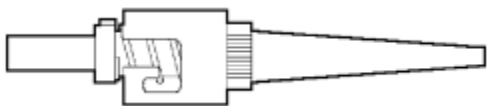
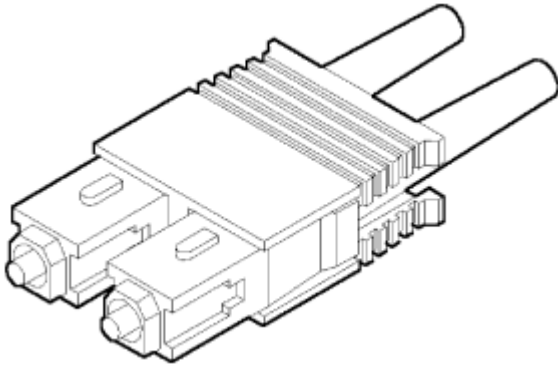


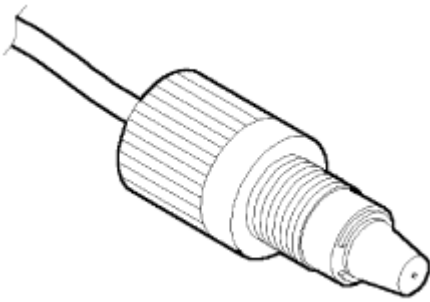
Figure 6. ST Physical-Contact Connector



*Figure 7. SC-Duplex Connector*

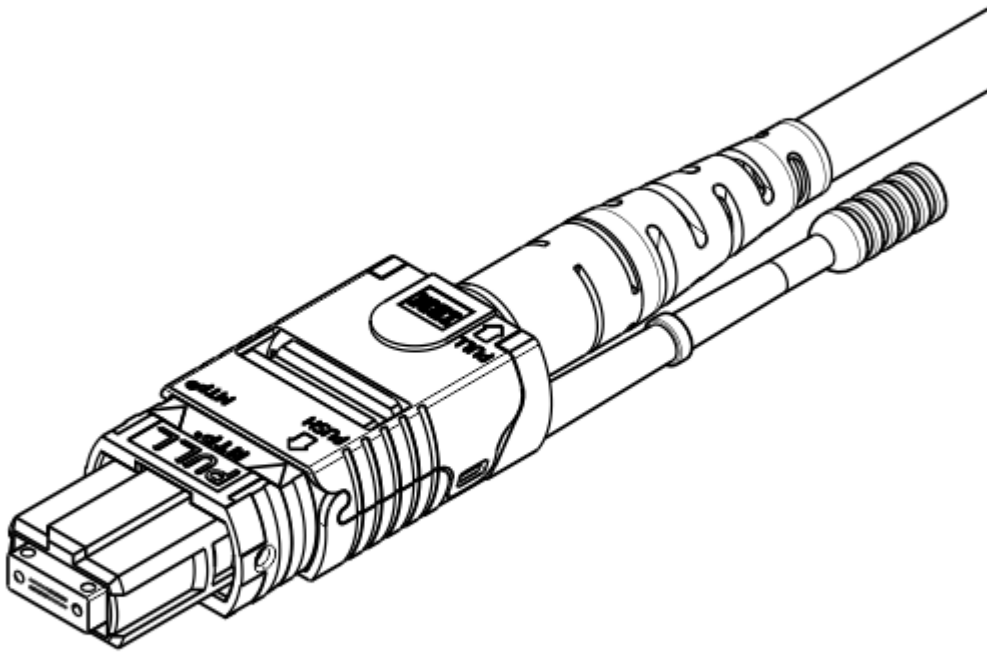


*Figure 8. FC Physical-Contact Connector*

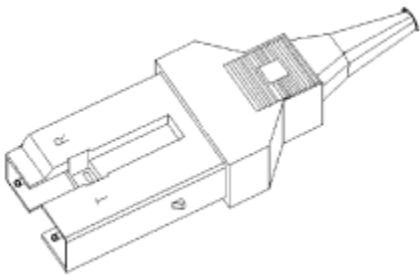


*Figure 9. Biconic Nonphysical-Contact Connector*

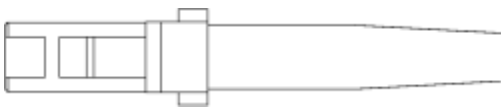




*Figure 10. Multifiber Terminated Push-on Connector (MTP). Twelve and twenty-four fiber connector available on IBM Global Services trunk cables and harnesses. This connector is also used for 12x InfiniBand optical (IFB-O) and 24x (ICA-SR) cable but is referred to as an MPO connector.*



*Figure 11. MIC (FDDI) Connector*



*Figure 12. MT-RJ Connector*

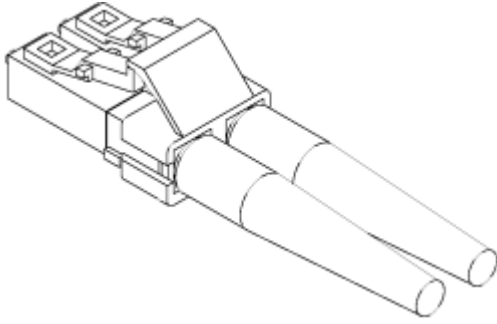


Figure 13. LC Duplex Connector

## Connector color coding

IBM simplex connectors use color-coding to show the direction that light travels through a link (see [“Determining the direction of light propagation”](#) on page 21). These connectors are black (or use a black marking) and white (or use a white marking).

IBM duplex cable connectors use color-coding to differentiate between multi-mode and single-mode. multi-mode cables have black connectors and single-mode cables have gray connectors. They do not require color coding to determine the direction that light travels, or propagates, through the cable because the connectors are physically keyed. This provides proper orientation and allows the fibers to be labeled "A" and "B", which is shown on the connector. See [“Determining the direction of light propagation”](#) on page 21.

The FICON SC-duplex connector is an industry standard optical connector (as defined in *ANSI Fiber Channel Standard Physical and Signaling Interface (FC-PH)*, published by the *American National Standards Institute*. Since it may be purchased from a variety of vendors, there is no consistent scheme of color coding or labeling the ends of a simplex cable with FICON SC connectors. These connectors can be identified by their shape (see [Figure 7](#) on page 4) and the direction of light propagation must be verified from the vendor specifications. For IBM supplied cables, the single-mode FICON jumper has a yellow connector with grey clip and a yellow cable jacket, while the multi-mode has a blue connector with black clip and an orange jacket.

## IBM jumper cables

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Cabling is a customer responsibility. Single-mode fiber optic cabling (9/125 micrometer) has a yellow outer coating. multi-mode standard bandwidth fiber optic cabling (50/125 and 62.5/125 micrometer) has an orange outer coating. The OM3 50/125 micrometer multi-mode fiber optic cabling (2000 MHz-km) has an aqua outer coating.

**Note:** A fiber optic link (device-to-device connection) must consist entirely of one type of fiber. It must be entirely single-mode, entirely standard multi-mode, or entirely OM multi-mode.

The elements in an IBM duplex jumper cable ([Figure 14](#) on page 7) consist of 2 tight-buffered optical fibers (core and cladding) surrounded by a strength member, all of which are encased in a common flexible jacket. Duplex cables for coupling links (or ESCON XDF) ([Figure 15](#) on page 7) are similar, except that they are not encased in a single jacket. Both single-mode and multi-mode jumper cables have a cladding diameter of 125  $\mu\text{m}$ . Single-mode cable has a mode field diameter (MFD) of about 9  $\mu\text{m}$ ; multi-mode cable has a core diameter of either 62.5  $\mu\text{m}$  or 50.0  $\mu\text{m}$ .

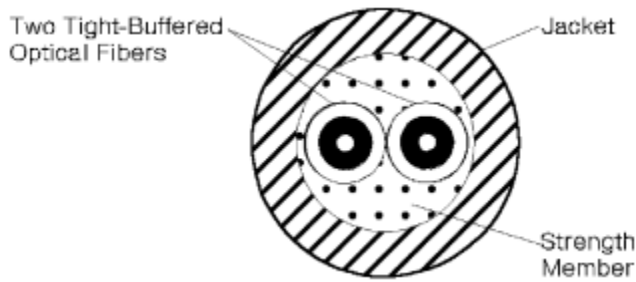


Figure 14. IBM duplex jumper cable elements

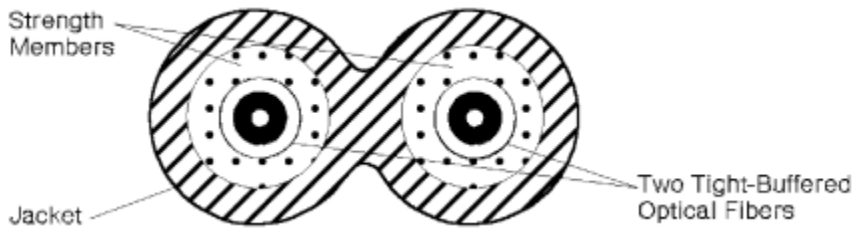


Figure 15. Coupling Facility or ESCON XDF jumper cable elements. (Jumper cables which use FICON SC duplex connectors.)

All IBM jumper cables have a duplex connector on one end, which attaches to a fiber optic channel link device. Attaching a jumper cable to a distribution panel, however, could require jumper cables with other connector types (see [“Optical cable connectors”](#) on page 2). IBM offers these jumper cables:

- **Single-mode and multi-mode applications:**

- Duplex-to-duplex jumper cables have an IBM duplex connector on both ends.
- Duplex-to-duplex jumper cables have an FICON SC duplex connector on both ends.
- Duplex-to-duplex jumper cables have an LC duplex connector on both ends.
- Duplex-to-duplex jumper cable conversion kits:
  - IBM duplex receptacle on one end and an FICON SC duplex connector on the other end.
  - An LC connector on one end and a duplex receptacle on the other end.

- **Multi-mode applications only:**

- Duplex-to-biconic jumper cables have a pair of color-coded biconic connectors on one end and are available to support the 3044 Models C02 and D02.
- Duplex-to-ST jumper cables have a pair of color-coded, physical-contact ST connectors on one end.
- Duplex-to-FC jumper cables have a pair of color-coded, physical-contact FC connectors on one end.
- Duplex-to-unterminated jumper cables have an unterminated end (no connector) that allows the attachment of any connector type.
- Duplex-to-duplex jumper cables with female MT-RJ on both ends.
- Duplex-to-duplex jumper cables with male MT-RJ on both ends.
- Adapter kits:
  - ESCON receptacle to female MT-RJ connector
  - ESCON connector to female MT-RJ connector

**Note:** If a single-mode ESCON XDF link using the SC-duplex connector interface must be connected to a single-mode ESCON XDF connector interface, use the ESCON XDF Adapter Kit (46H9223). The kit consists of a 2-meter single-mode jumper cable with SC-duplex-to-ST connectors (46H9222) assembled to the single-mode ESCON-to-ST adapter. Instructions are provided with each kit.

## Trunk cable

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Fiber optic trunk cable is generally used for longer links, such as between floors or buildings. It should also be used in single-floor fiber optic channel link environments when many jumper cables and connections are required. If trunk cable is used, distribution panels must provide the hardware used to attach the IBM jumper cables.

A trunk cable typically contains from 12 to 144 fibers and has a strength member and an outer jacket. Each fiber optic channel link requires trunk fibers. The physical trunk cable configuration varies and depends on user requirements, environmental conditions, and the type of installation required (for example, above ground or underground).

## Splices

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Fiber optic trunk cables can be joined by two splicing methods. Either method, when performed by a trained technician using high-quality materials, can produce a splice having a very low optical power loss.

- Fusion splices are joined by an electric arc.
- Mechanical splices are joined within a holder and sometimes use epoxy to bond the fibers.

## Distribution panels

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Many types of distribution panels exist. They are available in various sizes and styles and are called different names, depending primarily on their application or use. For example, they can be called central distribution panels, main distribution panels, zone panels, patch panels, building interface panels, enclosures, or cabinets. In a fiber optic channel link, they provide the hardware attachment capability between trunk cables and IBM jumper cables. They can also be used for floor-to-floor cable connections within a building or for connections between buildings. For more information about distribution panel requirements, contact your IBM marketing representative.

## Couplers and adapters

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Distribution panels must provide couplers or adapters to allow attachment of IBM jumper cables. Couplers join **the same** connector types, while adapters join **different** connector types. The following couplers and adapters, available from IBM, are shown in [Figure 16 on page 9](#) through [Figure 23 on page 10](#). Other types of adapters for patch panels may be available as RPQs, including the FICON SC-duplex-to-ST adapter. A conversion kit is available to adapt an FICON duplex interface to an ESCON duplex interface.

- IBM duplex coupler
- ST coupler
- FC/PC coupler
- MT-RJ duplex coupler (joins male to female MT-RJ)
- LC duplex coupler
- IBM duplex-to-ST adapter
- IBM duplex-to-FC/PC adapter
- FICON SC-duplex-to-ST adapter
- FICON SC-duplex-to-FC adapter
- FICON SC-duplex-to-duplex coupler
- MTP-to-MTP coupler
- MIC coupler

- MIC-to-ST adapter
- MIC-to-FC adapter

**Note:** IBM recommends using IBM duplex-to-duplex jumper cables between ESCON-capable devices and distribution panels, FICON SC-duplex-to-duplex jumper cables between coupling link devices and distribution panels, and IBM duplex-to-ST or IBM duplex-to-FC/PC adapters in distribution panels.

Other adapters for patch panels may be available as RPQs.

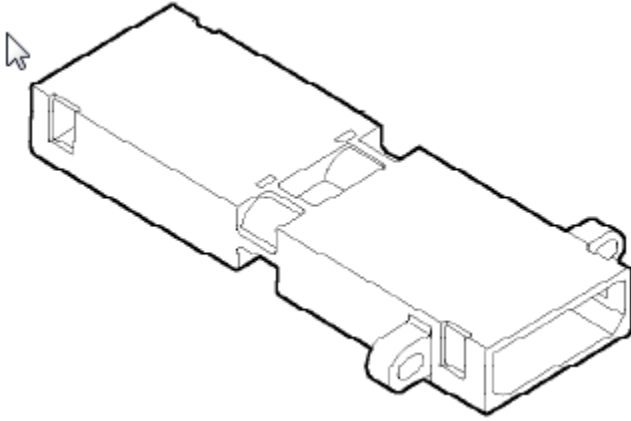


Figure 16. IBM Duplex Coupler

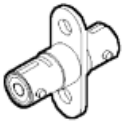


Figure 17. ST Coupler

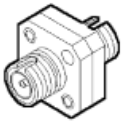


Figure 18. FC/PC Coupler

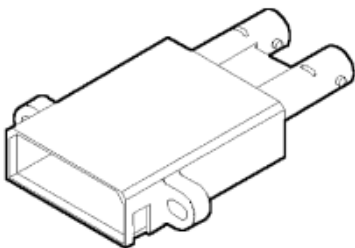


Figure 19. IBM Duplex-to-ST Adapter

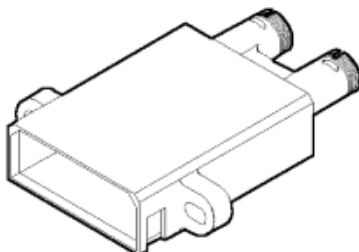


Figure 20. IBM Duplex-to-FC/PC Adapter

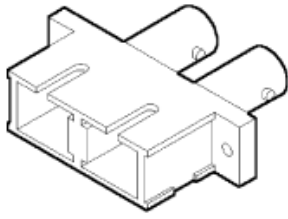


Figure 21. FICON SC-Duplex-to-ST Adapter

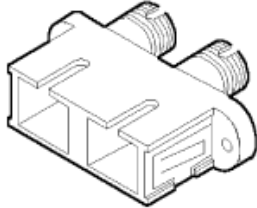


Figure 22. FICON SC-Duplex-to-FC Adapter

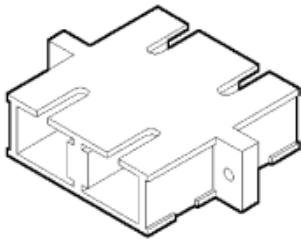


Figure 23. FICON SC-Duplex-to-Duplex Coupler

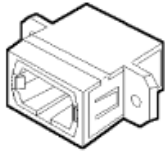


Figure 24. MTP-to-MTP Coupler

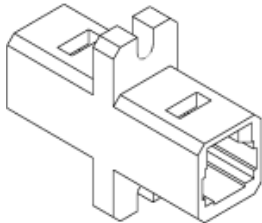


Figure 25. MT-RJ Coupler

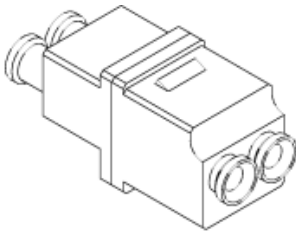


Figure 26. LC Coupler

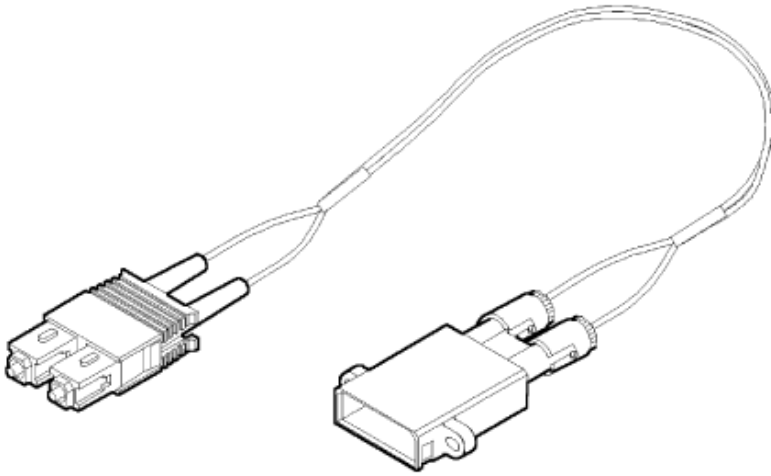


Figure 27. FICON-ESCON Kit

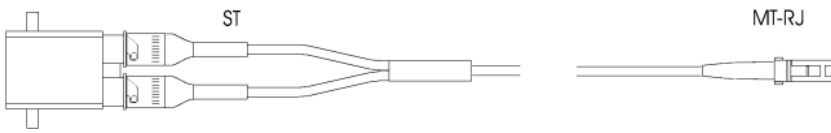


Figure 28. MT-RJ-to-ESCON Kit

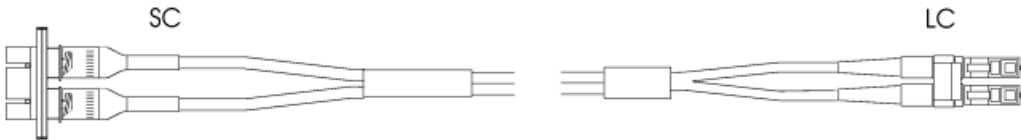


Figure 29. LC-to-FICON Kit

## Mode conditioning patch cables

In some fiber optic applications, it is possible to use a long wavelength (1300 nm) single-mode transceiver with multi-mode fiber by placing a special device known as a mode conditioning patch (MCP) cable at both ends of the link. The MCP cable resembles a standard 2 meter jumper cable. As shown in Figure 30 on page 12, the MCP is unique. It contains both single-mode and multi-mode fibers in a single jumper cable assembly. Without the MCP, it is not possible to use a single-mode transceiver with multi-mode fiber because the laser source does not launch an equal amount of optical power into all modes of the fiber. Using a single-mode transceiver with multi-mode fiber without an MCP cable leads to excessive dispersion of the data pulses, and the link will not function.

IBM supports reuse of existing multi-mode fiber optic cabling with Long Wavelength (LX) transceivers, as a migration aid, if the link data rate does not exceed 1 Gbps. MCP cables are supported for use with ISC-3 links, Gigabit Ethernet LX, and FICON LX, provided the link data rate is 1 Gbps. The unrepeated distance is limited to 550 meters (1,804 feet).

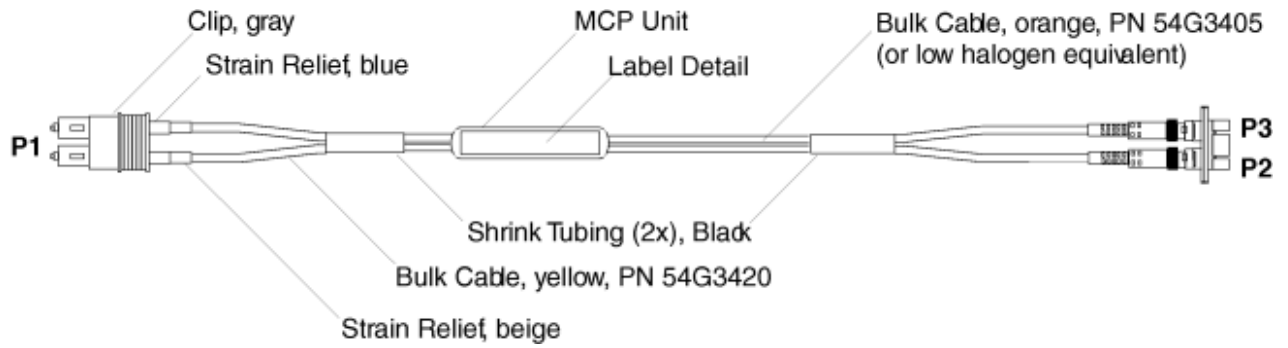


Figure 30. Mode Conditioner Patch Cable (MPC). Connections P2 and P3 may be terminated with either an SC duplex or an ESCON duplex coupler. Connector P1 is available in either an SC duplex or LC duplex connector.

## Splitter tool

An optical splitter is used to measure optical power levels in a coupling facility. The optical splitter tool is shown in Figure 31 on page 12 for multi-mode links and Figure 32 on page 13 for single-mode links.

Refer to “Isolating link segments using the splitter tool” on page 82 for more information.

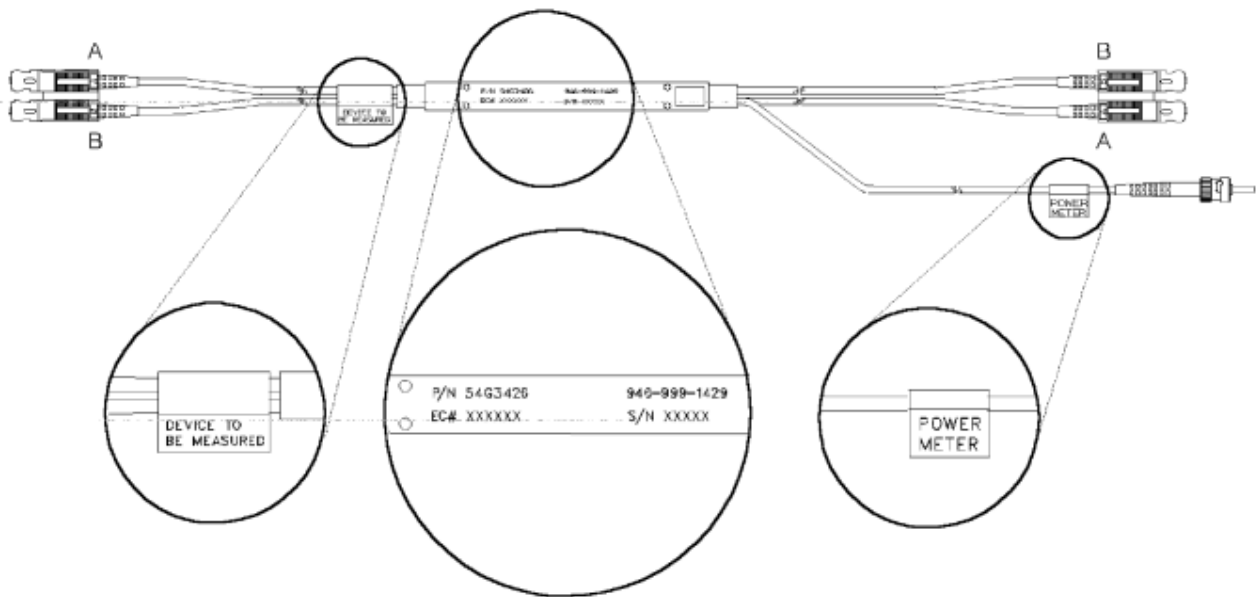


Figure 31. Optical splitter tool for multi-mode links



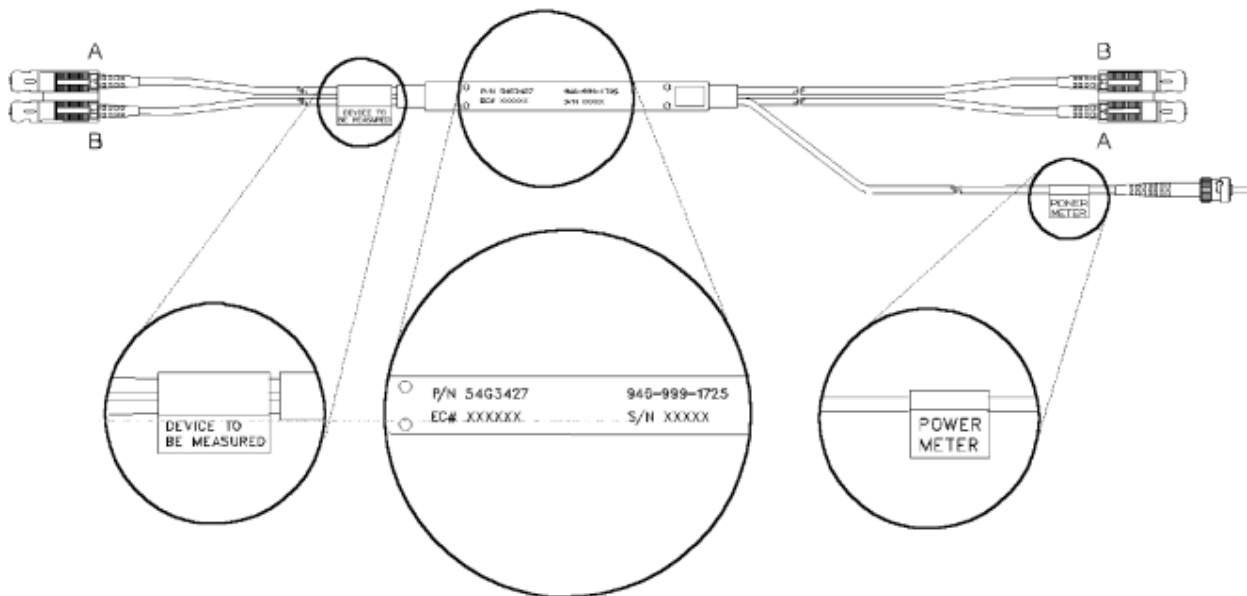


Figure 32. Optical splitter tool for single-mode links

## Fiber optic channel link configuration

**Note:** IBM offers help in the planning, design, and installation of fiber optic channel links through its Connectivity Services offering (Fiber Transport System) of IBM Global Services. For more details, contact your IBM marketing representative. Also, the IBM Fiber Transport Services (FTS) offering provides planning assistance, commodities, and installation for multi-mode and single-mode fiber trunk systems.

Fiber optic channel links, which require separate optical fibers for sending and receiving information, use IBM duplex or FICON duplex connectors, duplex jumper cables, and 2 trunk fibers. A fiber optic channel link could consist of only 1 jumper cable that connects devices, or it could have many cables, distribution panels, adapters, couplers, and connectors.

Parallel Sysplex® using InfiniBand (PSIFB) 12x links use InfiniBand optical (IFB-O) 12x cables which package 12 fibers for transmit and 12 fibers for receive. The IFB-O 12x cables utilize the Multi-fiber Push-On (MPO) connector. ICA-SR 24x cables also utilize the Multi-fiber Push-On connector, but with 24 fibers.

Regardless of the number of cables and components, a fiber optic channel link attaches 2 devices and **must consist entirely of either single-mode or multi-mode cables.**

Figure 33 on page 14 shows an example of a fiber optic channel link having:

- Two IBM duplex-to-duplex jumper cables
- Two distribution panels, each containing an IBM duplex-to-ST adapter
- Four ST connectors
- Two trunk cable fibers
- Four trunk cable splices

### Important

IBM duplex-to-duplex jumper cables should be used between ESCON devices and distribution panels, FICON SC duplex-to-duplex jumper cables should be used between coupling link devices and distribution panels, and IBM duplex-to-ST, or IBM duplex-to-FC adapters should be used in distribution panels.

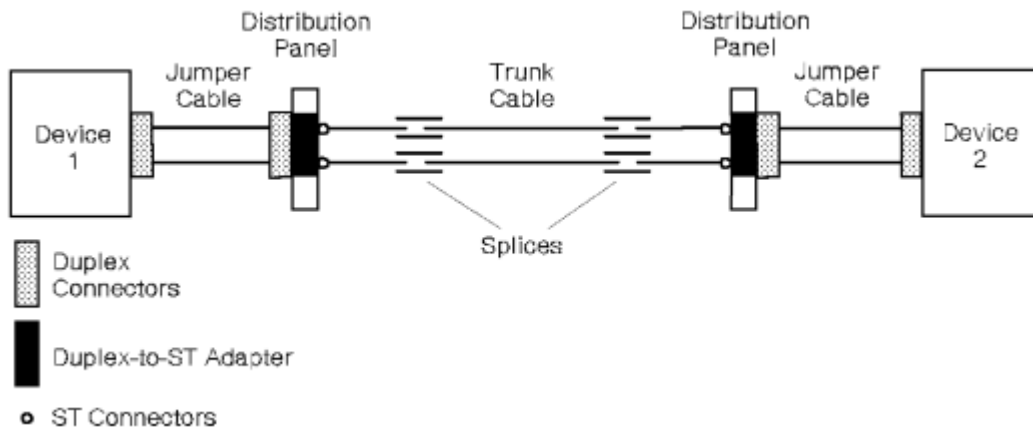


Figure 33. Example of components in a fiber optic channel link.

In an OSA link (FDDI, ATM, GbE, or 10GbE) environment, a link consists of the physical connection between the TRS of one device and the TRS of another device.

An FDDI link can consist of one access station connected to a concentrator, or a concentrator connected to a concentrator on a dual access counter-rotating ring (other point-to-point configurations are also possible). Individual FDDI access stations are electronically made into logical rings at the concentrator. Concentrators with counter-rotating rings also have the connections managed electronically. The physical FDDI connection, however, is handled by placing *primary out* and *secondary in* into one MIC housing and *primary in* and *secondary out* in the other MIC housing. Figure 34 on page 14 shows a possible FDDI link employing a device-to-concentrator connection.

Links other than FDDI may not use concentrators or hubs, but will usually run to switches or distribution panels.

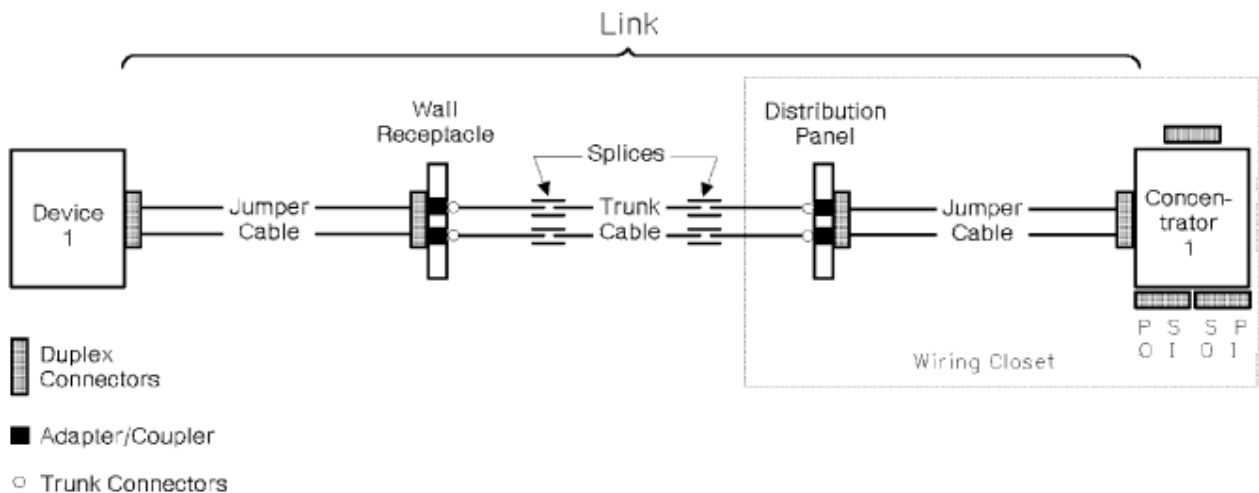


Figure 34. Components in a typical link

## FDDI service limitations

The following paragraphs describe limitations that could exist while servicing FDDI links; they do not apply to other types of fiber optic links.

### Jumper cable

The FDDI specifications for connector design are not specific enough to guarantee that every FDDI connector will work with every product under all conditions. IBM recommends the use of IBM jumper cables with IBM products to meet FDDI specifications and to ensure performance expectations. Some

jumper cables used with IBM products might not yield the correct amount of launched power. An Original Equipment Manufacturer (OEM) product might use a jumper cable other than IBM's for the same reason.

**Note:** The amount of power launched from the device into the fiber is affected by the connector-to-device interface and the fiber size. IBM jumper cables can be directly connected to an OEM device and measurements will be accurate if the device manufacturer has specified IBM jumper cables as acceptable. Other measurements at any connection in the link or the end-to-end link loss measurement are *not* subject to this condition.

## Link bandwidth

An FDDI multi-mode link can be limited by dispersion instead of attenuation. Link length, fiber type, fiber specifications, transmitter spectral width, and transmitter center wavelength are factors that have the potential to produce FDDI link errors. This potential can exist even if all factors are within the FDDI specifications. However, if the link is 2 km or less and consists of optical fiber that is 500 MHz·km at 1300 nm or better, excessive attenuation, not dispersion, is the most probable cause of the problem.

**Note:** Optical bypass switches, although permitted in the FDDI standard, make the link longer. This can cause a link to become inoperative due to dispersion, even if attenuation is within specification.

## Link error conditions

---

There are 2 basic types of link error conditions:

- A link failure occurs when the receiver does not detect a signal, which is usually caused by a:
  - Weak or defective transmitter or receiver
  - Defective jumper cable
  - Dirty or misplugged connector
  - Defective or misplugged segment of the optical fiber cabling.
- A link error occurs when the status of one or more bits has changed, which is usually caused by:
  - A weak transmitter or receiver
  - A dirty or misplugged connector
  - A dirty transmitter-receiver subassembly
  - An incorrect transmitter-to-receiver relationship
  - Excessive link attenuation
  - Dispersion of the link signal.

## Link error analysis

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Because dispersion is not usually measured in the field, it is important to determine if attenuation is the most likely cause of a link failure. Therefore, analyze the failing link environment before proceeding with fault isolation.

The following questions can help isolate the error when performing link failure analysis.

- What is the status of similar links and devices?
- Are there any substitute devices?
- Are there any spare optical fiber pairs?
- Is this the first time that the failing link or links have been used?
- Has this cabling combination been used before?
- If it is an FDDI link, has an optical bypass switch been installed in the link?
- Has this cabling combination been used for another application that had a different wavelength?

- Is the cabling plant a new installation?
- Was the cabling plant installed to support an ATM, FICON, or FDDI environment?
- Was the cabling plant installed over a period of time?
- Was the cabling plant previously used to support other applications?
- Is there a mixture of fiber types within the cabling plant?
- Is there a mixture of fiber types within the same distribution panel?
- Is there a mixture of applications using the same distribution panel?
- Is this the first time that part of the cabling plant was configured in the link?
- Are the cabling plant lengths and specifications available?

## Examples of link error analysis

The following examples show how experience and good diagnostic judgment can aid in error analysis for a link environment.

- The failing link uses the same cabling components, has approximately the same length, and attaches the same device types as another link that is currently operational. It is most likely that attenuation, not dispersion, caused the link error.
- The failing link operates correctly when a substitute device is attached. Again, attenuation is probably the cause of the error.
- The failing link operates correctly when substitute link components (spare or backup cables) are used. Attenuation is usually the cause of the error.
- All links with this configuration are failing. If attenuation measurements are within specifications, the length of the link and optical fiber specifications should be checked.
- The failing link has never been used before. The length of the link and optical fiber specifications should be checked if attenuation measurements are within specifications.
- The failing link is the only link in this location. If attenuation measurements are within specifications, the length of link and fiber plant specifications should be checked.
- The failing link was previously used for an entirely different type of system. If a customer determines that the link was optimized for an application employing a wavelength other than 1300 nm, then excessive dispersion could be the cause of the error.

## Dispersion

Under some conditions (in an FDDI link only), it is difficult to determine if the most probable cause of an error is attenuation or dispersion (for example, a link of 2.1 km with an attenuation of 11.3 dB). Because dispersion testing is an expensive procedure, it might be more cost-effective for the customer to reconfigure the link or replace the fiber rather than determine the exact cause of the failure. The following items can aid in this analysis:

- Customer records of the measurements done by cabling installation personnel can be checked. These records often include attenuation measurements from a power meter, as well as a copy of Optical Time Domain Reflectometer (OTDR) data.
- It is possible that a given pair of attached devices meets FDDI specifications because of a "hot" transmitter and a sensitive receiver. This combination could allow satisfactory operation for a specific link, but the individual link components are still not within specifications. This combination is not possible under the ATM or FICON specification.
- Similarly, a weak transmitter and receiver pair could meet FDDI specifications but still not operate correctly on the link.

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## Chapter 2. Service Strategy and Maintenance Activities

This chapter summarizes the service strategy and activities associated with Fiber Optic Channel link installation, maintenance, problem determination, verification, repair, and testing. See [Chapter 3, "Problem Determination Procedures,"](#) on page 25 for specific maintenance procedures.

Additional services, including design, installation connectivity, and link restoration are available through the IBM Global Services offering.

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### Link problem determination summary

Service representatives can use either the maintenance analysis procedures (MAPs) or a "fast-path" method to perform problem determination, and return a link to operational status for ESCON links. For coupling links, only the Fast-Path method may be used because these links use a different type of laser safety control that does not permit use of the MAPs. This problem determination also includes IBM jumper cables.

Both procedures consist of measuring the end-to-end link loss (attenuation) using an optical source and a power meter. See [Appendix B, "Tools, Test Equipment, and Parts,"](#) on page 67 for the part numbers of all service tools, materials, and test equipment.

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### Link service activities

The following paragraphs summarize the link activities performed by service representatives.

#### Installation activities

Service representatives install and connect IBM jumper cables to devices and distribution panels. For installations that use connectors or cables other than those supported by IBM, IBM Marketing and Services must provide recommendations to the customer and to IBM planning and service personnel.

#### Repair activities

Service representatives perform either major or minor repair actions:

- A major repair action consists of replacing an IBM jumper cable.
- A minor repair action consists of replacing the spring and connector shroud on the IBM duplex connector.

#### Test activities

Service representatives also perform test activities on IBM fiber optic cables and components.

For non-IBM components, the customer must provide test cables and adapters. IBM will perform activities relating to these components, but this service could be billable.

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### Link training topics

The base level of link training for IBM CEs includes:

- Basic fiber optic theory
- Light budget concepts

- General link commodities information
- Link loss calculations
- Link operational characteristics
- Fiber optic cable handling and cleaning procedures
- Power meter and light source usage procedures
- Basic fiber optic test procedures
- Problem determination for a major link component
- Minor repair of the IBM duplex connector.

## Keying and installing an IBM FDDI connector

This section describes how to install FDDI keys and labels. It also lists some potentially serious cabling errors and explains the keying techniques that could prevent these errors. (LC FDDI, FICON and ATM do not use these keying methods.)

**Note:** Retain all protective covers and unused keys. When connectors and receptacles are not being used, all protective covers should be installed because dirt can cause excessive loss and prevent correct operation of the link.

Using FDDI cable keying can also prevent system cabling defects that are difficult to detect and diagnose. Three serious defects are:

- The reversal of a dual-attachment station within the ring trunk such that what was intended to be the A connection is the B, and what was intended to be the B connection is the A. This causes the station media access controls (MACs) to be inserted in the opposite position of the intended trunk ring.
- The connection of a single attachment station directly to the trunk ring by connecting it to either an A or B receptacle. This results in a break in the trunk ring.
- The connection of the M receptacle of a concentrator directly into the trunk ring by connecting it to either an A or B receptacle. This also results in a break in the trunk ring.

### IBM FDDI connector keys

The FDDI standard specifies four types of keyed connectors and receptacles: A, B, M, and S. Three field-installable key inserts and four color-coded labels are provided with each connector:

- Port A - Red key and red label
- Port B - Blue key and blue label
- Master - Green key and green label
- Slave - No key and white label.

Each connector assembly comes with a set of color-coded labels to identify a keyed connector after it has been inserted in a receptacle. To position the label on the connector, select the label that matches the key type being used. White labels identify the Slave (S) connector, which does not have a separate key. Position the label on the back of the connector. See [Table 1 on page 18](#).

**Note:** Without a key installed, the connector can be inserted in any type of FDDI receptacle. Correct keying is recommended to avoid installation errors and to provide efficient cable management.

Connection	Key type
Workstation to wall	S / S
Distribution panel to Concentrator M port	M / M
Distribution panel to Concentrator A port	A / A

<i>Table 1. Recommendations for keying FDDI networks (continued)</i>	
<b>Connection</b>	<b>Key type</b>
Distribution panel to Concentrator B port	B / B
Concentrator A to Concentrator M port	A / M
Concentrator B to Concentrator M port	B / M
Concentrator 1A to Concentrator 2B port	A / B
Concentrator 1B to Concentrator 2A port	B / A
Workstation to Concentrator M port	S / M

**Installing the key**

To install a key:

1. Remove the selected color-coded key from the protective cover of the connector.
2. Insert the tab on the key in the slot on the top of the connector.
3. Push firmly on the key until it snaps into place.

**Removing the key**

To remove a key:

1. Insert the tip of a paper clip or narrow mechanical pen into the small hole in the bottom of the connector.
2. Push firmly until the key pops out of its locked position.
3. Put the key in the protective cover attached to the connector.

**Cleaning the connector**

The connector should be cleaned before inserting it in the receptacle to avoid possible contamination from dirt and dust particles. Refer to [Appendix F, “Fiber optic cleaning procedures,”](#) on page 105.

**Installing and removing the connector**

Insert the connector by pushing it into the receptacle until it clicks into place. Do not force the connector. If it binds, make sure that the receptacle and connector keys are aligned and that they are of the same type.

To remove the connector from the receptacle, simply pull back on the connector housing. Replace all protective covers on the connector and the receptacle to avoid contamination or damage.

**Typical link configurations**

To perform problem determination, a fiber optic channel link should be considered as one of the following configurations:

- One jumper cable between 2 devices ([Figure 35 on page 20](#))
- Two jumper cables connected through 1 distribution panel ([Figure 36 on page 20](#))
- Two jumper cables, each connected to a distribution panel, and a trunk cable ([Figure 37 on page 20](#)).

**Note:** The trunk cable in this configuration could be a short length of fiber optic cable (within a single distribution panel) that joins the 2 jumper cables.

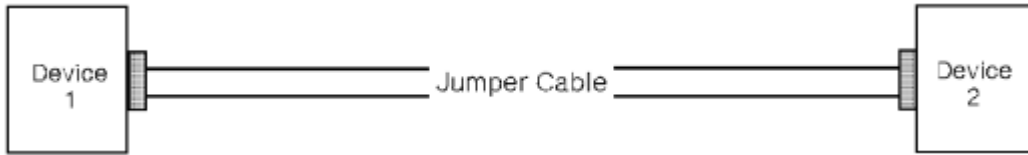


Figure 35. Link configuration 1 consisting of 1 jumper cable between 2 devices

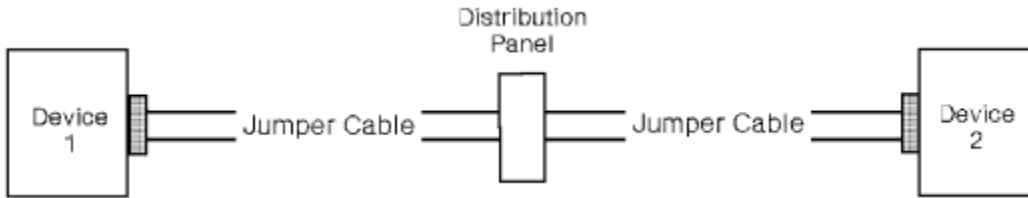


Figure 36. Link configuration 2 consisting of 2 jumper cables and 1 distribution panel

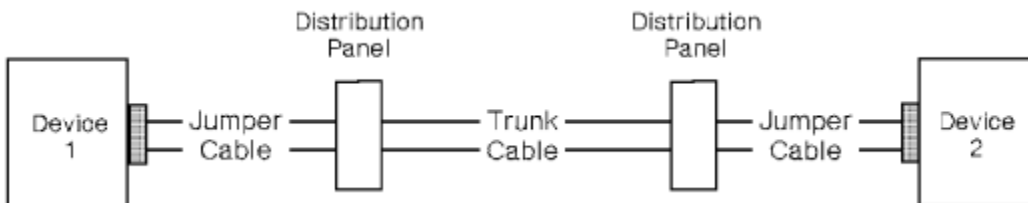


Figure 37. Link configuration 3 consisting of 2 jumper cables, a trunk cable, and 1 or 2 distribution panels

FDDI links connect devices in logical rings, but are physically connected in a star configuration. Devices could contain only a single pair of fibers, such as a device to a concentrator. Critical devices, such as concentrators, contain 2 pairs of fibers formed into counter-rotating rings. From this description, a concentrator would contain multiple single-station interfaces to multiple devices and a pair of interfaces to possibly another concentrator. It is likely, therefore, that several devices within a rack would be connected by jumpers only within an equipment closet, whereas 2 ports would exit the closet on counter-rotational links to other concentrators.

Other fiber optic links may be configured in a wide variety of ways, including star and ring configurations. Figure 38 on page 20 shows a closet-connected concentrator.

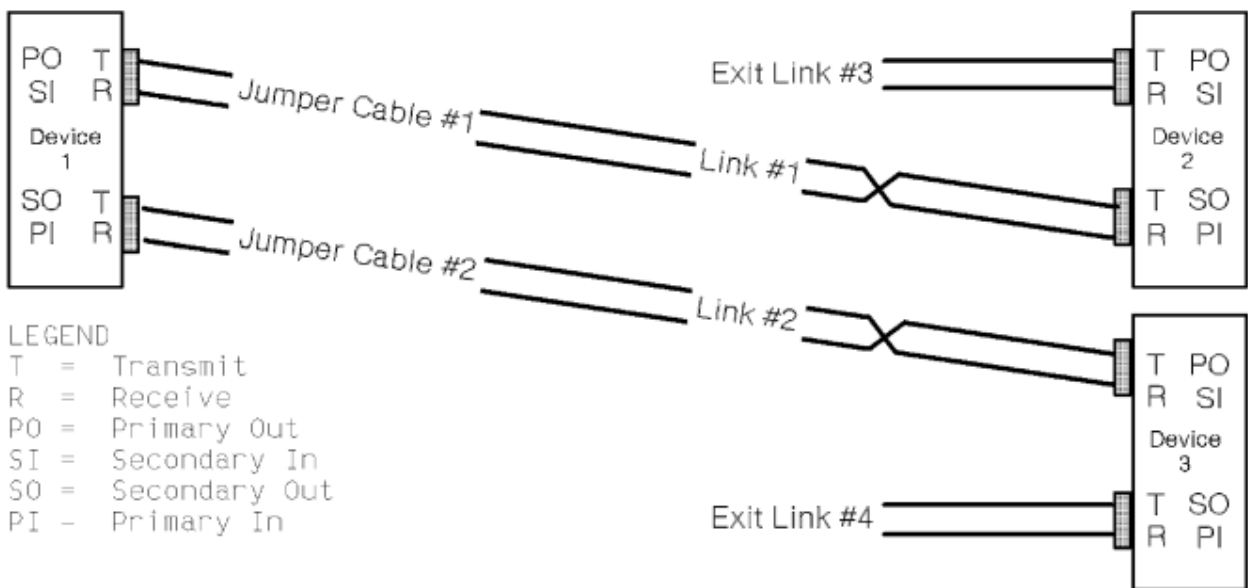


Figure 38. Link configuration—2 jumper cables in a counter-rotating ring



## Common link failures

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Before performing problem determination, you should consider the following failure possibilities, which are typical during and after installation. If the problem, symptom, or condition exists, perform the action suggested.

- For a "no-light" condition during an installation or after a reconfiguration, the link could have 2 device transmitters connected rather than having each transmitter connected to a receiver. Make sure an odd number of link crossovers exists. See [“Determining the direction of light propagation” on page 21](#) for more detailed information.

If jumper cables with FICON SC-duplex connectors are provided by a vendor other than IBM, consult the vendor's specifications to determine the correct direction of light propagation.

After determining that a "no-light" condition exists and with the optical source and power meter attached, swap the biconic test cable connectors on the power meter. If the "no-light" condition disappears, the link is not properly connected.

- The quality and cleanliness of connections can be a large source of loss. Check for dirty or broken connectors at the devices and distribution panel(s). These problems can be found by isolating each link segment. See [Appendix F, “Fiber optic cleaning procedures,” on page 105](#), and use the supplies contained in the fiber optic cleaning kit (IBM part number 45P5948).
- Patch cords (used to attach 1 distribution panel position to another) can cause additional link loss in a configuration using multiple distribution panels. Isolating each link segment can determine if the IBM jumper cables are within specifications.
- Device distance limitations exist. If I/O overruns or timeouts occur, check the distance specifications of the I/O device.
- Link distance limitations also exist. See [Table 4 on page 61](#) for maximum link lengths.

## Determining the direction of light propagation

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Before performing problem determination, an understanding of light travel (propagation) is necessary to allow measurement of:

- Transmit levels
- Receive levels
- End-to-end link loss

The transmitter (output) of each Fiber Optic Channel link device propagates light to the receiver (input) of the next device. For this to occur, an odd number of physical crossovers must exist for each fiber. [Figure 39 on page 22](#) shows the direction of light propagation through an IBM jumper cable, which is keyed to maintain this crossover requirement.

[Figure 39 on page 22](#) also shows that an IBM duplex connector has **A** and **B** embossed on the plastic housing and that IBM's biconic, ST, and FC connectors are color-coded.

- For IBM duplex-to-duplex jumper cables, the transmit signal enters 1 connector at **B** and exits the other connector at **A**.
- For IBM duplex-to-biconic, duplex-to-ST, and duplex-to-FC jumper cables, the transmit signal enters the duplex connector at **B** and exits the other end at the **black** connector.

[Figure 40 on page 23](#) shows three examples of physical fiber connections that satisfy the crossover requirement for device-to-device attachment.

### Notes:

1. In a Fiber Optic Channel environment containing duplex-to-duplex jumper cables and a trunk cable, the trunk must incorporate a crossover.

2. Fiber Optic Cables using FICON SC-duplex connectors obtained from vendors other than IBM may not have a built-in crossover or be labeled according to the conventions above. Consult the manufacturer's specifications.
3. The ISC coupling facility link is serviced using either the multi-mode splitter tool (IBM part number 54G3426) or the single-mode splitter tool (54G3427). These splitters may be inserted anywhere in an operating link without affecting link functions.
4. IBM's biconic, ST, and FC connectors are color-coded (white and black). The MIC duplex connector has the letters *R* and *T* embossed on the plastic housing.
5. Industry standard color coding for single-mode links is a yellow cable jacket with a blue duplex connector; multi-mode links use an orange cable jacket with a beige duplex connector. Not all connectors will conform to these color coding standards.

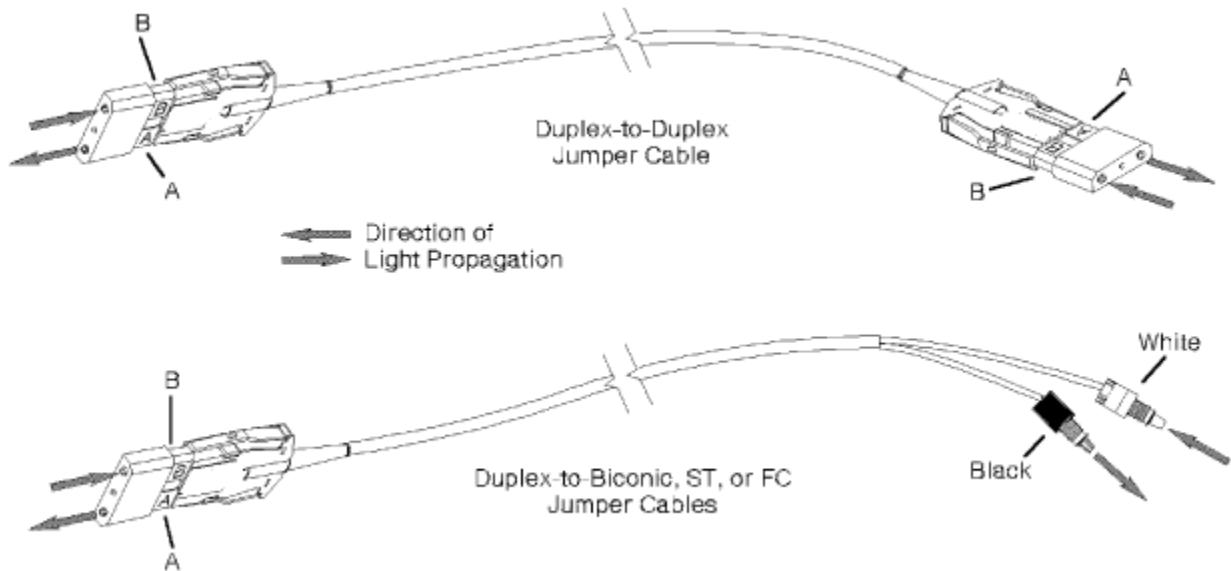


Figure 39. Determining the direction of light propagation in IBM jumper cables

(ESCON connectors are shown in this figure).

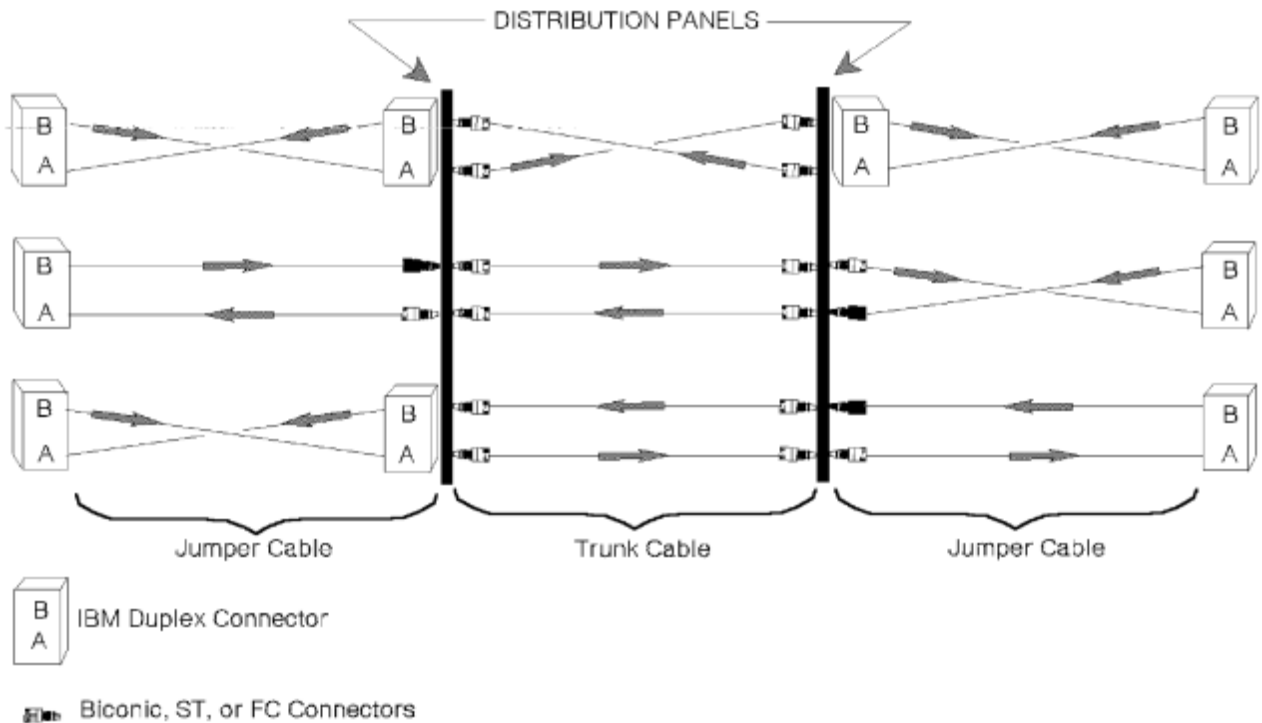


Figure 40. Determining the direction of light propagation in fiber optic channel links

## Link verification summary

Link verification ensures that a link meets IBM specifications, thereby allowing attachment of Fiber Optic Channel devices. Verifying a link requires using an optical source to transmit a signal through the link and a power meter to measure this signal at the other end. For multi-mode links, an optical mode conditioner (OMC) tool provides consistent power loss measurements.

Before you begin link verification, you need the following information:

- Link distance.
- Link bandwidth (multi-mode only).
- Link documentation, such as a link diagram, schematic, or blueprint, and link performance data, such as trunk cable data sheets or operational test results. Also, the customer must provide the necessary documentation and specifications for the premises and external trunk cables if installed.

You can also use the *Cable Administration Work Sheet, SX23-0415*, to record the required link information. [Figure 66 on page 59](#) shows an example of a completed worksheet.

Link verification consists of (1) calibrating the test equipment, (2) obtaining reference levels, and (3) substituting a link cable for a test cable to obtain the loss measurements. This measured loss should be less than the maximum allowable link loss.

The amount of loss introduced by the link depends on the jumper cable length(s), the trunk cable length and specifications, and the number and type of link splices and connectors.

To perform link verification, follow the step-by-step procedures described in [“Link problem determination using MAPs” on page 26](#).



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## Chapter 3. Problem Determination Procedures

This chapter contains link problem determination that can be performed by using either the maintenance analysis procedures (MAPs) or the "fast-path" method. The procedure you use depends on the amount of guidance you require and the type of link you are servicing.

- Use the MAPs and follow the step-by-step instructions to perform link problem determination, link verification, and jumper cable verification.
- Use the fast-path method (see [“Link problem determination using the fast-path method”](#) on page 37) if you know how to perform Fiber Optic Channel link problem determination and do not want to use the MAPs, or if you are working on a coupling link.

### Notes:

1. The MAPs use the optical mode conditioner (OMC) tool for multi-mode ESCON link measurements; the fast-path method does not.
2. The MAPs use the term *simplex* when referring to non-duplex connectors or connections such as ST, FC, or biconic. Most figures, however, show only biconic or duplex components.
3. Before beginning this section, network problem determination should have isolated the problem to a specific link and device maintenance procedures should have been completed.
4. An optical power meter reading LO indicates that no light has been detected by the meter. There are several possible causes for this condition:
  - A jumper cable is either unplugged or plugged in the wrong direction.
  - A jumper cable terminated with simplex connectors could be plugged as transmit-to-transmit and receive-to-receive instead of transmit-to-receive.
  - The entire link does not have an odd number of crossovers.
  - A link component is damaged and a connector or coupler has failed.

---

### Start link problem determination

During fiber optic channel link problem determination, the devices at each end of the link are identified as device 1 and device 2. Always refer to the device where you start these procedures as device 1.

Problem determination consists of measuring the link at specific points. These measured values are then compared to acceptable or maximum values to determine if the link loss is within specifications. [Table 2 on page 26](#) and [Table 3 on page 29](#) contain these values for the MAP procedures; [Table 7 on page 89](#) contains the fast-path values. If it is determined that a device transmitter or receiver is not within specifications and the device is maintained by IBM, replace the transceiver card according to the device maintenance procedure and verify correct link operation. If the device is not maintained by IBM, inform the customer that the transceiver is out of specification and that this is the probable source of the error, then return to the IBM device that generated the call and follow its maintenance procedures for end of call. If the problem still exists after replacing the transceiver card, go to [“0300: Start” on page 25](#) to perform link problem determination or verification.

Go to [“0300: Start” on page 25](#) to perform link problem determination or verification.

### 0300: Start

#### Procedure

1. a. **Do you want to use the maintenance analysis procedures (MAPs) to perform link problem determination or verification?**

**Note:** You must use the fast path procedures if you are working on coupling links.

If **yes** go to step 3. If **no**, continue with the next step.

2. a. Go to [“Link problem determination using the fast-path method”](#) on page 37
3. a. Go to [“Link problem determination using MAPs”](#) on page 26

## Link problem determination using MAPs

Begin at [“0310: Testing a link”](#) on page 30 to perform step-by-step problem determination or verification of a link segment or component. Before you begin, see [“Common link failures”](#) on page 21 for additional information.

<i>Table 2. Maximum link loss with optical source tool as a transmitter (at 1300 nm)</i>			
Link/Fiber type	Maximum loss	Maximum length	Trunk size
<b>ESCON</b>			
Multi-mode	7.0 dB (Note 1)	2.0 km (1.24 miles)	62.5 µm (500 MHz•km)
Multi-mode	6.5 dB (Note 1)	2.0 km (1.24 miles)	50.0 µm
Multi-mode	7.0 dB (Note 1)	3.0 km (1.86 miles)	62.5 µm (800 MHz•km)
Single-mode (discontinued)	14.0 dB	20 km (12.4 miles)	9 to 10 µm
<b>Coupling Links</b>			
Single-mode 1.06 Gbps or 2.1 Gbps	7.0 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode card with 50 micron optical mode conditioner over multi-mode fiber	5.0 dB	550 meters (0.34 miles)	50.0 µm
<b>FDDI</b>			
Multi-mode (discontinued)	9.0 dB	2.0 km (1.24 miles)	62.5 µm
<b>ATM</b>			
Multi-mode (discontinued)	11.0 dB	2.0 km (1.24 miles)	62.5 µm
Single-mode (discontinued)	15.0 dB	20.0 km (12.4 miles)	9 to 10 µm
<b>FICON</b>			
Multi-mode with 50 micron optical mode conditioner on an LX link	5.0 dB	550 meters (0.34 miles)	50.0 µm (Note 3)
Multi-mode with 62.5 micron optical mode conditioner on an LX link	5.0 dB	550 meters (0.34 miles)	62.5 µm (Note 3)
Single-mode LX 1gbps (100-SM-LC-L)	7.8 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode LX 2gbps (200-SM-LC-L)	7.8 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode LX 4gbps 10km (400-SM-LC-L)	7.8 dB	10 km (6.2 miles)	9 to 10 µm
Single-mode LX 4gbps 4km (400-SM-LC-M)	4.8 dB	4 km (2.5 miles)	9 to 10 µm
Single-mode LX 8gbps 10km (800-SM-LC-L)	6.4 dB	10 km (6.2 miles)	9 to 10 µm

Table 2. Maximum link loss with optical source tool as a transmitter (at 1300 nm) (continued)

Link/Fiber type	Maximum loss	Maximum length	Trunk size
Single-mode LX 16gbps 10km (1600-SM-LC-L)	6.4 dB	10 km (6.2 miles)	9 to 10 $\mu\text{m}$
Single-mode LX 32gbps 10km (3200-SM-LC-L)	6.34 dB	10 km (6.2 miles)	9 to 10 $\mu\text{m}$
Multi-mode SX 1gbps (100-M6-SN-I)	2.76 dB	250 meters (0.155miles)	62.5 $\mu\text{m}$ (160 MHz•km)
Multi-mode SX 2gbps (200-M6-SN-I)	1.98 dB	120 meters (0.075 miles)	62.5 $\mu\text{m}$ (160 MHz•km)
Multi-mode SX 4gbps (400-M6-SN-I)	1.72 dB	55 meters (0.034 miles)	62.5 $\mu\text{m}$ (160 MHz•km)
Multi-mode SX 1gbps (100-M6-SN-I)	3.00 dB	300 meters (0.186 miles)	62.5 $\mu\text{m}$ (200 MHz•km)
Multi-mode SX 2gbps (200-M6-SN-I)	2.10 dB	150 meters (0.093 miles)	62.5 $\mu\text{m}$ (200 MHz•km)
Multi-mode SX 4gbps (400-M6-SN-I)	1.78 dB	70 meters (0.043 miles)	62.5 $\mu\text{m}$ (200 MHz•km)
Multi-mode SX 8gbps (800-M6-SN-I)	1.58 dB	21 meters (0.013 miles)	62.5 $\mu\text{m}$ (200 MHz•km)
Multi-mode SX 16gbps (1600-M6-SN-S)	1.56 dB	15 meters (0.009 miles)	62.5 $\mu\text{m}$ (200 MHz•km)
Multi-mode SX 1gbps (100-M5-SN-I)	3.85 dB	500 meters (0.311 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 2gbps (200-M5-SN-I)	2.62 dB	300 meters (0.186 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 4gbps (400-M5-SN-I)	2.06 dB	150 meters (0.093 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 8gbps (800-M5-SN-I)	1.68 dB	50 meters (0.031 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 16gbps (1600-M5-SN-S)	1.63 dB	35 meters (0.021 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 32gbps (3200-M5-SN-S)	1.57 dB	20 meters (0.012 miles)	50 $\mu\text{m}$ (500 MHz•km)
Multi-mode SX 1gbps (100-M5-SN-I)	4.62 dB	860 meters (0.534 miles)	50 $\mu\text{m}$ (2000 MHz•km)
Multi-mode SX 2gbps (200-M5-SN-I)	3.31 dB	500 meters (0.311 miles)	50 $\mu\text{m}$ (2000 MHz•km)
Multi-mode SX 4gbps (400-M5-SN-I)	2.88 dB	380 meters (0.236 miles)	50 $\mu\text{m}$ (2000 MHz•km)
Multi-mode SX 8gbps (800-M5-SN-I)	2.04 dB	150 meters (0.093 miles)	50 $\mu\text{m}$ (2000 MHz•km)
Multi-mode SX 16gbps (1600-M5E-SN-S)	1.86 dB	100 meters (0.062 miles)	50 $\mu\text{m}$ (2000 MHz•km)

<i>Table 2. Maximum link loss with optical source tool as a transmitter (at 1300 nm) (continued)</i>			
<b>Link/Fiber type</b>	<b>Maximum loss</b>	<b>Maximum length</b>	<b>Trunk size</b>
Multi-mode SX 32gbps (3200-M5E-SN-S)	1.75 dB	70 meters (0.043 miles)	50 µm (2000 MHz·km)
Multi-mode SX 4gbps (400-M5F-SN-S)	2.95 dB	400 meters (0.248 miles)	50 µm (4700 MHz·km)
Multi-mode SX 8gbps (800-M5F-SN-S)	2.19 dB	190 meters (0.118 miles)	50 µm (4700 MHz·km)
Multi-mode SX 16gbps (1600-M5F-SN-S)	1.95 dB	125 meters (0.077 miles)	50 µm (4700 MHz·km)
Multi-mode SX 32gbps (3200-M5F-SN-S)	1.86 dB	100 meters (0.062 miles)	50 µm (4700 MHz·km)
<b>Gigabit Ethernet (GbE) LX</b>			
Multi-mode with 50 micron optical mode conditioner	2.4 dB	550 meters (0.340 miles)	50 µm
Multi-mode with 62.5 micron optical mode conditioner	2.4 dB	550 meters (0.340 miles)	62.5 µm
Single-mode	4.6 dB	5 km (3.1 miles)	9 to 10 µm
<b>Gigabit Ethernet (GbE) SX</b>			
Multi-mode 50 micron	3.6 dB	550 meters (0.34 miles)	50 µm
Multi-mode 62.5 micron	2.6 dB	275 meters (0.17 miles)	62.5 µm
<b>10 Gigabit Ethernet (10GbE) LR</b>			
10 Gigabit Ethernet (10GbE) Single-mode	6.0dB	10 km (6.2 miles)	9 to 10 µm
<b>RoCE (10GbE) SR</b>			
Multi-mode 50 micron (OM4)	2.9 dB	400 meters (0.248 miles)	50 µm
Multi-mode 50 micron (OM3)	2.6 dB	300 meters (0.19 miles)	50 µm
Multi-mode 50 micron (OM2)	1.8 dB	82 meters (0.05 miles)	50 µm
Multi-mode 62.5 micron (OM1)	1.6 dB	33 meters (0.02 miles)	62.5 µm
<b>RoCE (25GbE) SR</b>			
Multi-mode 50 micron (OM4)	1.9 dB	100 meters (0.062 miles)	50 µm
Multi-mode 50 micron (OM3)	1.8 dB	70 meters (0.043 miles)	50 µm
<b>Parallel Sysplex using InfiniBand</b>			
1x IFB	5.66 dB	10 km (6.2 miles)	9 to 10 µm
12x IFB	2.06 dB	150 meters (0.93 miles)	50 µm
<b>Integrated Coupling Adapter (ICA) and zHyperLink Express</b>			
24x PCIe (OM3)	1.9 dB	100 meters (0.062 miles)	50 µm (2000 MHz·km)



Table 2. Maximum link loss with optical source tool as a transmitter (at 1300 nm) (continued)

Link/Fiber type	Maximum loss	Maximum length	Trunk size
24x PCIe (OM4)	1.5 dB	150 meters (0.093 miles)	50 $\mu$ m (4700 MHz•km)

**Notes:**

1. This value does **not** include the higher-order-mode loss because the MAPs use the OMC tool for multi-mode link measurements.
2. Multi-mode coupling links operate at wavelengths of 770 - 850 nm; their maximum distance is 1 km (0.62 miles) using 50 micron fiber, with a maximum allowable loss of 3 dB/km measured at 850 nm.
3. The use of MCP cables is not supported over 1 gb.

Table 3. Maximum IBM jumper cable attenuation (including connectors)

Fiber type	Cable length in meters (ft.)	Maximum loss
<b>ESCON, ATM, FICON LX, FDDI, GbE LX</b>		
Multi-mode	4 to 85 (12 to 279)	1.0 dB at 1300 nm
Multi-mode	86 to 143 (280 to 469)	1.1 dB at 1300 nm
Multi-mode	144 to 200 (470 to 656)	1.2 dB at 1300 nm
Multi-mode	201 to 257 (657 to 843)	1.3 dB at 1300 nm
Multi-mode	258 to 314 (844 to 1030)	1.4 dB at 1300 nm
Multi-mode	315 to 371 (1031 to 1217)	1.5 dB at 1300 nm
Multi-mode	372 to 428 (1218 to 1404)	1.6 dB at 1300 nm
Multi-mode	429 to 485 (1405 to 1591)	1.7 dB at 1300 nm
Multi-mode	486 to 500 (1592 to 1640)	1.75 dB at 1300 nm
<b>Coupling link, FICON SX, GbE SX</b>		
Multi-mode	4 to 50 (12 to 164)	1.0 dB at 850 nm
Multi-mode	51 to 117 (165 to 384)	1.2 dB at 850 nm
Multi-mode	118 to 183 (385 to 600)	1.4 dB at 850 nm
Multi-mode	184 to 250 (601 to 820)	1.6 dB at 850 nm
Multi-mode	251 to 317 (821 to 1040)	1.8 dB at 850 nm
Multi-mode	318 to 383 (1041 to 1257)	2.0 dB at 850 nm
Multi-mode	384 to 450 (1258 to 1476)	2.2 dB at 850 nm
Multi-mode	451 to 500 (1476 to 1640)	2.35 dB at 850 nm
<b>ESCON, coupling link, ATM, FICON, GbE</b>		
Single-mode	4 to 300 (12 to 984)	1.0 dB at 1300 nm
Single-mode	301 to 500 (985 to 1640)	1.1 dB at 1300 nm
<b>Note:</b> Use supplier attenuation values if jumpers are not supplied by IBM.		

## 0310: Testing a link

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### Procedure

1. a. 1) Compare the configuration of the link you want to test to those shown on page “[Typical link configurations](#)” on page 19; then select a work sheet from [Appendix E, “Work Sheets,”](#) on page 87 that most resembles this configuration.  
2) Go to “[2](#)” on page 30.
2. a. 1) Record the device 1 and device 2 identification information on the work sheet. **Remember that you are at device 1.**  
2) Test both fibers in the link, starting with “[0320: Testing fiber 1](#)” on page 30.

## 0320: Testing fiber 1

---

### Procedure

1. a. Go to “[Obtaining reference levels and attaching test equipment to a link](#)” on page 42 to obtain **P1** and to attach the test equipment; then return here. The optical source and attached test equipment should now be connected to the device 1 end, and the power meter and attached test equipment to the device 2 end. Go to step “[2](#)” on page 30.
2. a. 1) Record the values for **P1** and **L** in the **Fiber 1** column on the work sheet:  
**P1** = the reference level from the applicable procedure in “[Obtaining reference levels and attaching test equipment to a link](#)” on page 42  
**L** = the maximum link loss value from [Table 2](#) on page 26.  
2) Calculate the minimum acceptable receive level **F1**, and record the value in the **Fiber 1** column on the work sheet. See the example below, and go to step “[3](#)” on page 30.

### Example:

		Multi-mode	Single-mode
<b>P1</b>	Reference level	-21.0 dBm	-10.0 dBm
<b>L</b>	Maximum link loss	7.0 dB	14.0 dB
		(-) -----	-----
<b>F1</b>	Minimum acceptable receive level at <b>A1</b>	-28.0 dBm	-24.0 dBm

3. a. Observe the power meter display, and go to step “[4](#)” on page 30.
4. a. **Is the meter reading at **A1** less than the minimum acceptable receive level **F1**? (Example: -32.0 dBm is less than -29.0 dBm.)**  
If **yes** go to step 6. If **no** continue with next step.
5. a. Fiber 1 loss is within specifications. Fiber 2 must now be tested. Go to “[0340: Testing fiber 2](#)” on page 33.
6. a. Fiber 1 loss is **not** within specifications. Go to step “[7](#)” on page 30.
7. a. **Does this link configuration consist of only 1 jumper cable?**

- If **yes** go to step 11. If **no** continue with next step.
8.
    - a. Take the power meter and attached test equipment to **C1**.
    - b. **Is jumper 1 duplex-to-duplex?**  
If **yes**, go to step 10. If **no**, continue with next step.
  9.
    - a. Go to “Obtaining P2 for a multi-mode link” on page 46. Record the **P2** value in the area labeled **Px** in the **Fiber 1** column on the work sheet; then go to “0330: Fiber 1 loss unacceptable” on page 31.
  10.
    - a. Record the value **P1** in the area labeled **Px** in the **Fiber 1** column on the work sheet; then go to “0330: Fiber 1 loss unacceptable” on page 31.
  11.
    - a. Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

## 0330: Fiber 1 loss unacceptable

### Procedure

1.
  - a. 1) The value **P1** or **P2** obtained in the reference level procedure should have been recorded in the area labeled **Px** in the **Fiber 1** column on the work sheet.
  - 2) Obtain the maximum jumper cable dB loss values for both jumper 1 and jumper 2 from [Table 3 on page 29](#). Record these values in the areas labeled **J1** and **J2** in the **Fiber 1** column on the work sheet as required for your configuration.
  - 3) Calculate the minimum acceptable receive level **G1**, and record this value in the **Fiber 1** column on the work sheet. See the example below, and go to step 2.

### Example:

		<b>Multi-mode</b>	<b>Single-mode</b>
<b>Px</b>	Reference level	-20.2 dBm	-10.0 dBm
<b>J1</b>	Maximum jumper loss	1.2 dB	1.1 dB
	(-)	-----	-----
<b>G1</b>	Minimum acceptable receive level at <b>C1</b>	-21.4 dBm	-11.1 dBm

2.
  - a. 1) If disconnected in a previous step, connect the optical source and attached test equipment to jumper 1 at **B1**.
  - 2) Disconnect jumper 1 from the distribution panel at **C1**. If jumper 1 has simplex connectors, remove **only** the black-coded connector from the distribution panel.
  - 3) Connect the power meter and attached test equipment to jumper 1 at **C1**. If jumper 1 has simplex connectors, attach the black-coded connector to the test equipment.
  - 4) Observe the power meter display, and go to “3” on page 31.
3.
  - a. **Is the meter reading at **C1** less than the minimum acceptable receive level **G1**? (Example: -22.5 dBm is less than -21.4 dBm.)**  
If **yes**, go to “7” on page 32. If **no**, go to “4” on page 31.
4.
  - a. **Does this configuration consist of 2 jumper cables and 1 distribution panel (no trunk)?**  
If **yes**, go to “6” on page 30. If **no**, go to “5” on page 30.

5. a. 1) Disconnect the power meter and attached test equipment from jumper 1 at **C1**.  
 2) Reconnect jumper 1 to the distribution panel at **C1**.  
 3) Disconnect the optical source and attached test equipment from **B1**.  
 4) Take the optical source, power meter, and all attached test equipment to **D1**; then go to “8” on page 32.
6. a. Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.
7. a. Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.
8. a. **Is jumper 2 duplex-to-duplex?**  
 If **yes** go to “10” on page 32. If **no** go to “9” on page 32
9. a. Go to “Obtaining reference levels and attaching test equipment to a link” on page 42, and obtain **P3**. Record this value in the area labeled **Py** in the **Fiber 1** column on the work sheet; then go to “11” on page 32.
10. a. Record the value **P1** in the area labeled **Py** in the **Fiber 1** column on the work sheet; then go to “11” on page 32.
11. a. Calculate the minimum acceptable receive level **H1**, and record the value in the **Fiber 1** column on the work sheet. See the example below, and go to “12” on page 32.

**Example:**

		<b>Multi-mode</b>	<b>Single-mode</b>
<b>Py</b>	Reference level	-20.0 dBm	-10.0 dBm
<b>J2</b>	Maximum jumper loss	1.2 dB	1.1 dB
		(-)	-----
<b>H1</b>	Minimum acceptable receive level at <b>A1</b>	-21.2 dBm	-11.1 dBm

12. a. 1) Disconnect jumper 2 from the distribution panel at **D1**. If jumper 2 has simplex connectors, remove **only** the white-coded connector.  
 2) Connect the optical source and attached test equipment to jumper 2 at **D1**. If jumper 2 has simplex connectors, attach the white-coded connector to the test equipment.  
 3) Take the power meter and attached test equipment to **A1**; then connect it to jumper 2.  
 4) Observe the power meter display, and go to “13” on page 32.
13. a. **Is the meter reading at **A1** less than the minimum acceptable receive level **H1**? (Example: -25.0 dBm is less than -21.2 dBm.)**  
 If **yes**, go to “15” on page 33. If **no**, go to “14” on page 32.
14. a. The problem is in the trunk or distribution panel(s). If this link segment includes:
  - Fiber Transport Services (FTS) components, contact your local Availability Services Marketing Specialist.
  - Components covered by another service agreement or maintenance offering, contact the IBM marketing representative

- Components not covered by any service agreement or maintenance offering, inform the customer
15. a. Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

## 0340: Testing fiber 2

---

### Procedure

1. a. **Note:** When using this MAP, the optical source and attached test equipment should be connected to the device 2 end, and the power meter and attached test equipment should be connected to the device 1 end.

#### Have you obtained **P1** and not switched off power to the optical source?

If **yes**, go to “3” on page 33. If **no**, go to “2” on page 33.

2. a. Go to “Obtaining reference levels and attaching test equipment to a link” on page 42 to obtain **P1**, and attach the test equipment; then go to step “4” on page 33.
3. a. Go to step “4” on page 33.
4. a. Make sure the optical source and attached test equipment are connected at the device 2 end, and the power meter and attached test equipment are connected at the device 1 end.

1) Record the values for **P1** and **L** in the **Fiber 2** column on the work sheet:

**P1** = the reference level from the applicable procedure in “Obtaining reference levels and attaching test equipment to a link” on page 42

**L** = the maximum link loss value from Table 2 on page 26.

2) Calculate the minimum acceptable receive level **F2**, and record the value in the **Fiber 2** column on the work sheet. See the example below, and go to step “5” on page 33.

#### Example:

		Multi-mode	Single-mode
<b>P1</b>	Reference level	-21.0 dBm	-10.0 dBm
<b>L</b>	Maximum link loss	7.0 dB	14.0 dB
		(-) _____	_____
<b>F2</b>	Minimum acceptable receive level at <b>A2</b>	-28.0 dBm	-24.0 dBm

5. a. Observe the power meter display, and go to “6” on page 33.
6. a. **Is the meter reading at **A2** less than the minimum acceptable receive level **F2**? (Example: -32.0 dBm is less than -29.0 dBm.)**  
If **yes**, go to “8” on page 33. If **no**, go to “7” on page 33.
7. a. Fiber 2 loss is within specifications. If you have already tested fiber 1, the test procedure is complete. Return to the procedure that directed you here. If the problem still exists, contact your next level of support.
8. a. Fiber 2 loss is **not** within specifications. Go to step “9” on page 33.
- 9.

- a. **Does this link configuration consist of only 1 jumper cable?**  
If **yes**, go to “13” on page 34. If **no**, go to “10” on page 34.
10. a. Take the power meter and attached test equipment to **D2**.  
**Is jumper 2 duplex-to-duplex?**  
If **yes**, go to “12” on page 34. If **no**, go to “11” on page 34.
11. a. Go to “Obtaining P2 for a multi-mode link” on page 46. Record the **P2** value in the area labeled **Px** in the **Fiber 2** column on the work sheet; then go to “0350: Fiber 2 loss unacceptable” on page 34.
12. a. Record the value **P1** in the area labeled **Px** in the **Fiber 2** column on the work sheet; then go to “0350: Fiber 2 loss unacceptable” on page 34.
13. a. Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

## 0350: Fiber 2 loss unacceptable

---

### Procedure

1. a. 1) The value **P1** or **P2** obtained in the reference level procedure should have been recorded in the area labeled **Px** in the **Fiber 2** column on the work sheet.  
2) Obtain the maximum jumper cable dB loss values for both jumper 2 and jumper 1 from Table 3 on page 29. Record these values in the areas labeled **J2** and **J1** in the **Fiber 2** column on the work sheet as required for your configuration.  
3) Calculate the minimum acceptable receive level **G2**, and record this value in the **Fiber 2** column on the work sheet. See the example below, and go to step “2” on page 34.

### Example:

		Multi-mode	Single-mode
<b>Px</b>	Reference level	-21.5 dBm	-10.0 dBm
<b>J2</b>	Maximum jumper loss	1.4 dB	1.1 dB
		(-) -----	-----
<b>G2</b>	Minimum acceptable receive level at <b>D2</b>	-22.9 dBm	-11.1 dBm

2. a. 1) If disconnected in a previous step, connect the optical source and attached test equipment to jumper 2 at **B2**.  
2) Disconnect jumper 2 from the distribution panel at **D2**. If jumper 2 has simplex connectors, remove **only** the black-coded connector from the distribution panel.  
3) Connect the power meter and attached test equipment to jumper 2 at **D2**. If jumper 2 has simplex connectors, attach the black-coded connector to the test equipment.  
4) Observe the power meter display, and go to step “3” on page 34.
3. a. **Is the meter reading at **D2** less than the minimum acceptable receive level **G2**? (Example: -30.5 dBm is less than -22.9 dBm.)**  
If **yes**, go to “7” on page 35. If **no**, go to “4” on page 34.
4. a. **Does this configuration consist of 2 jumper cables and 1 distribution panel (no trunk)?**

If **yes**, go to “6” on page 35. If **no**, go to “5” on page 35.

5. a. 1) Disconnect the power meter and attached test equipment from jumper 2 at **D2**.  
2) Reconnect jumper 2 to the distribution panel at **D2**.  
3) Disconnect the optical source and attached test equipment from **B2**.  
4) Take the optical source, power meter, and all attached test equipment to **C2**; then go to step “8” on page 35.
6. a. Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.
7. a. Jumper 2 loss is **not** within specifications. Replace jumper 2, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.
8. a. **Is jumper 1 duplex-to-duplex?**  
If **yes**, go to “10” on page 35. If **no**, go to “9” on page 35.
9. a. Go to “Obtaining reference levels and attaching test equipment to a link” on page 42, and obtain **P3**. Record this value in the area labeled **Py** in the **Fiber 2** column on the work sheet; then go to step “11” on page 35.
10. a. Record the value **P1** in the area labeled **Py** in the **Fiber 2** column on the work sheet; then go to step “11” on page 35.
11. a. Calculate the minimum acceptable receive level **H2**, and record the value in the **Fiber 2** column on the work sheet. See the example below, and go to step “12” on page 35.

**Example:**

		<b>Multi-mode</b>	<b>Single-mode</b>
<b>Py</b>	Reference level	-20.0 dBm	-10.0 dBm
<b>J1</b>	Maximum jumper loss	1.2 dB	1.1 dB
		(-)	-----
<b>H2</b>	Minimum acceptable receive level at <b>A2</b>	-21.2 dBm	-11.1 dBm

12. a. 1) Disconnect jumper 1 from the distribution panel at **C2**. If jumper 1 has simplex connectors, remove **only** the white-coded connector.  
2) Connect the optical source and attached test equipment to jumper 1 at **C2**. If jumper 1 has simplex connectors, attach the white-coded connector to the test equipment.  
3) Take the power meter and attached test equipment to **A2**; then connect it to jumper 1.  
4) Observe the power meter display, and go to step “13” on page 35.
13. a. **Is the meter reading at **A2** less than the minimum acceptable receive level **H2**? (Example: -25.0 dBm is less than -21.2 dBm.)**  
If **yes**, go to “15” on page 36. If **no**, go to “14” on page 35.
14. a. The problem is in the trunk or distribution panel(s). If this link segment includes:
  - Fiber Transport Services (FTS) components, contact your local Availability Services Marketing Specialist.
  - Components covered by another service agreement or maintenance offering, contact the IBM marketing representative

- Components not covered by any service agreement or maintenance offering, inform the customer
15. a. Jumper 1 loss is **not** within specifications. Replace jumper 1, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

## 0360: Jumper cable verification

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### Procedure

1. a. **Obtaining the reference level:**
  - 1) Go to [“Obtaining reference levels and attaching test equipment to a link” on page 42](#), and obtain the level (**P1**, **P2**, or **P3**) that matches the cable configuration and direction of light propagation for the fiber being tested. **If obtaining **P1**, do not attach the test equipment to the link.**
  - 2) Go to step [“2” on page 36](#).
2. a. **Measuring the jumper loss:**
  - 1) Connect the jumper cable that you want to verify to the couplers; then observe the power meter display.
  - 2) The difference between the meter reading and the reference level must not exceed the maximum jumper loss found in [Table 3 on page 29](#). See the example below, and go to [“3” on page 36](#).

#### Example:

	Multi-mode	Single-mode
Reference level	-21.0 dBm	-12.0 dBm
Meter reading	-25.0 dBm	-15.0 dBm
	(-) -----	-----
Jumper loss	4.0 dB	3.0 dB

3. a. **Is the jumper loss greater than the maximum jumper loss value?**  
If **yes**, go to [“5” on page 36](#). If **no**, go to [“4” on page 36](#).
4. a. The fiber is within specifications.
  - If you need to verify the second fiber in the jumper cable, go to [“6” on page 36](#).
  - If not, return to the fast-path procedure, and continue with the next step.
5. a. The jumper is **not** within specifications. Replace the jumper, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.
6. a. **Verifying the second fiber in the jumper cable:**
  - 1) Go to [“Obtaining reference levels and attaching test equipment to a link” on page 42](#), and obtain the level (**P1**, **P2**, or **P3**) that matches the cable configuration and direction of light propagation for the fiber being tested. **If obtaining **P1**, do not attach the test equipment to the link.**
  - 2) Move the optical source and the power meter to the jumper cable ends opposite their previous attachment in step [“2” on page 36](#).



- 3) Reconnect both ends of the jumper cable to the couplers; then observe the power meter display.
- 4) The difference between the meter reading and the reference level must not be greater than the maximum jumper loss found in [Table 3 on page 29](#). See the example below, and go to [“7” on page 37](#).

**Example:**

	<b>Multi-mode</b>	<b>Single-mode</b>
Reference level	-21.0 dBm	-12.0 dBm
Meter reading	-25.0 dBm	-15.0 dBm
(-)	-----	-----
Jumper loss	4.0 dB	3.0 dB

7. a. **Is the jumper loss greater than the maximum jumper loss value?**  
If **yes**, go to [“9” on page 37](#). If **no**, go to [“8” on page 37](#).
8. a. The jumper is within specifications. Jumper cable verification is complete. Return to the fast-path procedure, and continue with the next step.
9. a. The jumper is **not** within specifications. Replace the jumper cable, and verify the repair using the maintenance procedures that directed you here if the devices are available. If the problem still exists, contact your next level of support.

## Link problem determination using the fast-path method

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Use this method to isolate a failing link by either excluding (swapping) each link segment or by measuring optical power through each of the 2 fibers. See also [“Common link failures” on page 21](#) for additional information. If you cannot determine the problem using this method, contact your next level of support.

**Note:** Before you begin, make a copy of the [“Fast path work sheet: all link configurations” on page 93](#). You will use this work sheet to record the optical power levels at specific points in the link, and then determine where the failure exists.

**Note:** Although the procedures refer only to IBM duplex and biconic connectors and components, they can also be performed using ST, FC, MT-RJ, LC, and FICON connector types. The optical source tool can only be used on links with a wavelength of 1300  $\mu\text{m}$ ; links operating at other wavelengths (such as SX links at 850 nm or wavelength multiplexed links near 1550 nm) must use the attached device as a light source. As a rule of thumb, typical optical fiber loss at 1300  $\mu\text{m}$  is 0.5dB/km; at 850 nm is 3dB/km; and at 1550 nm is 0.3dB/km.

1. Have you already obtained the transmit and receive levels for both devices (device 1 and device 2)?
  - If **Yes**, record the values on the fast-path work sheet as **B1** (device 1 transmit), **A2** (device 1 receive), **B2** (device 2 transmit), and **A1** (device 2 receive).
  - If **No**, go to [Appendix C, “Measuring Device Transmit and Receive Levels,” on page 69](#) to obtain them. Record these values on your fast-path work sheet; then return here when done.
2. Use the work sheet to calculate if the loss of either of the 2 link fibers exceeds the maximum link loss shown in [Table 8 on page 93](#).
  - a. If **both** fibers **are** within specifications, either return to the maintenance procedures that directed you here or contact your next level of support.
  - b. If **1** or **both** fibers **are not** within specifications, and the link consists of only 1 jumper cable, replace the jumper cable.

c. If the link has more than 1 jumper cable or has both jumper and trunk cables, you must isolate one segment of the link at a time until you locate the failure. See also any previous link loss data for comparison, including the installer's records if available.

- 1) If you want to exclude each link segment, go to step 3.
- 2) If you want to measure each link segment, go to step 4.

3. To exclude a link segment, use:

- A spare link
- A spare pair of trunk fibers
- A spare jumper cable
- A spare coupler or adapter

4. To measure a link segment, first refer to the work sheet. You should have already determined if fiber 1 or fiber 2 is not within specifications. This determines the points within the link that you should measure. You also need to know the length of the jumper cable(s) to determine if the power level at these points is within specifications. See also [“Determining the direction of light propagation” on page 21](#) if necessary.

If you are measuring a link in a coupling facility with open fiber control, you can only isolate link segments using the splitter tool; see [“Isolating link segments using the splitter tool” on page 82](#).

a. If fiber 1 **is not** within specifications (**B1** to **A1**):

1) Take measurements at **C1** and **D1**. Measure **C1** at the jumper 1 connector (removed from the distribution panel), and measure **D1** at the distribution panel.

• For ESCON links:

- Multi-mode links-See [Figure 41 on page 39](#) and [Figure 42 on page 39](#).
- Single-mode links-See [Figure 43 on page 40](#) and [Figure 44 on page 40](#).

• For coupling facility links use a splitter tool to isolate a link segment:

- Multi-mode links - See [Figure 47 on page 41](#).
- Single-mode links - See [Figure 48 on page 42](#).
- FDDI links - see [Figure 45 on page 41](#).
- ATM, FICON, or GbE links - see [Figure 46 on page 41](#).

• For more information on the splitter tools, see [“Isolating link segments using the splitter tool” on page 82](#).

2) Is the power level at **C1** **less** than the value shown in [Table 7 on page 89](#) (use the jumper 1 cable length)?

- If **Yes**, jumper 1 could be defective. Verify the jumper cable loss before replacing the cable. Go to [“0360: Jumper cable verification” on page 36](#).
- If **No**, go to the next step.

3) Is the power level at **D1** **greater** than the value shown in [Table 7 on page 89](#) (use the jumper 2 cable length)?

- If **Yes**, jumper 2 could be defective. Verify the jumper cable loss before replacing the cable. Go to [“0360: Jumper cable verification” on page 36](#).
- If **No**, go to step 5.

b. If fiber 2 **is not** within specifications (**B2** to **A2**):

1) Take measurements at **C2** and **D2**. Measure **C2** at the distribution panel, and measure **D2** at the jumper 2 connector (removed from the distribution panel). See [Figure 41 on page 39](#) and [Figure 42 on page 39](#) for multi-mode links; see [Figure 43 on page 40](#) and [Figure 44 on page 40](#) for single-mode links.

- 2) Is the power level at **D2** less than the value shown in [Table 7 on page 89](#) (use the jumper 2 cable length)?
    - If **Yes**, jumper 2 could be defective. Verify the jumper cable loss before replacing the cable. Go to [“0360: Jumper cable verification” on page 36](#).
    - If **No**, go to the next step.
  - 3) Is the power level at **C2** greater than the value shown in [Table 7 on page 89](#) (use the jumper 1 cable length)?
    - If **Yes**, jumper 1 could be defective. Verify the jumper cable loss before replacing the cable. Go to [“0360: Jumper cable verification” on page 36](#).
    - If **No**, go to step “5” on page 39.
5. The trunk cable is the most probable cause of the failure. Switch to an alternate pair of trunk fibers (if available), and inform the customer. If the problem still exists, contact your next level of support

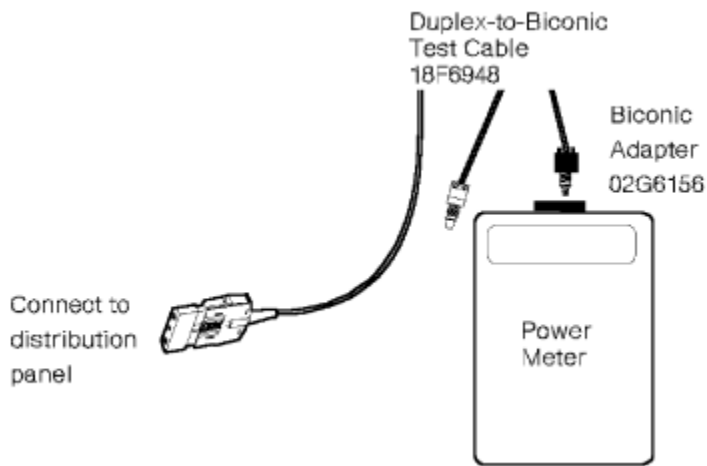


Figure 41. Measuring **C2** or **D1** for a multi-mode link

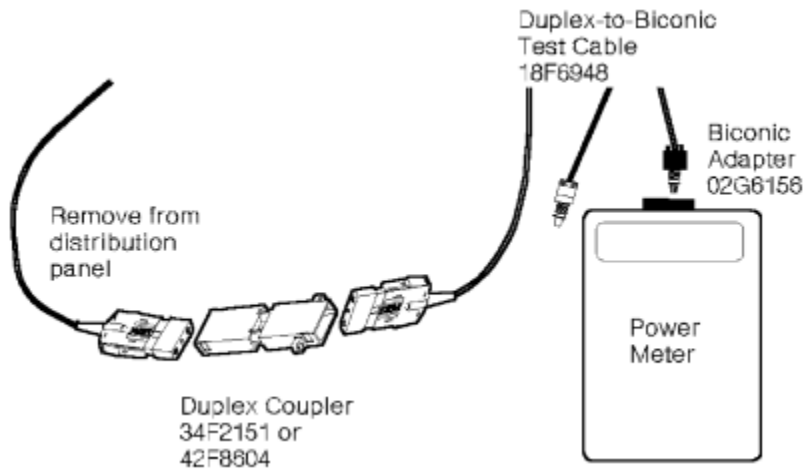


Figure 42. Measuring **C1** or **D2** for a multi-mode link

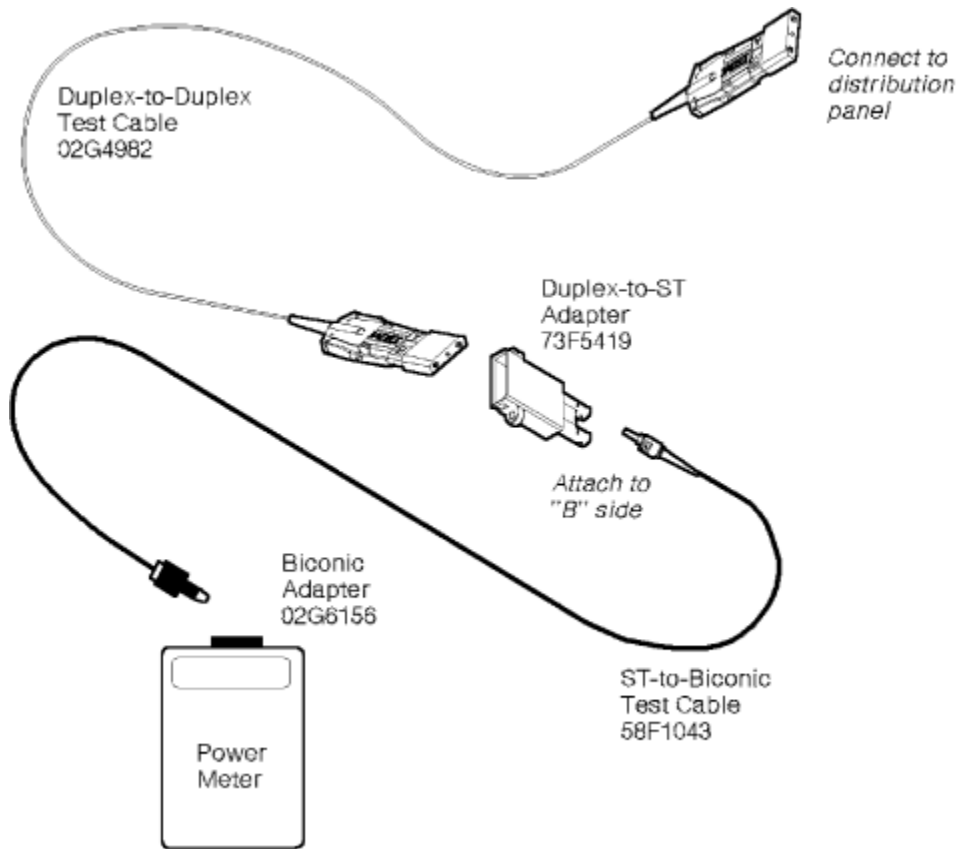


Figure 43. Measuring **C2** or **D1** for a single-mode link

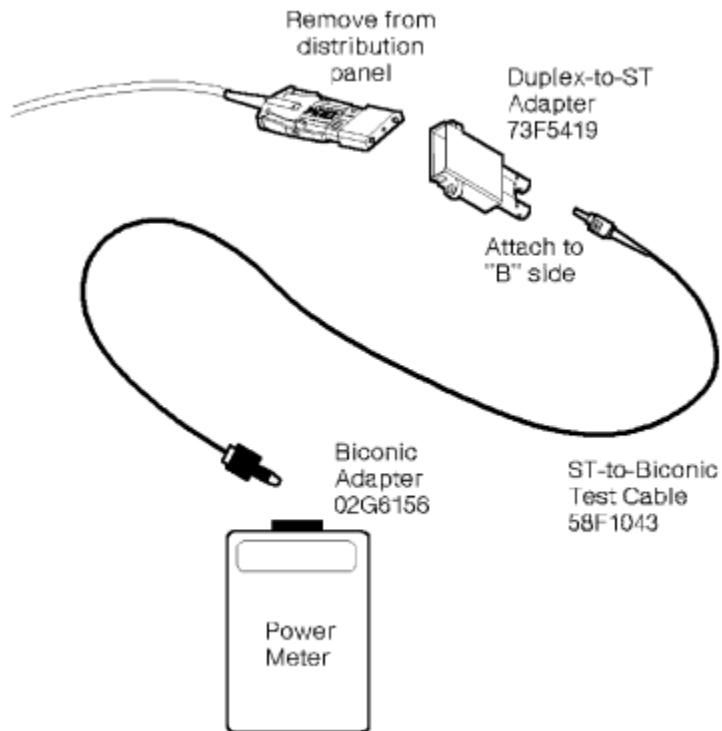


Figure 44. Measuring **C1** or **D2** for a single-mode link

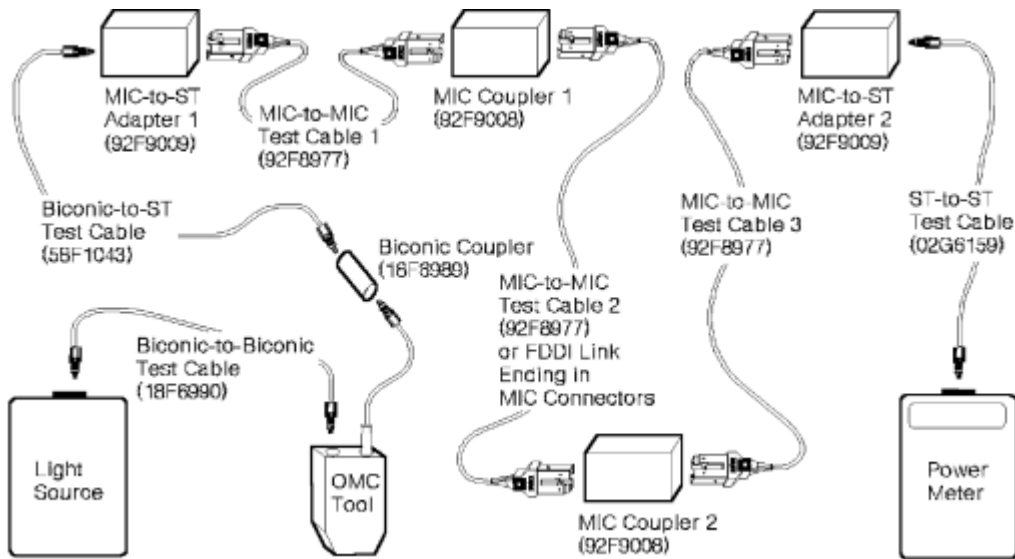


Figure 45. Obtaining the FDDI end-to-end link loss using the fast-path method

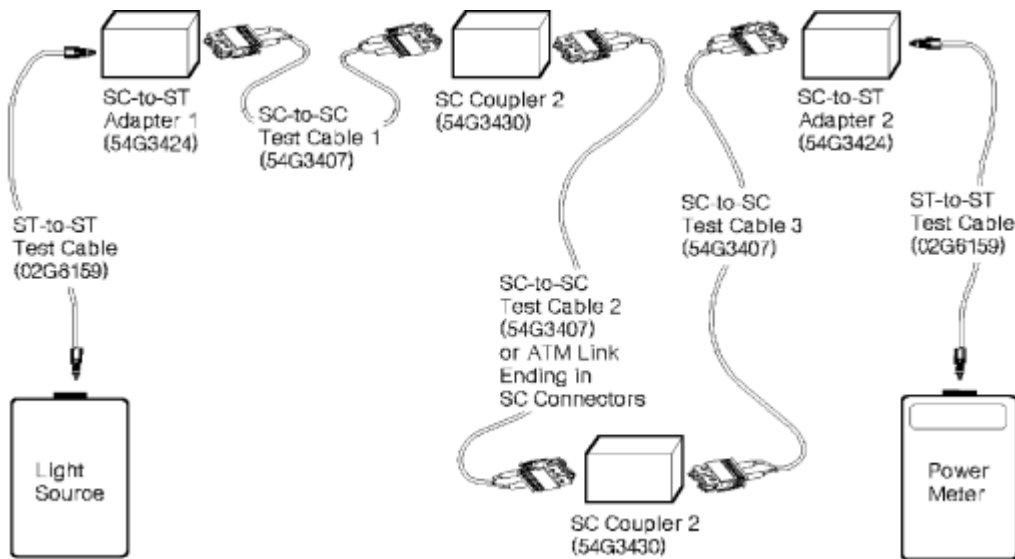


Figure 46. Obtaining the ATM end-to-end link loss using the fast-path method

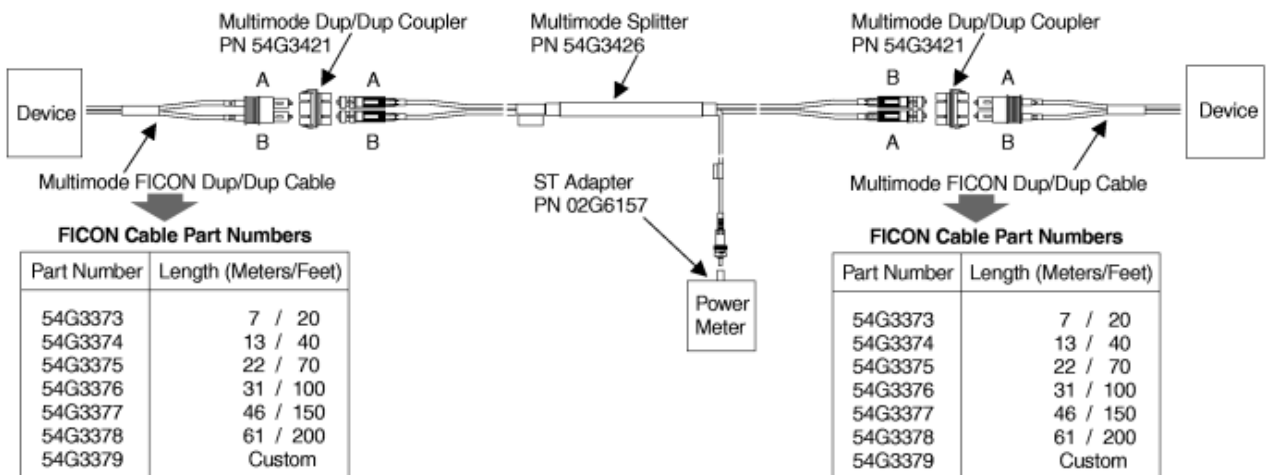


Figure 47. Isolating a multi-mode link segment with a splitter tool

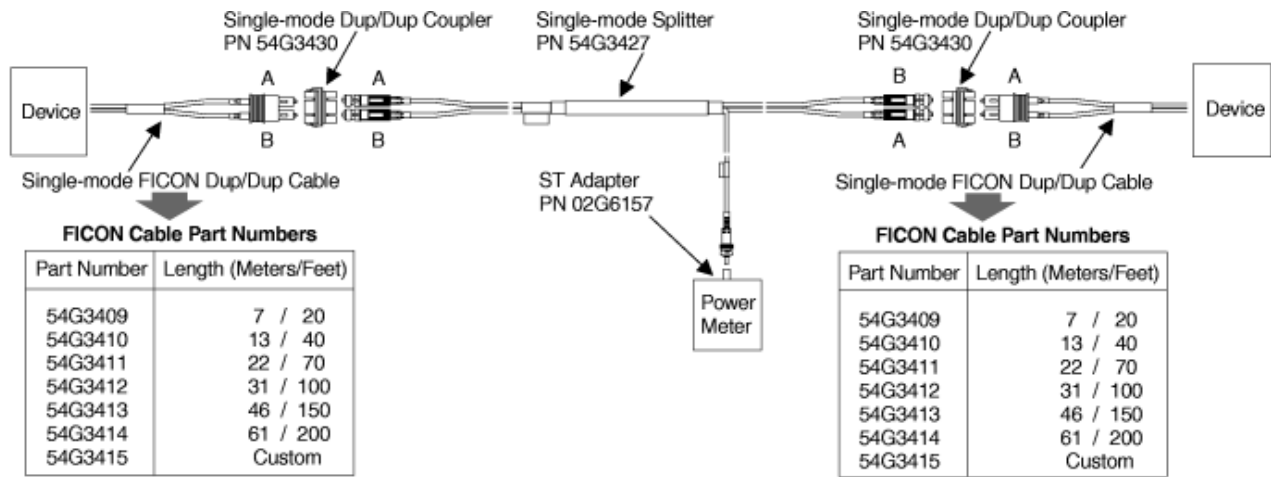


Figure 48. Isolating a single-mode link segment with a splitter tool

## Obtaining reference levels and attaching test equipment to a link

These procedures:

- Make sure the test equipment is calibrated.
- Provide instructions to obtain optical power reference levels for the problem determination procedures.
- Describe how to attach the calibrated test equipment to a link.

The figures used as examples in these procedures show the IBM part numbers of the test equipment. See Appendix B, “Tools, Test Equipment, and Parts,” on page 67 for the part numbers of all test equipment.

### Notes:

1. There are separate procedures for multi-mode and single-mode links and for links at different operating wavelengths. Make sure you are using the correct procedure.
2. The configuration chosen for a reference measurement should match the configuration of the link or jumper cable under test.
3. Only the multi-mode procedures for long wave (1300  $\mu\text{m}$ ) links use the OMC tool; multi-mode links for short wave (850  $\mu\text{m}$ ) links may use the same procedures as single-mode links.
4. Although the multi-mode procedures refer only to duplex and biconic connectors and components, they can also be performed using ST, FC, or FICON SC connector types.

**P0** is the base measurement used to calibrate the power meter. It is also used as a reference for the other test configurations to make sure the test cables are operating within specifications. See “Obtaining P0 for a multi-mode link” on page 43 or “Obtaining P0 for a single-mode link” on page 48.

**Note:** If unusual or unexpected readings occur while measuring power levels, verify that the **P0** value has not changed by more than 0.3 dB. If it has, clean the cable connectors and test equipment connections; then retry the test. If the problem still exists, replace the cable, the optical source, then the OMC tool (if applicable), and finally the power meter with known operational components.

**P1** is the reference measurement used for end-to-end link problem determination. It is also used as a reference for jumper cable measurements when both ends of the jumper cable have duplex connectors. See “Obtaining P1 and attaching test equipment to a multi-mode link” on page 43 or “Obtaining P1 and attaching test equipment to a single-mode link” on page 49.

**P2** and **P3**, used for long wavelength multi-mode only, are the reference measurements that apply when testing a duplex-to-biconic jumper cable. See “Obtaining P2 for a multi-mode link” on page 46 and “Obtaining P3 for a multi-mode link” on page 47.

After completing a reference measurement, leave the test cables and couplers plugged into the optical source and power meter. Then move the optical source, power meter, test cables, and couplers to the

appropriate location, and plug them into the link cables. **If power to the optical source has been switched off, or if the test cables or couplers have been disconnected from the optical source or the power meter, repeat the reference measurement.**

## Obtaining **P0** for a multi-mode link

This procedure applies only to ESCON or ATM long wavelengths links; other multi-mode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for single-mode fiber attachment. This procedure ensures proper operation of the optical source and the power meter, and establishes the power output of the optical source. If you require detailed operating instructions for the test equipment, refer to the manufacturer's operating manuals. The IBM Fiber Optic Field Test Support Kits (see [Appendix B, "Tools, Test Equipment, and Parts,"](#) on page 67) provide space for these manuals.

1. Make sure 1) the connectors are clean, 2) the LED module "plug-in" is inserted into the optical source, and 3) the biconic adapter is inserted into the power meter.
2. Switch on both instruments, and allow approximately 5 minutes for warm-up.

**Note:** Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.

3. Set the power meter to 1300 nm.
4. Zero the power meter with darkened sensor.
5. Attach one end of a biconic-to-biconic test cable to the optical source; then attach the other end to the receptacle on the OMC tool (see [Figure 49 on page 43](#)).
6. Attach the biconic cable from the OMC tool to the power meter.
7. Adjust the optical source output to obtain a reading of -25.0 dBm ( $\pm 1.0$  dB) on the power meter display.
  - If the reading **is** within specifications, record this value as **P0** on the work sheet selected from [Appendix E, "Work Sheets,"](#) on page 87 for the fiber being tested; then go to ["Obtaining P1 and attaching test equipment to a multi-mode link"](#) on page 43. Do not disconnect the OMC tool, and do not switch off power to the optical source.
  - If the reading **is not** within specifications, remove the OMC tool, and connect the biconic-to-biconic test cable directly to the power meter. Adjust the optical source output to obtain -15.0 dBm ( $\pm 1.0$  dB) on the power meter.
    - If the reading **is** within specifications, reconnect the biconic-to-biconic test cable to the OMC tool, and reconnect the OMC tool to the power meter. If the power meter reads -25.0 dBm ( $\pm 5.0$  dB), adjust the optical source to obtain -25.0 dBm ( $\pm 1.0$  dB). If the optical source cannot be adjusted, replace the OMC tool.
    - If the reading **is not** within specifications, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace the cable, then the optical source, and finally the power meter with known operational components.

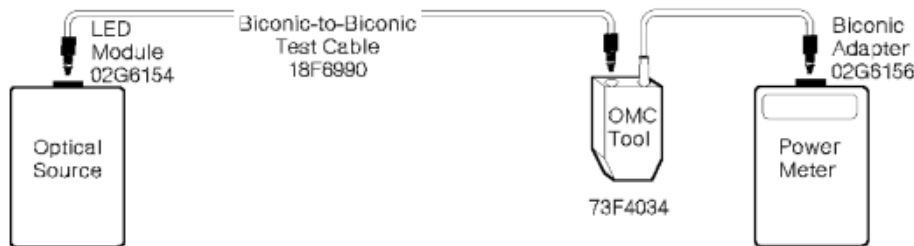


Figure 49. Obtaining **P0** for a multi-mode Link

## Obtaining **P1** and attaching test equipment to a multi-mode link

This procedure applies only to ESCON or ATM long wavelengths links; other multi-mode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for single-mode fiber attachment. This procedure checks the multi-mode test cables and establishes the power output of the optical source

using these cables. It then shows how to attach this test equipment to a multi-mode link terminated by duplex connectors on both ends.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off, or if the OMC tool has been disconnected from the optical source.
2. Make sure the LED module "plug-in" is inserted into the optical source, and the biconic adapter is inserted into the power meter.
3. Make sure all connectors are clean; then assemble the test equipment (see [Figure 50 on page 44](#), [Figure 52 on page 45](#), or [Figure 53 on page 45](#)).
  - a. Remove the cable from the OMC tool to the power meter, and attach it to a biconic coupler.
  - b. Attach the white-coded biconic connector of duplex-to-biconic test cable 1 to the other end of the biconic coupler; then attach the duplex connector to duplex coupler 1.
  - c. Attach one end of a duplex-to-duplex test cable to duplex coupler 1; then attach the other end to duplex coupler 2.
  - d. Attach the duplex connector of duplex-to-biconic test cable 2 to duplex coupler 2; then attach the black-coded biconic connector to the power meter.
4. Observe the power meter display. The maximum difference allowed between **P1** and **P0** is 2.5 dB.
  - If the difference is **less than** 2.5 dB, record the value as **P1** on the work sheet selected from [Appendix E, "Work Sheets," on page 87](#) for the fiber being tested; then go to the next step.
  - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.
5. Remove the duplex-to-duplex test cable between the 2 duplex couplers. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
6. Attach the test equipment to the link as follows (see [Figure 51 on page 45](#)):
  - a. Connect one end of the link to duplex coupler 1.
  - b. Take the power meter and attached test equipment to the next point in the link you want to check; then connect that end to duplex coupler 2.
7. Return to the MAP that directed you here.

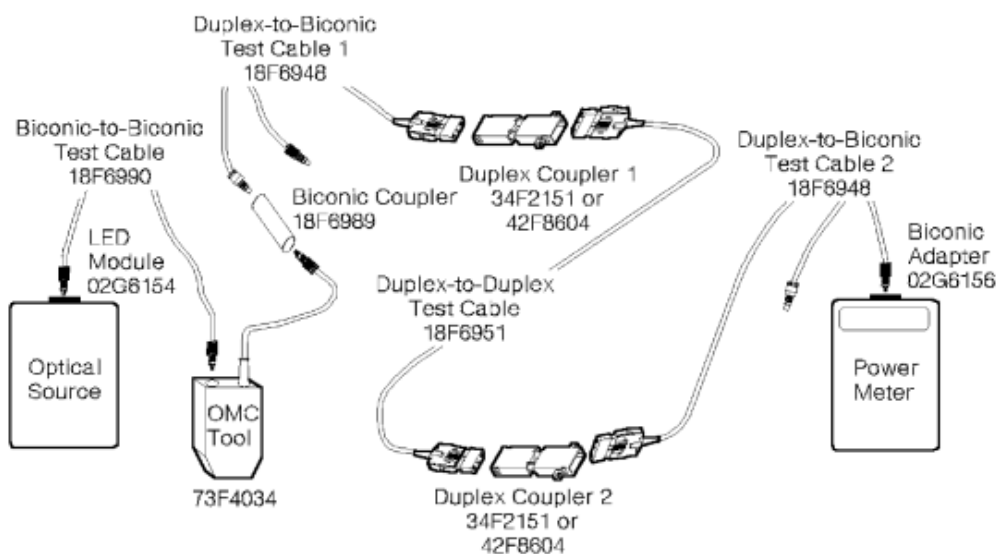


Figure 50. Obtaining **P1** for a multi-mode link



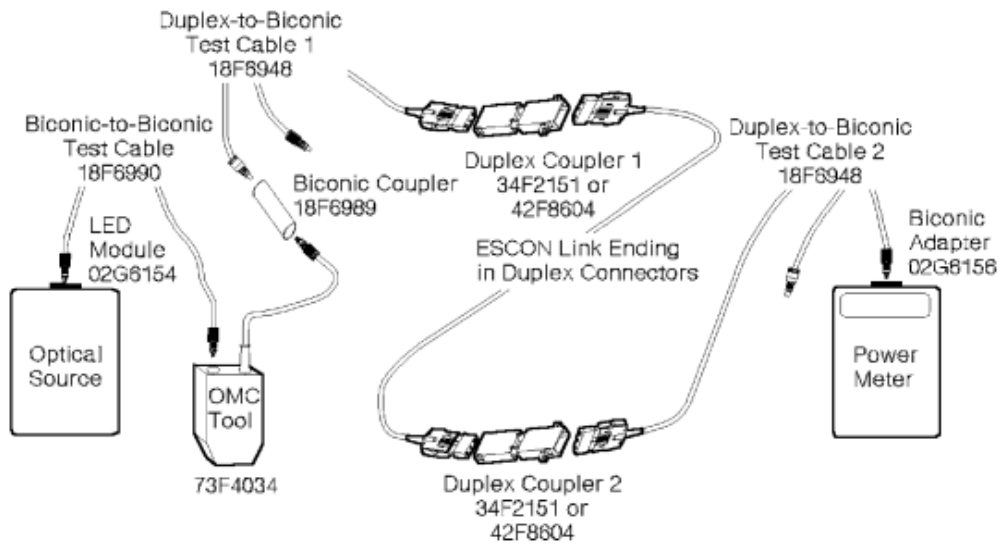


Figure 51. Connecting the test equipment to a multi-mode link

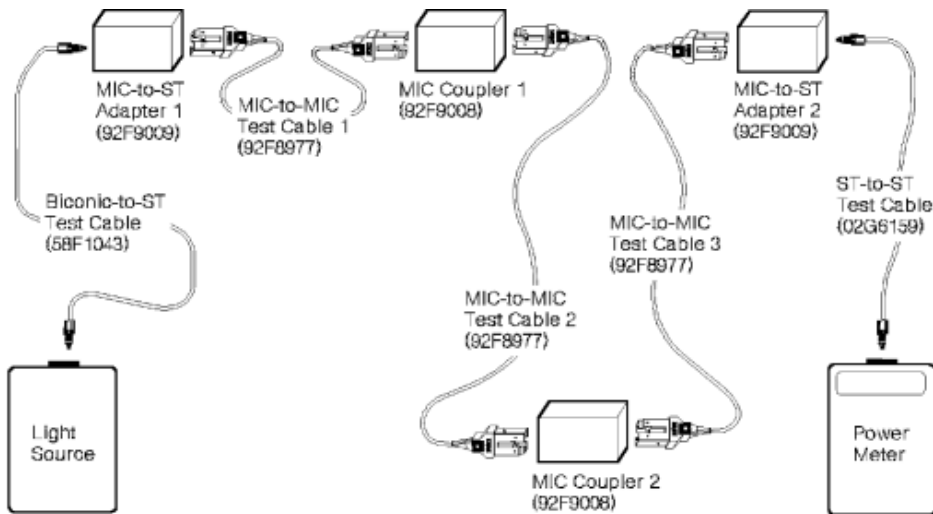


Figure 52. Obtaining the link loss reference level (P1) - FDDI

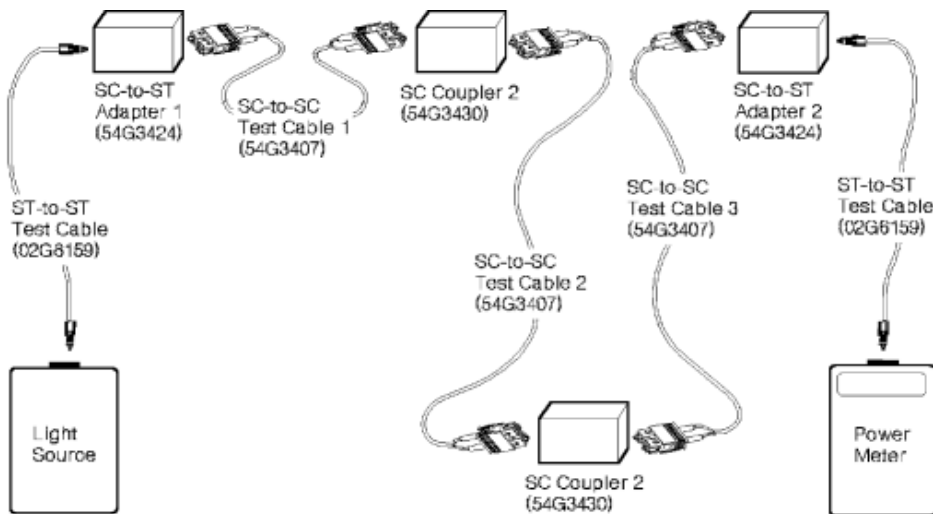


Figure 53. Obtaining the link loss reference level (P1) - ATM or FICON

## Obtaining **P2** for a multi-mode link

### Notes:

- Although this procedure refers only to duplex-to-biconic jumper cables, it also can be performed using IBM duplex-to-ST or duplex-to-FC cables and their associated adapters and couplers.
- If a step directs you to connect a test component that is already attached, continue with the next step.

This procedure applies only to ESCON or ATM long wavelengths links; other multi-mode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for single-mode fiber attachment.

**P2** is used as a reference level for a duplex-to-biconic jumper cable when the direction of light propagation is from the optical source into the duplex connector and out of the biconic connector into the power meter.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off.
2. Make sure all connectors are clean; then assemble the components (see [Figure 54 on page 47](#)).
  - a. Attach one end of a biconic-to-biconic test cable to the optical source; then attach the other end to the OMC tool.
  - b. Attach the cable from the OMC tool to one end of biconic coupler 1.
  - c. Attach the white-coded biconic connector of a duplex-to-biconic test cable to the other end of biconic coupler 1; then attach the duplex connector to the duplex coupler.
  - d. Attach the duplex connector of a duplex-to-biconic test cable to the other end of the duplex coupler; then attach the black-coded biconic connector to biconic coupler 2.
  - e. Attach one end of biconic-to-biconic test cable 2 to biconic coupler 2; then attach the other end to the power meter.
3. Observe the power meter display. The maximum difference allowed between **P2** and **P0** is 2.5 dB.
  - If the difference is **less** than 2.5 dB, record the value **P2** on the work sheet selected from [Appendix E, "Work Sheets," on page 87](#) in the area labeled **PX** for the fiber being tested; then go to the next step.
  - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.
4. Remove duplex-to-biconic test cable 2 (between the duplex coupler and biconic coupler 2) from the test equipment setup. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
5. Return to the MAP that directed you here.

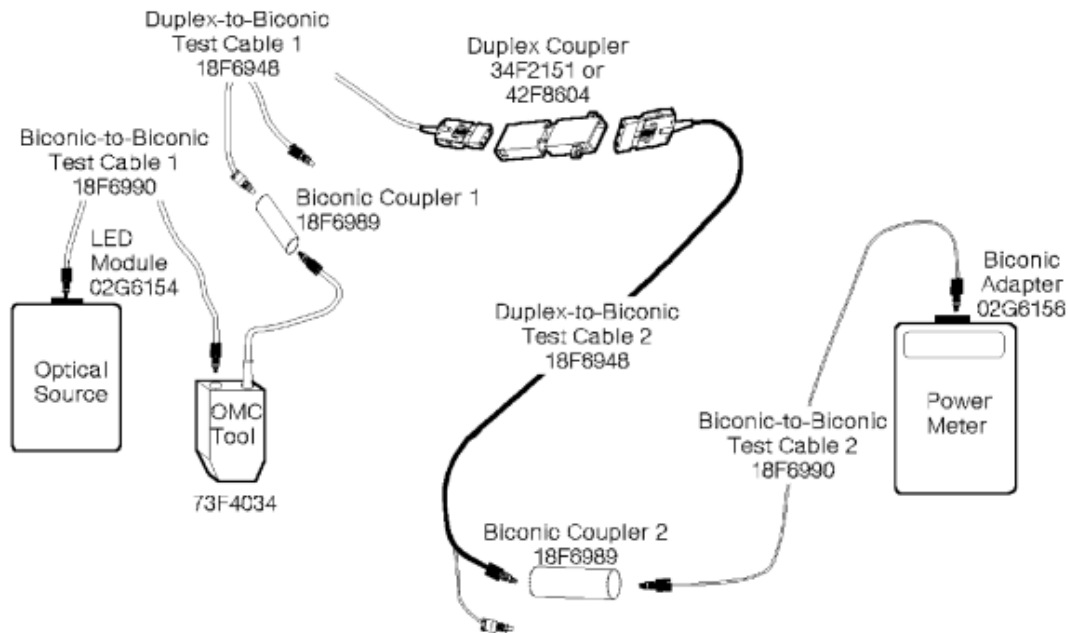


Figure 54. Obtaining **P2** for a multi-mode link

## Obtaining **P3** for a multi-mode link

### Notes:

- Although this procedure refers only to duplex-to-biconic jumper cables, it also can be performed using IBM duplex-to-ST or duplex-to-FC cables and their associated adapters and couplers.
- If a step directs you to connect a test component that is already attached, continue with the next step.

This procedure applies only to ESCON or ATM long wavelengths links; other multi-mode laser links such as FICON SX or Gigabit Ethernet SX may use the same procedures as for single-mode fiber attachment.

**P3** is used as a reference level for a duplex-to-biconic jumper cable when the direction of light propagation is from the optical source into the biconic connector and out of the duplex connector into the power meter.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off.
2. Make sure all connectors are clean; then assemble the components (see [Figure 55 on page 48](#)).
  - a. Attach one end of biconic-to-biconic test cable 1 to the optical source; then attach the other end to the OMC tool.
  - b. Attach the cable from the OMC tool to one end of biconic coupler 1.
  - c. Attach one end of biconic-to-biconic test cable 2 to biconic coupler 1; then attach the other end to biconic coupler 2.
  - d. Attach the white-coded biconic connector of duplex-to-biconic test cable 1 to the other end of biconic coupler 2; then attach the duplex connector to the duplex coupler.
  - e. Attach the duplex connector of duplex-to-biconic test cable 2 to the duplex coupler; then attach the black-coded biconic connector to the power meter.
3. Observe the power meter display. The maximum difference allowed between **P3** and **P0** is 2.5 dB.
  - If the difference is **less** than 2.5 dB, record the value **P3** on the work sheet selected from [Appendix E, "Work Sheets," on page 87](#) in the area labeled **Py** for the fiber being tested; then go to the next step.
  - If the difference is **greater** than 2.5 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known

operational components until the test does not fail. If the test continues to fail, replace the OMC tool, then the optical source, and finally the power meter.

4. Remove duplex-to-biconic test cable 1 (between biconic coupler 2 and the duplex coupler) from the test equipment setup. **Do not** switch off power to the optical source, and **do not** disconnect the test cables or couplers from the optical source or the power meter.
5. Return to the MAP that directed you here.

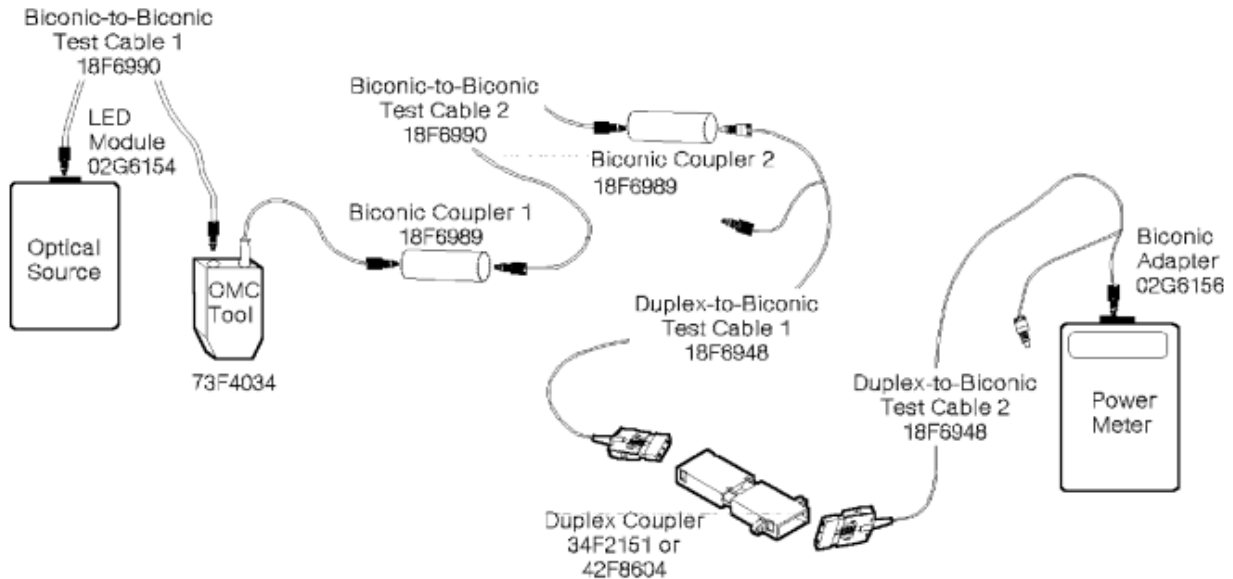


Figure 55. Obtaining **P3** for a multi-mode link

## Obtaining **P0** for a single-mode link

This procedure may also be used for short wavelength (SX) links if an 850  $\mu\text{m}$  light source is available. This procedure ensures proper operation of the optical source and the power meter, and establishes the power output of the optical source. If you require detailed operating instructions for the test equipment, see the manufacturer's operating manuals. The IBM Fiber Optic Field Test Support Kits (see [Appendix B, "Tools, Test Equipment, and Parts,"](#) on page 67) provide space for these manuals.

1. Make sure 1) the connectors are clean, 2) the laser module "plug-in" and key are inserted into the optical source, and 3) the ST adapter is inserted into the power meter.
2. Switch on both instruments, and allow approximately 5 minutes for warm-up.

**Note:** Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.

3. Set the power meter to 1300 nm.
4. Zero the power meter with darkened sensor.
5. Attach the yellow-coded connector of an ST-to-ST test cable to the optical source; then attach the red-coded connector to the power meter (see [Figure 56](#) on page 49).
6. Set the optical source to the maximum output position. The reading on the power meter display should be between -2.7 and -10.0 dBm.
  - If the reading **is** within specifications, record this value as **P0** on the work sheet selected from [Appendix E, "Work Sheets,"](#) on page 87 for the fiber being tested; then go to "Obtaining P1 and attaching test equipment to a multi-mode link" on page 43. Do not switch off power to the optical source.
  - If the reading **is not** within specifications, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace the cable, then the optical source, and finally the power meter with known operational components.

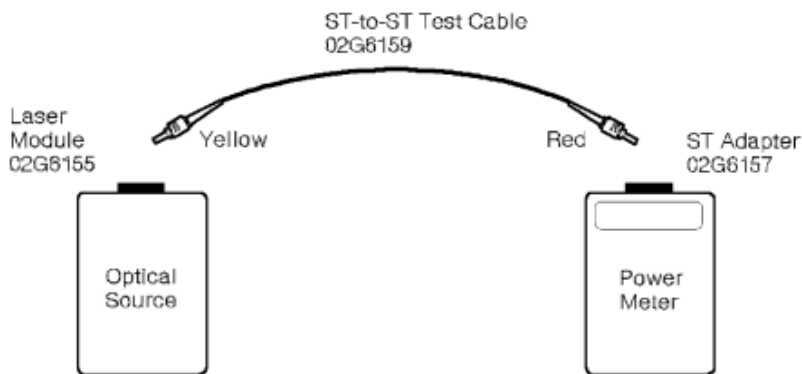


Figure 56. Obtaining **P0** for a single-mode link

## Obtaining P1 and attaching test equipment to a single-mode link

This procedure checks the single-mode test cables and establishes the power output of the optical source using these cables. It then shows how to attach this test equipment to a single-mode link terminated by duplex connectors on both ends.

1. Obtain **P0** if you have not already done so, or if power to the optical source has been switched off.
2. Make sure the laser module "plug-in" is inserted into the optical source, and the ST adapter is inserted into the power meter.
3. Make sure all connectors are clean; then assemble the test equipment (see [Figure 57 on page 50](#)).
  - a. Remove the red-coded connector of ST-to-ST test cable 1 from the power meter; then attach it to an ST coupler.
  - b. Attach the red-coded connector of ST test cable 2 to the other end of the ST coupler.
  - c. Attach the yellow-coded end of ST test cable 2 to the power meter.
4. Observe the power meter display. The maximum difference allowed between **P1** and **P0** is 0.4 dB.
  - If the difference is **less** than 0.4 dB, record the value as **P1** on the work sheet selected from [Appendix E, "Work Sheets," on page 87](#) for the fiber being tested; then go to the next step.
  - If the difference is **greater** than 0.4 dB, clean the cable connectors and test equipment connections; then retry the test. If the test still fails, replace each cable and then each coupler with known operational components until the test does not fail. If the test continues to fail, replace the optical source and then the power meter.
5. Remove the ST coupler between the 2 ST-to-ST test cables. **Do not** switch off power to the optical source, and **do not** disconnect the test cables from the optical source or the power meter.
6. Attach the test equipment to the link as follows (see [Figure 58 on page 50](#)):
  - a. Attach a duplex-to-ST adapter to each red-coded connector of the two ST-to-ST test cables.
    - 1) Attach ST-to-ST test cable 1 to the **A** side of duplex-to-ST adapter 1.
    - 2) Attach ST-to-ST test cable 2 to the **B** side of duplex-to-ST adapter 2.
  - b. Connect one end of the link to duplex-to-ST adapter 1.
  - c. Take the power meter and attached test equipment to the next point in the link you want to check; then connect that end to duplex-to-ST adapter 2.
7. Return to the MAP that directed you here.

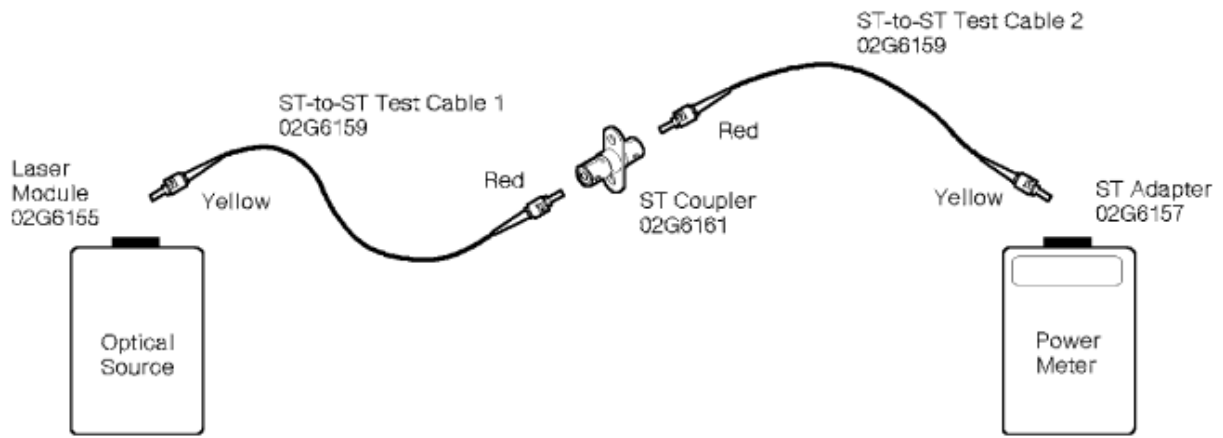


Figure 57. Obtaining **P1** for a single-mode link

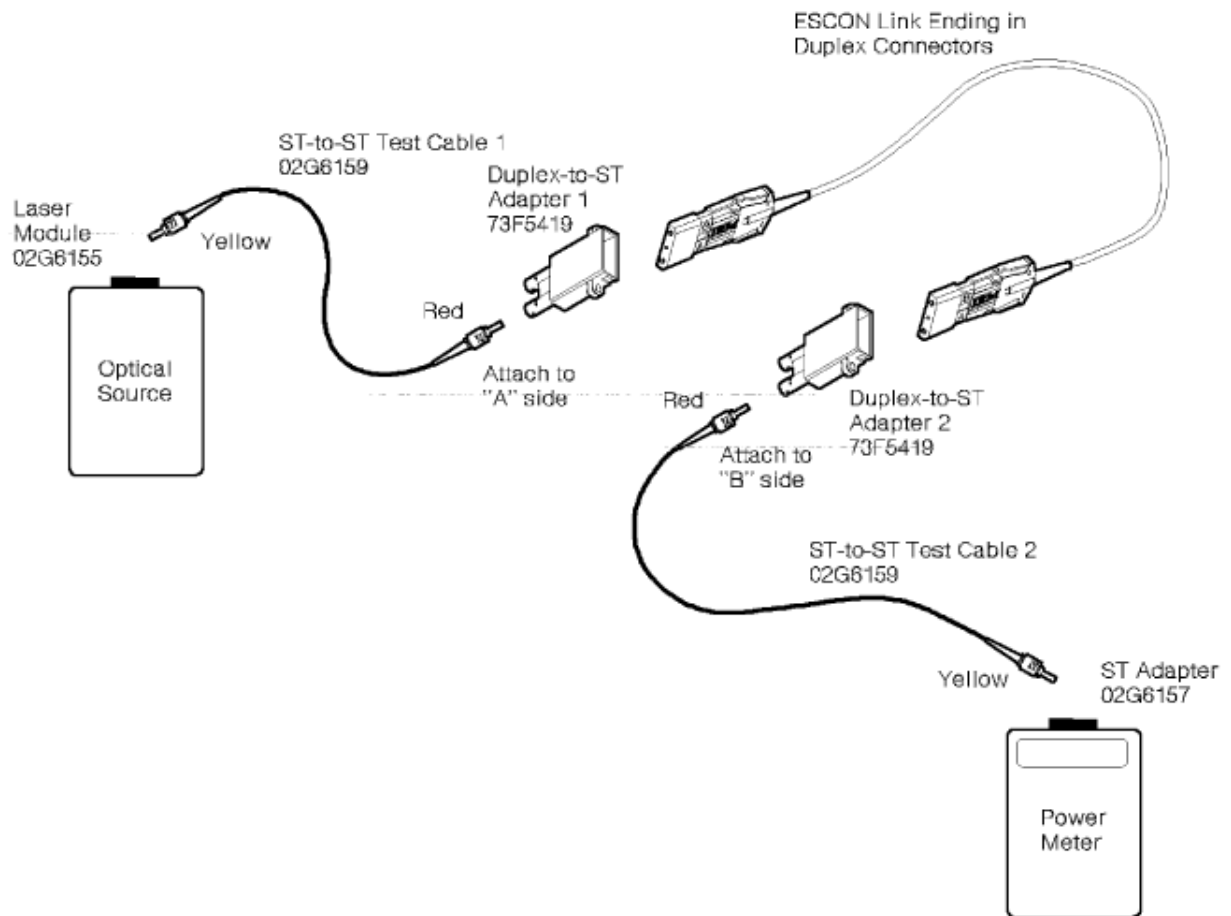


Figure 58. Connecting the test equipment to a single-mode link

---

# Chapter 4. Jumper Cable Handling and Installation Summary

This chapter provides guidance for handling fiber optic jumper cables and provides a summary of the tasks necessary to install them.

---

## Jumper cable handling precautions

The following precautions should be taken when handling fiber optic jumper cables:

- Make sure the cable cutouts in the floor tiles have the appropriate protective edging.
- Route the cables away from any sharp edges or projections that could cut the outer jacket.
- Do not route the cables near unprotected steam or refrigeration lines.
- Do not coil the cable to less than a 96.0-mm (3.78 in.) diameter.
- Do not bend the cable to less than a 12-mm (0.5 in.) radius.
- Do not pull cables into position; place them.
- Do not grasp the cable with pliers.
- Do not attach a pull rope or wire to the connectors.
- Always clean the connectors before attaching them.
- Do not remove the protective plugs or protective covers until you are ready to clean the connectors and attach the cables to a device.
- Always leave the protective plugs and protective covers on unused ports and cable connectors.
- Connect the cable carefully to prevent damage to the connector housing or the fiber optic ferrules.
- Before inserting the connector, make sure the connector and receptacle keying are aligned.
- Ensure that each FDDI connector has the correct keys installed for the intended application.

---

## Pre-installation checklist

### Cable inventory

- **Quantity:** Ensure that you have enough jumper cables.
- **Length:** Ensure that the jumper cables are long enough to reach each device or distribution panel, and that they have an additional length to allow for correct bend radius, slack, and minor equipment relocation.
- **Connectors:** Ensure that each end of the jumper cable has a compatible connector for attachment to the intended device or distribution panel, and that the connectors have protective covers.

---

## Jumper cable installation summary

This section summarizes the installation process; it **does not** provide detailed installation instructions. Fiber optic cables, cable planning, labeling, and installation are all customer responsibilities for new installations and upgrades.

IBM Networking Integration and Deployment Services for zSeries fiber cabling and for enterprise fiber cabling allow IBM to offer a comprehensive set of services for all customers, from product level to enterprise level. These services take into consideration the requirements for all of the protocols and

media types supported on IBM Z and LinuxONE (for example, FICON, Coupling Links, OSA), whether the focus is the data center, the Storage Area Network (SAN), the Local Area Network (LAN), or the end-to-end enterprise.

## Jumper cable labeling

Each IBM jumper cable has a jacket marking that contains the part number, EC number, length in meters and feet, and manufacturing/warranty data. Additional jacket markings may be added by the suppliers.

Example:

```
PN VVVVVVV/FFFFFFF EC1234567 31 m 100.0 ft 11210005 BAR CODE DATE ODE SNUM
```

Where V = variable length part number, F = fixed length part number. Manufacturing and warranty data includes: BAR CODE INFO

**1**

Vendor code

**1**

Last digit of year manufactured

**210**

Day-of-year manufactured (Julian date)

**005**

Sequence number

The above is bar code information for reference.

Cable labeling tags (IBM part number 84X7035) are available through your IBM branch office. These tags should also be "to" locations.

**Note:** The ST and FC connectors on the end of an IBM jumper cable are color-coded and should be labeled as follows:

Black = Transmit (light into the link)

White = Receive (light from the link)

**Note:** Fiber optic jumper cables and connectors using the FICON SC-duplex connector may be obtained from vendors other than IBM, and may not have the bar code label or conform to the color coded labeling. Consult the manufacturer's specifications for labeling conventions.

## Safety equipment

The following items should be available to warn of obstructions and hazardous conditions:

- Warning signs and tags
- Barricades for open floor tiles

## Test equipment

See *Technical Service Letter TSL #147 Fiber Optic Tools and Test Equipment* (revised 2/19/96 or later) for a list of fiber optic tools and materials.

## Documentation

The following documents should be available to ensure correct device connection:

- Floor plans
- Cable routing diagrams (as required)
- Physical configuration
- Logical configuration



## Cable routing

- **Raised floor:** Fiber cables can be installed under a raised floor. The following precautions must be taken besides those for IBM bus and tag cables:
  - Do not place the cables on top of moisture sensors or smoke detectors.
  - Cables should not be secured if an unloaded bend radius of less than 12 mm (0.5 in.) can exist.

**Note:** This precaution applies to cables installed both above and below a raised floor.

- **Raceway or cable tray:** Cables should be placed, not pulled, in a tray or raceway.
- **Ceiling or partition:** Cables must be protected from sharp corners, ceiling hangers, pipes, dropped ceiling grids, metal partition studs, and construction activity. Conduit can be used when additional protection is required.
- **Vertical shaft (between floors):** Cable should be left on the shipping spool, or in a loose coil, and lowered from above.

For installation in a vertical shaft, the cable must be protected against extreme temperature and possible damage from moving equipment. Cable ties must be used to secure the cable at intervals of 3 meters (10 ft.), and strain relief must be provided at intervals of 100 meters (328 ft.).

- **Plenum:** IBM jumper cables for FICON, FDDI, ATM, and GEN are plenum rated.

## Cable layout, slack management, and strain relief

There should be at least 2 meters (6.5 ft.) of cable at each end for any future equipment relocation.

Slack management should be used when storing excess jumper cable.

Strain relief, provided by devices and distribution panels, should be used to prevent connector damage.

## Connector protection

Attach connectors carefully to prevent damage to the housing or the fiber optic ferrules.

If possible, leave connectors in their protective shells until you are ready to attach them to the receptacles. Also, use the shells when temporarily unplugging the connectors.

Unused fiber optic duplex receptacles on an IBM device must have a protective plug (IBM part number 18F4017, 17G5609, or 78G9610) installed to prevent contamination (see [Figure 59 on page 53](#) or [Figure 60 on page 54](#)).

For non-IBM connectors, use the protection method recommended by the vendor for that connector.

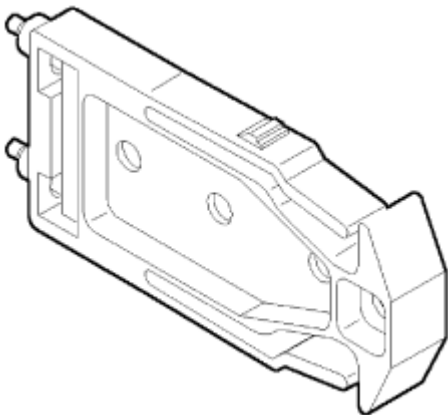
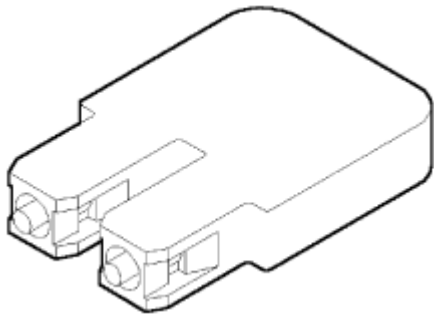


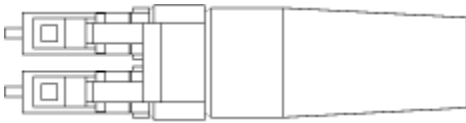
Figure 59. ESCON protective plug (part number 18F4017)



*Figure 60. Optical wrap/protective plug for FICON links*



*Figure 61. MT-RJ wrap plug*



*Figure 62. LC wrap plug*

---

## Chapter 5. Documentation

This chapter summarizes the information used to document link installations and provides instructions and a sample work sheet for recording link specifications and physical characteristics.

### Cable administration information

---

As the customer's fiber optic channel link environment grows, accurate records must be maintained to list the changes, modifications, and reconfigurations within the environment. This chapter describes the documentation required, explains the various types of ESCON link connections, and shows an example of the entries used to complete a *Cable Administration Work Sheet*, SX23-0415.

### Link installation documentation

---

The following documentation and information should be available to ensure link compatibility exists for IBM devices:

- Floor plans of existing facilities
- Switching and multiplexing requirements
- Equipment locations
- Logical connectivity diagrams
- Cable routing diagrams
- Installer's records

### Documentation for new installations

The following documentation and information should be available for new installations to ensure link compatibility exists for IBM devices:

- Link loss measurements.
- Contractor's warranty or verification statement.
- Compliance with national, state, and local building codes. New requirements have been added that specifically relate to installation of fiber optic cabling.

### Documentation for all installations

The following documentation and information should be available for all installations to ensure link compatibility exists for IBM devices:

- Device and link distances
- Product specifications
- Cable routing diagrams:
  - Location and length of each link
  - Type, location, and identification of connectors, adapters, and couplers
  - Locations of splices and distribution panels
- Manufacturer's data sheets:
  - Cable (see [Appendix A, "Specifications ,"](#) on page 61 for specification requirements)
  - Bend radius control
  - Connectors

- Strain relief
- Splices
- Distribution panels
- Attached devices
- Installer's warranty or verification statements

## Link connections and IOCDs and cable information

A link environment can consist of all fiber optic cables, or it can consist of copper bus and tag cables and fiber optic jumper and trunk cables. The following figures show these three link types:

- Logical link connection (Figure 63 on page 56)
- Physical point-to-point link connection (Figure 64 on page 56)
- Complex physical link connection (Figure 65 on page 57)

The complex physical link connection is used to complete the *Cable Administration Work Sheet* example shown on page Figure 66 on page 59.

### Logical link connection

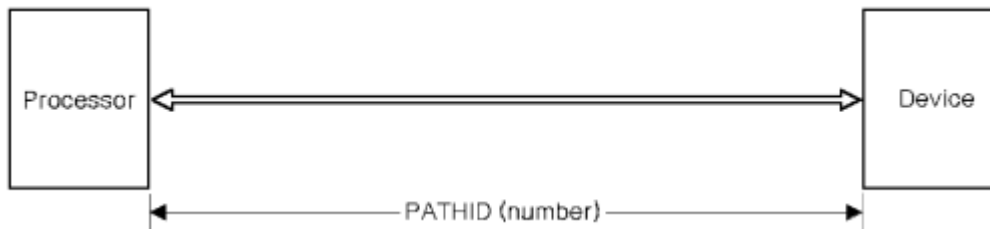


Figure 63. Example of a logical link connection

#### IOCDs and cable information:

PATHID	M/T	Serial	CHPID	Length	M/T	Serial	Conn ID
309001	3090	xxxx	01	100 ft.	3803	yyyy	02

### Physical point-to-point link connection

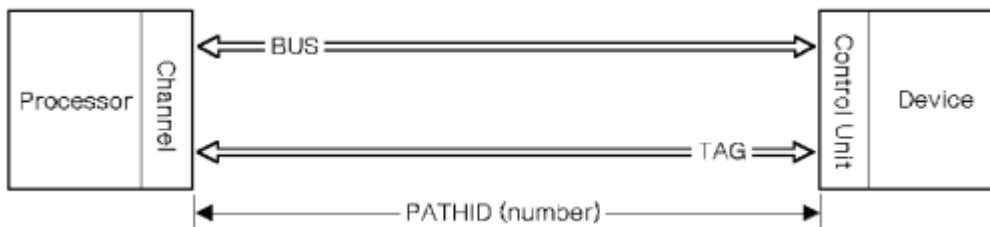


Figure 64. Example of a physical point-to-point link connection

#### IOCDs and cable information:

PATHID	M/T	Serial	CHPID	Length	M/T	Serial	Conn ID
309001	3090	xxxx	01	100 ft.	3803	yyyy	02

## Complex physical link connection

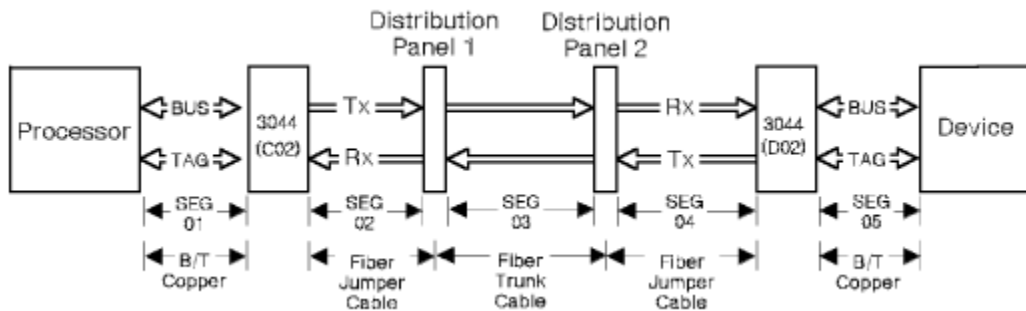


Figure 65. Example of a complex physical link connection

## Completing the cable administration work sheet

The following paragraphs list and explain the entries used in the completed *Cable Administration Work Sheet* example shown in Figure 66 on page 59. The work sheet uses the complex physical link connection shown in Figure 65 on page 57 as a basis and includes typical information available for that link.

When comparing Figure 65 on page 57 to the completed work sheet, notice where the information for one link segment ends and the other begins. For example, the column under 3090-12345 ends at the **To Label** entry of 3044-12345, which is the end of link segment 01. Link segment 02 then begins at the top of the next column (3044-98765) and ends at Distribution Panel 1 (labeled DP01C01 DP01C02). Continue down this column and up from the bottom of the next column to determine the trunk information (link segment 03). In the same manner, continue up the same column and down the next column for link segment 04 and 05 information.

### Product information

The **Product Information** column (1) consists of:

- **Machine Type:** The numeric (or alphanumeric) machine type.  
**Note:** Always start with the device closest to the processor or at the processor.
- **Ser#:** The 5-digit serial number.
- **Port#:** The port or channel path identifier (CHPID) of the device.
- **Strain Relief Used? (Y/N):** Is the device strain relief used?

### Jumper cable information

The **Jumper Cable Information** column (2) consists of:

- **Vendor:** The provider of the jumper cable assembly.
- **Length (meter or ft):** The length of the jumper cable in meters or feet. Either unit of measure is acceptable. It is specified in the cable label information. If not known, estimate the actual length.
- **Loss (dB or dB/km) and Bandwidth (MHz•km) Specifications:** Complete this column for non-IBM multi-mode jumper cables only.
- **Modified? If yes, Loss Measurement Fiber 1/Fiber 2:**  
**Note:** Cable modification is **not recommended**. For example, modification voids the cable warranty, and modified components are not supported by the IBM fiber optic tool kits.

If the jumper cable was modified, record the loss measurement for fiber 1 and fiber 2.

- **Connector Types:** The device end is a duplex connector unless the cable is attached to an original equipment manufacturer (OEM) device that uses other than a duplex receptacle. The other end depends on the type of distribution panel adapter or coupler used.

- **Slack Storage? (Y/N):** Is cable slack managed by using a slack-storage device?
- **From Label Fiber 1/Fiber 2 M/T Serial:** Unique label information at the "from" end of the cable (the distribution panel or device).
- **Path ID/Segment ID:** Path and segment identification.
- **To Label Fiber 1/Fiber 2:** Unique label information at the "to" end of the cable (the distribution panel or next device).

## Trunk information

The *Trunk Information* column (3) consists of:

- **Cable Manufacturer and Fiber Core Size (µm):** The cable manufacturer and the fiber core size in µm.
- **Installer:** Name of the company or contractor.
- **Length (km or ft):** Length of the trunk cable in kilometers or feet. Either unit of measure is acceptable.
- **Attenuation Specification (dB/km) or Loss Measurement (dB):** Trunk loss in dB/km (from the cable manufacturer) or dB (from the installer).
- **Bandwidth Specification (MHz•km):** multi-mode only. Specified by the cable manufacturer (for example, 500 MHz•km).
- **# of Splices and Type:** Should be part of the link schematic. Note if the splice is mechanical or fusion.
- **Connector Type(s) at Panel(s):** Type of connector used at the distribution panel (for example, IBM duplex, ST).
- **OTDR Print? If yes, ID:** Contractors and installers could have used an optical time domain reflectometer (OTDR) to record link trace information. Either hardcopy or softcopy records are acceptable and should provide link identification information.
- **From Panel ID Fiber 1/Fiber 2:** Distribution panel "from" locations for fiber 1 and fiber 2.
- **Path ID and Segment ID:** Path and segment identification.
- **To Panel ID Fiber 1/Fiber 2:** Distribution panel "to" locations for fiber 1 and fiber 2.

## Loss measurements

The *Loss Measurements* column (4) consists of:

- **Date Tested:** Date when link verification was performed.
- **End-End Link Verification Loss (dB):** Link loss from device connector to device connector.

## Service comments

The *Service Comments* column (5) can be used for information such as:

- IBM contract number
- Service comments
- OEM device information (machine type and serial)
- Hazardous area identification

## Cable Administration Work Sheet

							Machine Type Ser # Port #	Product Information	1
							Strain Relief Used? (Y/N)		
							Vendor	Jumper Cable Information	2
							Length (meter or ft)		
							Loss (dB or dB/km) and Bandwidth (Mhz *km) Specifications		
							Modified? If yes, Loss Measurement Fiber 1/Fiber 2		
							Connector Types		
							Stack Storage? (Y/N)		
							From Label Fiber 1/Fiber 2 M/T Serial		
							Path ID/Segment ID		
							To Label Fiber 1/Fiber 2		
							Cable Manufacturer and Fiber Core Size ( $\mu\text{m}$ )		
							Installer		
							Length (km or ft)		
							Attenuation Specification (dB/km) or Loss Measurement (dB)		
							Bandwidth Specifications (Mhz*km)		
							# of Splices and Type		
							Connector Type(s) and Panel(s)		
							OTDR Print? If Yes, ID		
							From Panel ID Fiber 1/Fiber 2		
							Path ID and Segment ID		
							To Panel ID Fiber 1/Fiber 2		
							Date Tested	Loss Measurement	4
							End-End Link Verification Loss (dB)		
								Service Comments	5

Figure 66. Example of a Cable Administration Work Sheet





# Appendix A. Specifications

This chapter lists the specifications and optical properties for a fiber optic channel link, IBM jumper cables, and trunk cable. To allow for growth, a trunk cable with higher modal bandwidth than the minimum specification should be considered.

## Link specifications

Table 4 on page 61 lists the specifications for links using single-mode (9/125- $\mu\text{m}$ ), or multi-mode (62.5/125- $\mu\text{m}$ , or 50/125- $\mu\text{m}$ ) fiber optic cable. The trunk to which the IBM jumper cables are connected must have optical properties that conform to the specifications in the table.

Link/fiber type	Maximum length	Maximum loss	Trunk size/wavelength	Minimum trunk modal bandwidth	Notes
<b>ESCON</b>					
Multi-mode	2.0 km (1.24 mi.)	8.0 dB	62.5 $\mu\text{m}$ /LX	500 MHz•km	1, 3, 8
Multi-mode	2.0 km (1.24 mi.)	8.0 dB	50.0 $\mu\text{m}$ /LX	800 MHz•km	1, 3, 4, 8
Multi-mode	3.0 km (1.86 mi.)	8.0 dB	62.5 $\mu\text{m}$ /LX	800 MHz•km	1, 3, 4, 8
Single-mode (Discontinued)	20 km (12.4 mi.)	14.0 dB	9.0 $\mu\text{m}$ /LX	NA	1, 2, 3, 5, 6, 7, 10
<b>Sysplex Timer (ETR/CLO)</b> Same as multi-mode ESCON					
<b>Coupling links (ISC, HiPerLinks/ISC-2, ISC-3, HCA-2, HCA-3, ICA)</b>					
Multi-mode (discontinued May, 1998)	1.0 km (.62 mi.)	8.0 dB	50.0 $\mu\text{m}$ /SX	500 MHz•km	1, 3, 9
Single-mode 1.06 and 2.1 Gbit/s	10 km (6.21 mi.)	7.0 dB	9.0 $\mu\text{m}$ /LX	NA	1, 3, 5, 6, 7
Single-mode card with 50 micron optical mode conditioner over multi-mode fiber	550 meters (0.34 mi.)	5.0 dB	50.0 $\mu\text{m}$ /LX		
Multi-mode 12x IFB	150 m (.093 mi.)	2.06 dB	50.0 $\mu\text{m}$ /SX	500 MHz•km	1, 3, 9
Single-mode 1x IFB	10.0 km (6.21 mi.)	5.66 dB	9.0 $\mu\text{m}$ /LX	NA	1, 3, 5, 6, 7
ICA SR 24x (MTP 24 - OM3)	100 m (.062 mi.)	2.06 dB	50.0 $\mu\text{m}$ /SX	2000 MHz•km	
ICA SR 24x (MTP 24 - OM4)	150 m (.093 mi.)	2.00 dB	50.0 $\mu\text{m}$ /SX	4700 MHz•km	
ICA SR 24x (MTP 24 - OM5)	150 m (.093 mi.)	2.00 dB	50.0 $\mu\text{m}$ /SX	4700 MHz•km	
zHyperLink Express SR (OM3)	100 m (.062 mi.)	2.06 dB	50.0 $\mu\text{m}$ /SX	2000 MHz•km	

Table 4. Link Specifications (continued)

Link/fiber type	Maximum length	Maximum loss	Trunk size/wavelength	Minimum trunk modal bandwidth	Notes
zHyperLink Express SR (OM4)	150 m (.093 mi.)	2.00 dB	50.0 μm/SX	4700 MHz•km	
zHyperLink Express SR (OM5)	150 m (.093 mi.)	2.00 dB	50.0 μm/SX	4700 MHz•km	
<b>FICON LX</b>					
Multi-mode with 50 micron optical mode conditioner	550 meters (0.34 mi.)	5.0 dB	50.0 μm/LX	500 MHz•km	1, 3, 12, 13
Single-mode LX1gb (100-SM-LC-L)	10.0 km (6.2 mi.)	7.8 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
Single-mode LX 2gb (200-SM-LC-L)	10.0 km (6.2 mi.)	7.8 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
Single-mode LX 4gb 10km (400-SM-LC-L)	10.0 km (6.2 mi.)	7.8 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
Single-mode LX 4gb 4km (400-SM-LC-M)	4 km (2.5 mi.)	4.8 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
Single-mode LX 8gb 10km (800-SM-LC-L)	10.0 km (6.2 mi.)	6.4 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
Single-mode LX 16gb 10km (1600-SM-LC-L)	10.0 km (6.2 mi.)	6.4 dB	9.0 μm/LX	NA	1, 3, 5, 6, 7
<b>FICON SX</b>					
Multi-mode SX 1gb (100-M6-SN-I) (OM1)	300 meters (0.186 mi.)	3.00 dB	62.5 μm/SX	200 MHz•km	1, 3
Multi-mode SX 2gb (200-M6-SN-I) (OM1)	150 meters (0.093 mi.)	2.10 dB	62.5 μm/SX	200 MHz•km	1, 3
Multi-mode SX 4gb (400-M6-SN-I) (OM1)	70 meters (0.043 mi.)	1.78 dB	62.5 μm/SX	200 MHz•km	1, 3
Multi-mode SX 8gb (800-M6-SN-I) (OM1)	21 meters (0.013 mi.)	1.58 dB	62.5 μm/SX	200 MHz•km	1, 3
Multi-mode SX 1gb (100-M5-SN-I) (OM2)	500 meters (0.311 mi.)	3.85 dB	50 μm/SX	500 MHz•km	1, 3
Multi-mode SX 2gb (200-M5-SN-I) (OM2)	300 meters (0.186 mi.)	2.62 dB	50 μm/SX	500 MHz•km	1, 3
Multi-mode SX 4gb (400-M5-SN-I) (OM2)	150 meters (0.093 mi.)	2.06 dB	50 μm/SX	500 MHz•km	1, 3
Multi-mode SX 8gb (800-M5-SN-I) (OM2)	50 meters (0.031 mi.)	1.68 dB	50 μm/SX	500 MHz•km	1, 3
Multi-mode SX 16gb (1600-M5)SN-I) (OM2)	35 meters (0.022 mi.)	1.63 dB	50 μm/SX	500 MHz•km	1, 3

<i>Table 4. Link Specifications (continued)</i>					
<b>Link/fiber type</b>	<b>Maximum length</b>	<b>Maximum loss</b>	<b>Trunk size/wavelength</b>	<b>Minimum trunk modal bandwidth</b>	<b>Notes</b>
Multi-mode SX 1gb (100-M5-SN-I) (OM3)	860 meters (0.534 mi.)	4.62 dB	50 µm/SX	2000 MHz•km	1, 3
Multi-mode SX 2gb (200-M5-SN-I) (OM3)	500 meters (0.311 mi.)	3.31 dB	50 µm/SX	2000 MHz•km	1, 3
Multi-mode SX 4gb (400-M5-SN-I) (OM3)	380 meters (0.237 mi.)	2.88 dB	50 µm/SX	2000 MHz•km	1, 3
Multi-mode SX 8gb (800-M5-SN-I) (OM3)	150 meters (0.094 mi.)	2.04 dB	50 µm/SX	2000 MHz•km	1, 3
Multi-mode SX 16 gb (1600-M5E-SN-I) (OM3)	100 meters (0.062 mi.)	1.86 dB	50 µm/SX	2000 MHz•km	1, 3
Multi-mode SX 16 gb (1600-M5F-SN-I) (OM4)	125 meters (0.077 mi.)	1.95 dB	50 µm/SX	4700 MHz•km	1, 3
<b>Gigabit Ethernet (GbE) LX</b>					
Single-mode	5 km (3.1 mi.)	4.6 dB	9.0 µm/LX	NA	1, 3, 5, 6, 7
<b>Gigabit Ethernet (GbE) SX</b>					
Multi-mode 50 micron	550 meters (0.34 mi.)	3.6 dB	50.0 µm/SX	500 MHz•km	1, 3
Multi-mode 62.5 micron	275 meters (0.17 mi.)	2.6 dB	62.5 µm/SX	200 MHz•km	1, 3
<b>10 Gigabit Ethernet (10GbE LR)</b>					
Single-mode	10 km (6.2 miles)	6.0 dB	9.0 µm/LX	NA	1, 3, 5, 6, 7
<b>10 Gigabit Ethernet (10GbE SR) including RoCE</b>					
Multi-mode 50 micron	300 meters (0.19 miles)	2.6 dB	OM3	2000 MHz•km	1, 3
Multi-mode 50 micron	82 meters (0.05 miles)	1.8 dB	OM2	500 MHz•km	1, 3
Multi-mode 62.5 micron	33 meters (0.02 miles)	1.6 dB	OM1	200 MHz•km	1, 3

**Notes:**

1. The maximum link length includes both jumper and trunk cables.
2. The ESCON Extended Distance feature (ESCON XDF) must be installed in both the channel and the ESCON Director to obtain a maximum link length of 20 kilometers (12.4 miles).
3. If the customer uses IBM's Fiber Transport Services (FTS), contact the marketing representative for distance considerations.
4. The maximum total jumper cable length cannot exceed 244 meters (800 ft.) when using either 50/125-µm trunk fiber or when a 62.5/125-µm link exceeds 2 kilometers (1.24 miles).
5. Single-mode connectors and splices must meet a minimum return loss specification of 28 dB.
6. In a single-mode jumper cable, the minimum distance between connectors or splices is 2 meters (6.5 ft).
7. In a single-mode trunk cable, the distance between connectors or splices must be enough to ensure that only the lowest-order bound mode propagates.

8. The maximum link loss for multi-mode fiber includes the higher-order-mode loss, which is 1.5 dB for 50  $\mu\text{m}$  and 1.0 dB for 62.5  $\mu\text{m}$  on ESCON links only.
9. Short wavelength (SX) versions of Gigabit Ethernet and FICON multi-mode links use a short wavelength laser (780 to 850 nm) over multi-mode fiber. Fiber loss at these wavelengths (3 to 4 dB/km) is higher than for other links using 1300 nm lasers (0.5 dB/km).
10. Some single-mode ESCON transceivers use the FICON duplex connector rather than the IBM ESCON duplex connector. The maximum length and loss values are the same for both connector types and the maximum loss/distance is not reduced by using the ESCON adapter kit (part number 46H9223).
11. The maximum FDDI link loss includes a system loss of 2.0 dB, which includes higher order mode losses, extinction ratio, and retiming penalties.
12. Although the ANSI Fibre Channel Connection does not support the use of long wavelength (1300 nm) lasers on multi-mode fiber, IBM will support this combination. Special mode conditioning patch cables or couplers may be required; Refer to the *Planning for Fiber Optic Links*, GA23-1407.
13. The use of MCP cables is not supported over 1 gb.

## Typical optical component loss values

The following loss values are typical for optical components used in the data communication industry. Use the manufacturer's loss values if available.

Component	Description	Size ( $\mu\text{m}$ )	Mean loss	Variance ( $\text{dB}^2$ )
<b>Connector</b> (See note 1)	Physical contact	62.5 to 62.5	0.40 dB	0.02
		50.0 to 50.0	0.40 dB	0.02
		9.0 to 9.0 (See note 2)	0.35 dB	0.06
		62.5 to 50.0	2.10 dB	0.12
		50.0 to 62.5	0.00 dB	0.01
		100 to 100	0.40 dB	0.02
		100 to 62.5	4.72 dB	0.12
<b>Connector</b> (See note 1)	Nonphysical contact (Multi-mode only)	62.5 to 62.5	0.70 dB	0.04
		50.0 to 50.0	0.70 dB	0.04
		62.5 to 50.0	2.40 dB	0.12
		50.0 to 62.5	0.30 dB	0.01
		100 to 100	0.70 dB	0.04
		100 to 62.5	4.90 dB	0.12
<b>Splice</b>	Mechanical	62.5 to 62.5	0.15 dB	0.01
		50.0 to 50.0	0.15 dB	0.01
		9.0 to 9.0 (See note 2)	0.15 dB	0.01
		100 to 100	0.15 dB	0.01
<b>Splice</b>	Fusion	62.5 to 62.5	0.40 dB	0.01
		50.0 to 50.0	0.40 dB	0.01
		9.0 to 9.0 (See note 2)	0.40 dB	0.01

Table 5. Typical optical component loss (continued)

Component	Description	Size (µm)	Mean loss	Variance (dB <sup>2</sup> )
		100 to 100	0.40 dB	0.01
<b>Cable</b>	IBM Multi-mode jumper	62.5	1.75 dB/km	NA
	IBM Multi-mode jumper	50.0	3.00 dB/km at 850 nm	NA
	IBM Single-mode jumper	9.0	0.8 dB/km	NA
	Trunk	62.5	1.00 dB/km	NA
	Trunk	50.0	0.90 dB/km	NA
	Trunk	9.0	0.50 dB/km	NA

**Notes:**

1. The connector loss value is typical when attaching identical connectors. The loss can vary significantly if attaching different connector types.
2. Single-mode connectors and splices must meet a minimum return loss specification of 28 dB.



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## Appendix B. Tools, Test Equipment, and Parts

A complete list of fiber optic tools and test equipment is available in *Technical Service Letter TSL #147 Fiber Optic Tools and Test Equipment*, revised 2/19/96 or later. This TSL contains a current list and description of all part numbers in the fiber optic tool kit, ordering information, and calibration of test equipment. Tool kits and field bills of material (BOMs) are available to service both single-mode and multi-mode optical fiber links using ESCON, Fiber Channel Connection (FICON or coupling facility links) and GbE; attachment to ST, FC, and biconic connector types is also supported.





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## Appendix C. Measuring Device Transmit and Receive Levels

This section contains procedures on how to measure the dB power levels of the device transmit and receive signals. This section also contains information to isolate sections of a coupling link using the splitter tool.

An optical power meter is required for troubleshooting fiber optic problems. An optical power meter (12G8814) and adapter cables are available at branch offices as part of the IBM fiber optic field tool kits (46G6836, 46G6837, or 46G6839).

An alternate is the miniature optical power meter (MOP), IBM P/N 25F9767, that plugs into a digital voltmeter. RETAIN tip H164015 contains information on part numbers, optical connection adapters, and ordering. Information is also available at the following IBM Intranet Web site at <http://rtpgsa.ibm.com/home/i/t/itstesc/web/public> (You will need your IBM Intranet ID and password for access.) To navigate, click on **Tools Catalog** --> **Test Equipment** --> **Fiber Optic**.

- **Set up the MOP meter and multimeter as follows:**

1. Plug the MOP meter into the multimeter
  - a. COM of the MOP meter to COM on the multimeter
  - b. Other pin to DC Volts
2. Select the desired wavelength on the MOP meter
3. Select mVdc on the multimeter.

All of the procedures in this appendix describe methods of measuring optical power using the attached device as a source; this is the only way to measure SX links at 850 nm or wavelength multiplexed links around 1550 nm.

This chapter contains:

[“Measuring receive-in power” on page 69](#)

[“Measuring transmit-out power” on page 72](#)

[“Coupling links \(InterSystem Channel - ISCs\) multi-mode power level measurement procedures” on page 74](#)

[“Coupling links \(InterSystem Channel - ISCs\) single-mode power level measurement procedures” on page 77](#)

[“Isolating link segments using the splitter tool” on page 82](#)

[“ETR link multi-mode power level measurement procedures” on page 83](#)

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### Measuring receive-in power

See [Appendix C, “Measuring Device Transmit and Receive Levels ,” on page 69](#) for information about using the Miniature Optical Power meter, P/N 25F9767.

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

**Note:** Some instruments have a power-on hold (POH) push-button to prevent automatic power-off.

2. For long wavelength (LX = 1300nm) links, set the power meter to 1300nm.

For short wavelength (SX = 850nm) links, set the power meter to 850nm.

**Note:** Refer to [Table 4 on page 61](#) for links which use LX or SX transmitters.

3. Zero the power meter with darkened sensor.
4. Make sure the connectors are clean; then assemble the test equipment using the appropriate figure:

Figure 67 on page 70; ESCON multi-mode link

Figure 68 on page 70; ATM, multi-mode FICON, or single-mode FICON link, or 10 GbE LR single-mode link

Figure 69 on page 71; FDDI multi-mode link

Figure 70 on page 71; ESCON or ETR multi-mode link with MT-RJ connector

Figure 71 on page 71; FICON or ISC-3 peer mode link with LC connector

**Note:** Some FDDI devices can send test signals; ask the customer to have "halt" signals sent from these devices.

5. Observe the power meter display, and record the value on the work sheet. The receive level should read within the specifications for the channel type. See [Table 6 on page 71](#).

**Note:** If the level is within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective.

6. Go to ["Measuring transmit-out power" on page 72](#).

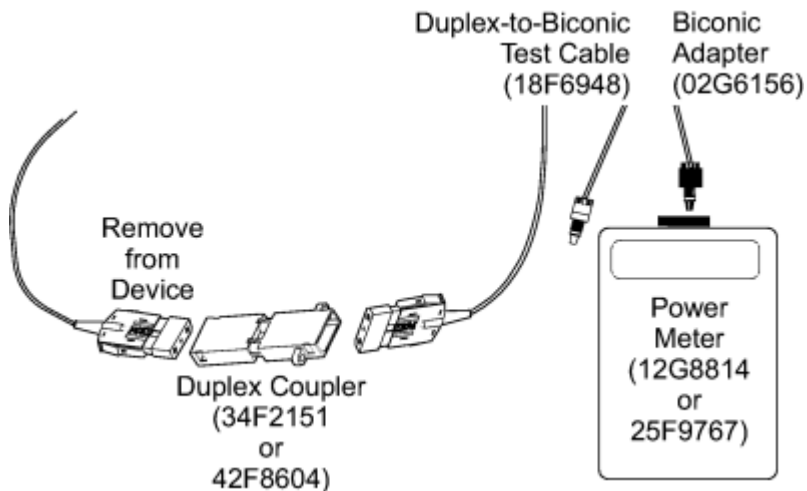


Figure 67. Measuring receive-in power for an ESCON multi-mode link

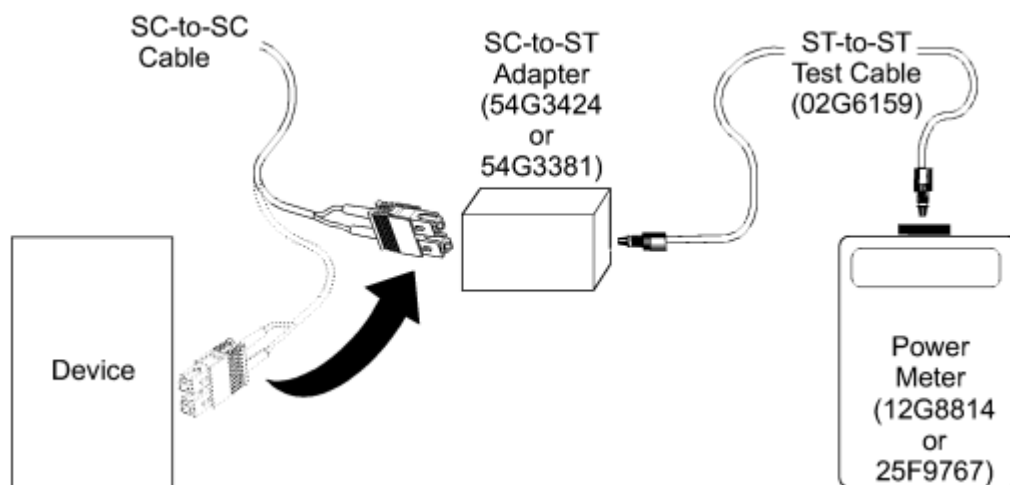


Figure 68. Measuring receive-in from the link - ATM, multi-mode FICON, single-mode FICON, or 10 GbE LR

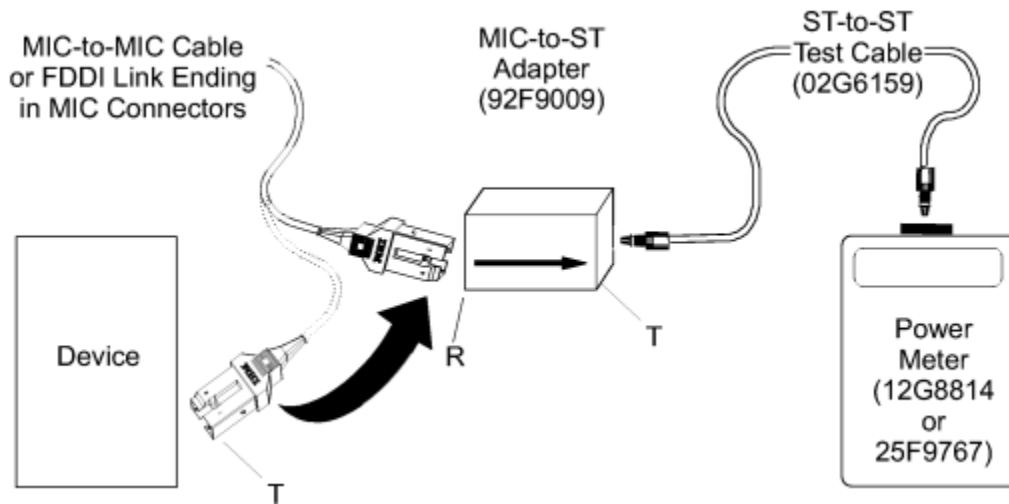


Figure 69. Measuring receive-in from the multi-mode link - FDDI

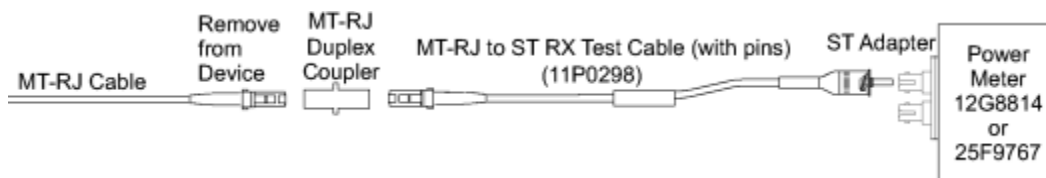


Figure 70. Measuring receive-in power for a multi-mode ESCON or ETR link with MT-RJ connector

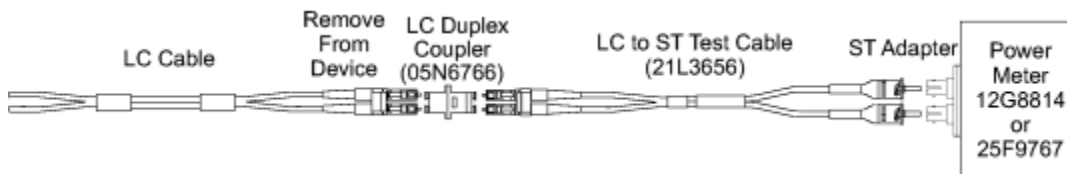


Figure 71. Measuring receive-in power for a FICON or ISC-3 peer mode link with LC connector

Link Type	TX Min	TX Max	RX Min	RX Max
Multi-mode FICON LX with MCP	-8.5 dBm	-4 dBm	-22 dBm	-3 dBm
Single-mode FICON LX 1gb (100-SM-LC-L)	-9.5 dBm	-3 dBm	-20 dBm	-3 dBm
Single-mode FICON LX 2gb (200-SM-LC-L)	-11.7 dBm	-3 dBm	-20 dBm	-3 dBm
Single-mode FICON LX 4gb 10km (400-SM-LC-L)	-8.4 dBm	-1 dBm	-16 dBm	-1 dBm
Single-mode FICON LX 4gb 4km (400-SM-LC-M)	-11.2 dBm	-1 dBm	-16 dBm	-1 dBm
Single-mode FICON LX 8gb 10km (800-SM-LC-L)	-8.4 dBm	-1 dBm	-13.5 dBm	-1 dBm
Single-mode FICON LX 16gb 10km (1600-SM-LC-L)	-5.0 dBm	2 dBm	-11.4 dBm	2 dBm
Single-mode FCP LX 32 Gbps 10 km (3200-SM-LC-L)	-5.0 dBm	2 dBm	-11.4 dBm	2 dBm
Multi-mode FICON SX 1gb (100-M5-SN-I, 100-M6-SN-I)	-10 dBm	-1 dBm	-16 dBm	0 dBm
Multi-mode FICON SX 2gb (200-M5-SN-I, 200-M6-SN-I)	-10 dBm	-1 dBm	-14 dBm	0 dBm
Multi-mode FICON SX 4gb (400-M5-SN-I, 400-M6-SN-I)	-9 dBm	-1 dBm	-13 dBm	0 dBm
Multi-mode FICON SX 8gb (800-M5-SN-I, 800-M6-SN-I)	-8.2 dBm	-1 dBm	-9.5 dBm	0 dBm
Multi-mode FICON SX 16gb (1600-M5-SN-I)	-7.8 dBm	0 dBm	-9.5 dBm	0 dBm

Table 6. Minimum and maximum acceptable power specifications (continued)

Link Type	TX Min	TX Max	RX Min	RX Max
Multi-mode FCP SX 32 Gbps (3200-M5-SN-I, 3200-M6-SN-I)	-6.2 dBm	2 dBm	-10.2 dBm	2 dBm
Multi-mode ESCON	-20.5 dBm	-15 dBm	-29 dBm	-14 dBm
Single-mode ESCON (Discontinued)	-8 dBm	-3 dBm	-28 dBm	-3 dBm
Single-mode GbE	-11 dBm	-3 dBm	-19 dBm	-3 dBm
Single-mode 10GbE LR (Including Coupling Express LR)	-8.2 dBm	0.5 dBm	-14.4 dBm	0.5 dBm
Multi-mode GbE	-9.5 dBm	-3 dBm	-17 dBm	-3 dBm
Multi-mode 10 Gbe SR (including RoCE)	-7.3 dBm	-1.0 dBm	-9.9 dBm	-1.0 dBm
Multi-mode 25 GbE SR	-8.4 dBm	2.4 dBm	-7.5 dBm	3 dBm
Single-mode Coupling Links (ISC, ISC-2, ISC-3) Operating at 1 Gbit/s (compatibility mode)	-11 dBm	-3 dBm	-20 dBm	-3 dBm
Single-mode Coupling Links (ISC, ISC-2, ISC-3) Operating at 2 Gbit/s (peer mode)	-9 dBm	-3 dBm	-20 dBm	-3 dBm
Multi-mode Coupling Links (ISC, ISC-2, ISC-3) Operating at 1 Gbit/s (Discontinued)	-16.5 dBm	-8.7 dBm	-26.5 dBm	-8.7 dBm
Single-mode Coupling Links (1 x IFB)	-7 dBm	0.5 dBm	-13 dBm	-0 dBm
Multi-mode Coupling Links (12 x IFB) Operating at 5 Gbit/s	-5.4 dBm	-1.5 dBm	-14.5 dBm	-1.5 dBm
Multi-mode ICA (24x PCIe) and zHyperLink Express	-7.6 dBm	2.4 dBm	-9.5 dBm	2.4 dBm
Sysplex Timer (ETR/CLO)	-20.5 dBm	-15 dBm	-29 dBm	-14 dBm

## Measuring transmit-out power

See [Appendix C, “Measuring Device Transmit and Receive Levels,”](#) on [page 69](#) for information about using the Miniature Optical Power meter, P/N 25F9767.

**Note:** The biconic or ST adapter should still be inserted into the power meter optical port, and the black-coded connector of the test cable should still be attached to the power meter.

1. Make sure the connectors are clean; then assemble the test equipment using the appropriate figure:

[Figure 72 on page 73](#); ESCON multi-mode link

[Figure 73 on page 73](#); FDDI multi-mode link

[Figure 74 on page 73](#); ATM, FICON, 10 GbE LR, or single-mode FICON link

[Figure 75 on page 74](#); ESCON multi-mode link with MT-RJ connector

[Figure 76 on page 74](#); FICON or ISC-3 peer mode link with LC connector

### Notes:

- a. For ISC-3 compatibility mode single-mode links, see [“Coupling links \(InterSystem Channel - ISCs\) single-mode power level measurement procedures”](#) on [page 77](#).
  - b. For ETR links, see [“ETR link multi-mode power level measurement procedures”](#) on [page 83](#).
2. Observe the power meter display and record the value on the work sheet. The transmit level should read within specifications for the channel type. See [Table 6 on page 71](#).

**Note:** If the level is not within this range, the device transmitter optical port could be dirty, or the transmitter could be defective.

3. Remove the coupler from the link jumper cable, and reconnect the jumper cable to the device.

4. Have you obtained the transmit and receive levels for both devices?

- If **Yes**, return to the fast-path step that directed you here.
- If **No**, return to “Measuring receive-in power” on page 69 and repeat the procedure for the other device.

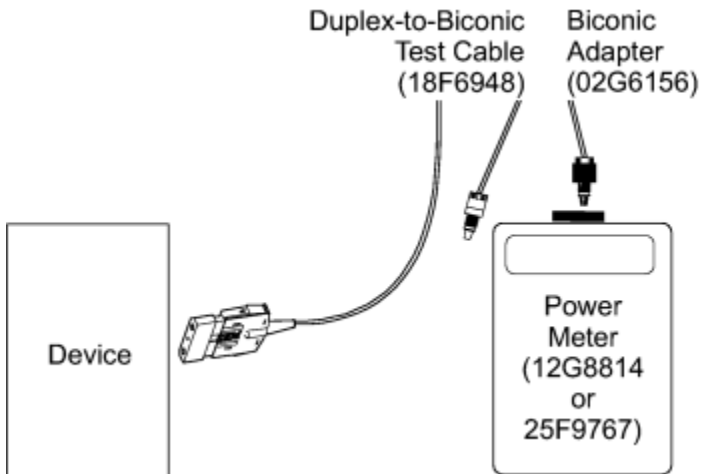


Figure 72. Measuring transmit-out power for an ESCON multi-mode link

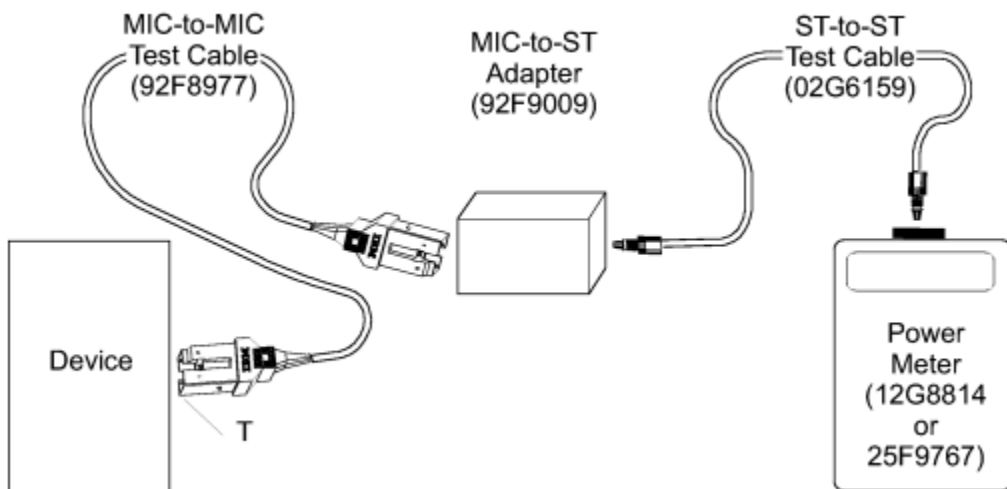


Figure 73. Measuring transmit-out from a multi-mode device - FDDI

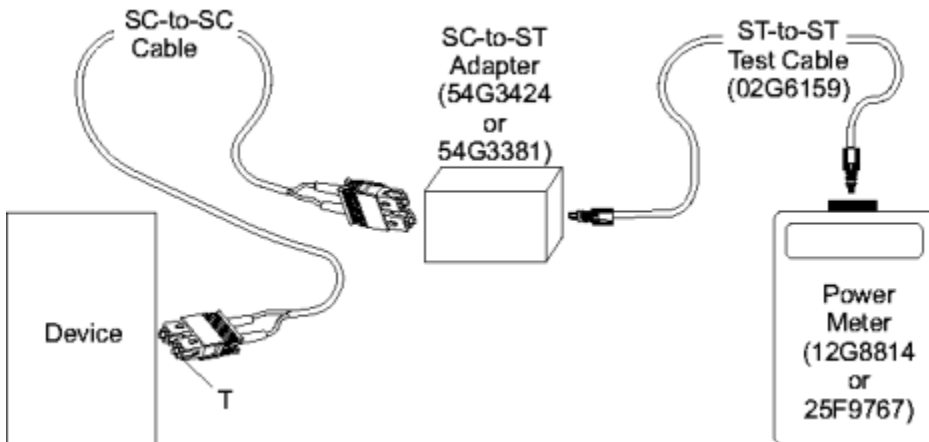


Figure 74. Measuring transmit-out from a device - ATM, FICON, 10GbE LR, or single-mode FICON

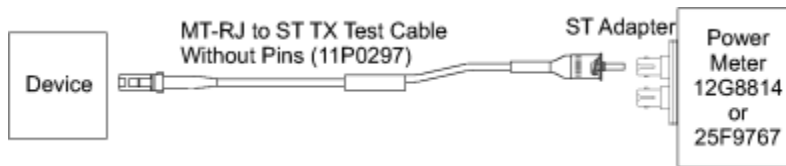


Figure 75. Measuring transmit-out power for an ESCON link with MT- RJ connectors

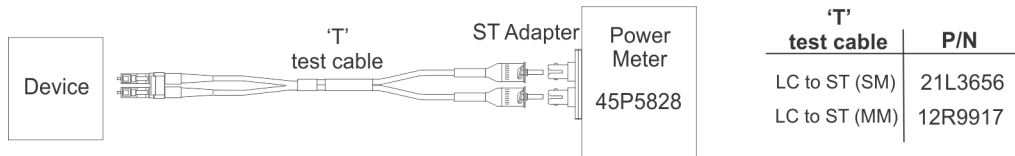


Figure 76. Measuring transmit-out power for a FICON or ISC-3 peer mode link with LC connectors

## Coupling links (InterSystem Channel - ISCs) multi-mode power level measurement procedures

Some coupling links use a different type of laser safety control than ESCON links, so they require a different method for measuring transmit and receive power levels. Coupling links operating at 2 Gbit/s (peer mode) do not require this procedure; the previous method for measuring single-mode links may still be used in this case (see Appendix C, “Measuring Device Transmit and Receive Levels ,” on page 69). Other coupling links operating at 1 Gbit/s use a safety method called Open Fiber Control (OFC); the transmitters on both ends of the link will only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as unplugging a connector or breaking a fiber) both transmitters automatically shut down as a safety measure. The transmitters will automatically turn on again within 10 seconds after the link is re-established. To maintain a complete link while measuring the power levels, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link. This measurement can be used to determine the power levels in the link according to the following procedures.

Because some coupling links use OFC laser safety control, it is not possible to measure the fiber loss using the MAPs. All link problem determination and link verification for these links must be performed using the Fast Path method.

The coupling links use a different type of optical connector than the ESCON links. The SC duplex connector should be held by the sides of the connector body when plugging so that the fibers on the transmit and receive sides are not accidentally pushed together. The connector should plug with a maximum force of about 5 lbs.; if plugging is difficult, move the connector slightly side to side, rather than forcing it into the housing. The connector is keyed to allow insertion in only one orientation; note the orientation of the keys when you remove the connector so that it will be easier to re-insert.

**Note:** Standard SC duplex products are available from many vendors; When using a non-IBM cable, consult the customer's specifications for insertion and withdrawal.

### Measuring device transmitter and receiver levels

If you did not measure the transmitter and receiver levels of the device, as instructed by the device maintenance publication, use the following procedure.

See Appendix C, “Measuring Device Transmit and Receive Levels ,” on page 69 for information about using the Miniature Optical Power meter, P/N 25F9767.

This procedure must be performed before measuring the power levels on the channel.

1. Insert the optical wrap plug (part number 16G5609 for SC and 15R7536 for LC) into the optical channel and perform any available hardware diagnostic tests. This will determine if the optical transmitter and receiver card are functioning properly. This will not, however, determine if they are operating within specification limits.

2. Run the wrap tests using the wrap test procedure in the maintenance information manual for the device:

If the wrap test fails, replace the channel card using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.

If the wrap test completes successfully, insert the optical splitter tool (part number 54G3426). Attach the splitter connector marked "DEVICE TO BE MEASURED" into the optical transceiver and connect the rest of the test equipment (see [Figure 77](#) on page 75).

3. Measure the transmit-out power level of the device; it should be between -8.7 and -16.5 dBm.

**Note:** Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. This reading should be between -5.0 and +1.3 dBm.

4. If the transmit-out level is out of specification limits, replace the channel card. using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.

5. If the transmitter power is within specification limits, connect the test equipment (see [Figure 78](#) on page 76).

6. Measure and record the receive-in power level.

**Note: Do not** replace the card on the basis of this measurement, even if the power meter continues to read **LO**. A bad receiver light level may be caused by a fault in the fiber optic cable or in the transmitter on the other end of the link.

7. If this is your first time through this procedure, repeat steps “1” on page 74 through “6” on page 75 for the device attached to the other end of the link.

If this is your second time through this procedure, continue with “[Measuring receive-in power for a multi-mode coupling link](#)” on page 75.

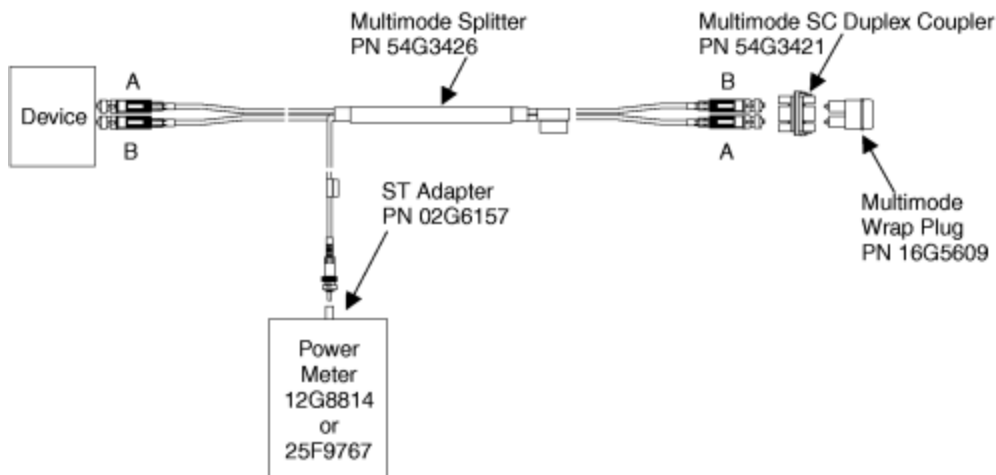


Figure 77. Measuring device transmitter levels for a multi-mode coupling link

## Measuring receive-in power for a multi-mode coupling link

See Appendix C, “[Measuring Device Transmit and Receive Levels](#),” on page 69 for information about using the Miniature Optical Power meter, P/N 25F9767.

Make sure the connectors are clean; then assemble the test equipment (using [Figure 78](#) on page 76) as follows:

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

**Note:** Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.

2. Set the power meter to 850 nm.
3. Zero the power meter with darkened sensor.
4. Remove the SC duplex connector from the device whose receiver is to be measured. Attach the duplex connector of the splitter (part number 54G3426) labeled "DEVICE TO BE MEASURED" to the open end of the link, using the SC duplex coupler (part number 54G3421).
5. Attach the other, unmarked end of the splitter to the device. The splitter is now positioned to measure the optical power coming from the other end of the link into the device receiver.
6. Attach the ST connector adapter (part number 02G6157) to the power meter, and insert the ST connection from the splitter into the power meter.
7. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 8.7 dBm and - 26.5 dBm.

**Notes:**

- a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The receiver optical power should be between -15.0 dBm and + 1.3 dBm,  $\pm 0.5$  dBm.
- b. If the level **is not** within this range, the receiver is not getting enough light; either the transmitter is bad or there is a fault in the cable connecting the transmitter and receiver. Continue with "Measuring transmit-out power for a multi-mode coupling link" on page 76.

If the level **is** within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective. Clean the TRS and repeat the measurement; if the level is still out of spec, then the receiver is defective; record the level measured, and replace the card with the defective receiver.

8. Go to "Measuring transmit-out power for a multi-mode coupling link" on page 76.

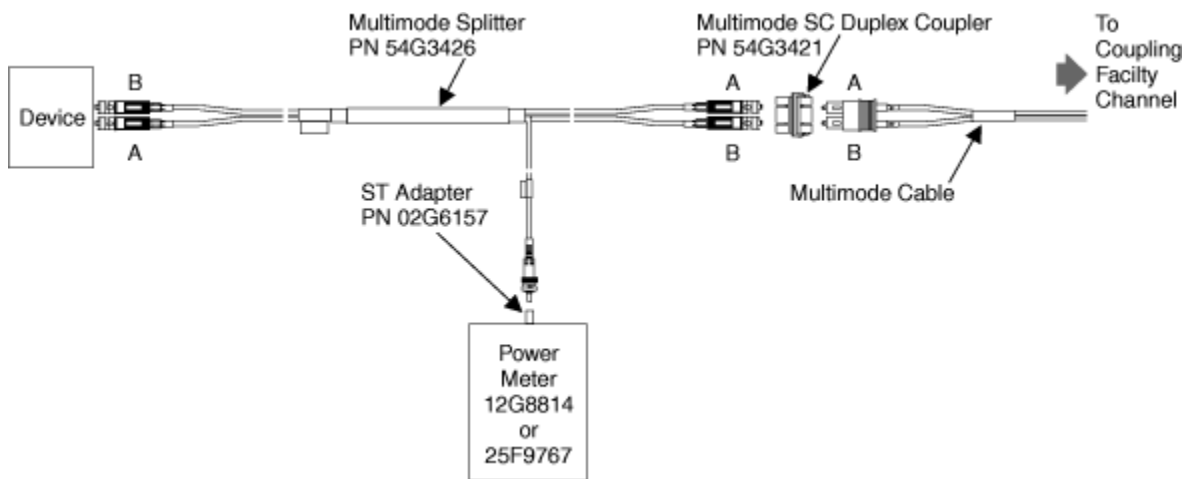


Figure 78. Measuring receive-in power for a multi-mode coupling link

## Measuring transmit-out power for a multi-mode coupling link

**Note:** The ST connector of the splitter (part number 54G3426) should remain connected to the power meter.

See Appendix C, "Measuring Device Transmit and Receive Levels," on page 69 for information about using the Miniature Optical Power meter, P/N 25F9767.

Assemble the test equipment (using Figure 79 on page 77) as follows:

1. Remove the splitter from the device and the link.



2. Attach the splitter connector marked "DEVICE TO BE MEASURED" to the device, and attach the unmarked splitter connector to the link using the SC duplex coupler (part number 54G3421). The splitter is now positioned to measure the transmitter output power of the device.
3. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading. The power meter reading should be between - 8.7 dBm and - 16.5 dBm.

**Notes:**

- a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical power reading. The transmitter optical power should be between -5.0 dBm and + 1.3 dBm,  $\pm 0.5$  dBm.
- b. If the level **is** within this range and the link is not operating properly, continue with the link maintenance procedure.

If the level **is not** within this range, the device transmitter optical port could be dirty, or the transmitter could be defective. Clean the transmitter port and repeat the measurement; if the level is still out of range, the transmitter is defective; replace the card with the bad transmitter.

4. Remove the splitter from both the device and the link, and reconnect the link to the device.
5. Have you obtained the transmit and receive levels for both devices?
  - If **Yes**, return to the Fast Path step that directed you here.
  - If **No**, return to “Measuring receive-in power for a multi-mode coupling link” on page 75 and repeat the procedure for the other device.

**Note:** The optical power meter reading taken with the splitter represents 10% of the true optical power in the link (10 dB), minus some loss associated with the splitter tool. The combined loss is marked on each splitter. To correct a power meter reading for the 10% power sampling, add the value given on the splitter to the power meter reading.

This measurement procedure is accurate to within  $\pm 0.5$  dB, because of variations in the splitter's optical connectors.

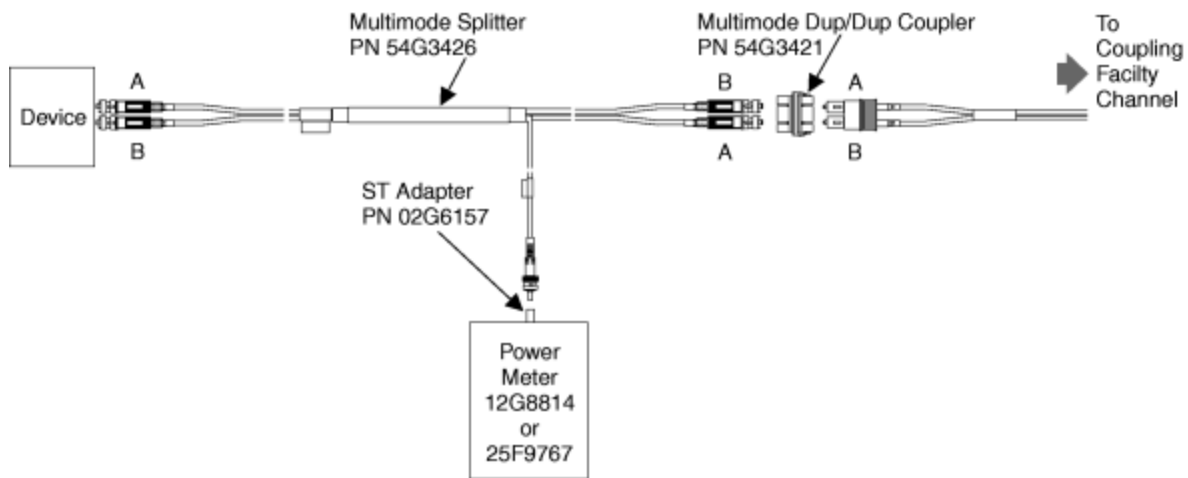


Figure 79. Measuring transmit-out power for a multi-mode coupling link

## Coupling links (InterSystem Channel - ISCs) single-mode power level measurement procedures

Some coupling links use a different type of laser safety control than ESCON links, so they require a different method for measuring transmit and receive power levels. Coupling links operating at 2 Gbit/s (peer mode) do not require this procedure; the previous method for measuring single-mode links may still be used in this case (see Appendix C, “Measuring Device Transmit and Receive Levels,” on page 69).

Other coupling links operating at 1 Gbit/s use a safety method called Open Fiber Control (OFC); the transmitters on both ends of the link will only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as unplugging a connector or breaking a fiber) both transmitters automatically shut down as a safety measure. The transmitters will automatically turn on again within 10 seconds after the link is re-established. To maintain a complete link while measuring the power levels, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link. This measurement can be used to determine the power levels in the link according to the following procedures.

Because some coupling links use OFC laser safety control, it is not possible to measure the fiber loss using the MAPs. All link problem determination and link verification for these links must be performed using the Fast Path method.

The coupling links use a different type of optical connector than the ESCON links. The SC duplex connector should be held by the sides of the connector body when plugging so that the fibers on the transmit and receive sides are not accidentally pushed together. The connector should plug with a maximum force of about 5 lbs.; if plugging is difficult, move the connector slightly side to side, rather than forcing it into the housing. The connector is keyed to allow insertion in only one orientation; note the orientation of the keys when you remove the connector so that it will be easier to re-insert.

**Note:** Standard SC duplex products are available from many vendors; if you are using a non-IBM cable, consult the vendor's specifications for insertion and withdrawal.

## Measuring device transmitter and receiver levels

If you did not measure the transmitter and receiver levels of the device, as instructed by the device maintenance publication, use the following procedure.

This procedure must be performed before measuring the power levels on the channel.

1. Insert the optical wrap plug (part number 78G9610 for SC and 15R7536 for LC) into the optical channel and perform any available hardware diagnostic tests. This will determine if the optical transmitter and receiver card are functioning properly. This will not, however, determine if they are operating within specification limits.
2. Run the wrap tests using the wrap test procedure in the maintenance information manual for the device:
  - If the wrap test fails, replace the channel card using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.
  - If the wrap test completes successfully, insert the optical splitter tool (part number 54G3427). Attach the splitter connector marked "DEVICE TO BE MEASURED" into the optical transceiver and connect the rest of the test equipment (see [Figure 80 on page 79](#)).

For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see [Figure 81 on page 79](#)).

3. Measure the transmit-out power level of the device.

**Note:** Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical transmit-out power level. This reading should be between -11.0 and -3.0 dBm.

4. If the transmit-out level is out of specification limits, replace the channel card. using the instructions in the maintenance information manual for the device. Then continue measuring the device transmitter and receiver levels using the procedure in that manual.
5. If the transmitter power is within specification limits, connect the test equipment (see [Figure 83 on page 80](#) or [Figure 81 on page 79](#)).
6. Measure and record the receive-in power level.

**Note: Do not** replace the card based on this measurement, even if the power meter continues to read **L0**. A bad receiver light level may be caused by a fault in the fiber optic cable or in the transmitter on the other end of the link.

- If this is your first time through this procedure, repeat steps “1” on page 78 through “6” on page 78 for the device attached to the other end of the link.

If this is your second time through this procedure, continue with “Measuring receive-in power for a single-mode coupling link” on page 79.

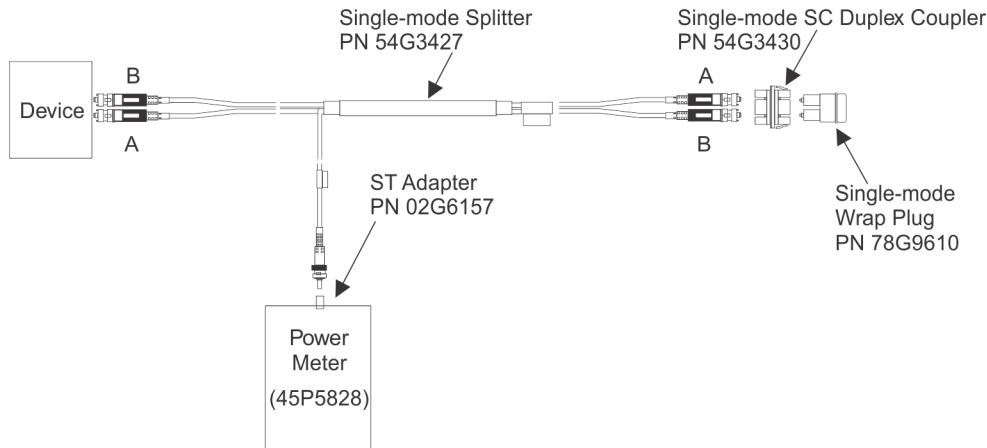


Figure 80. Measuring device transmitter levels for a single-mode coupling link

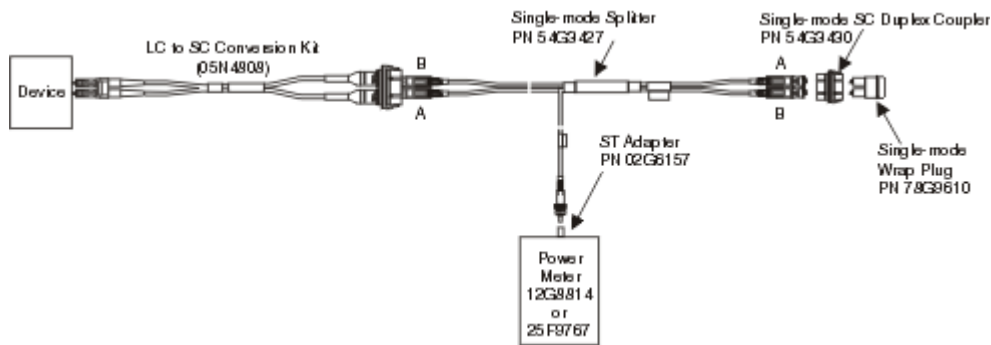


Figure 81. Measuring device transmitter levels for an ISC3 operating at compatibility mode

## Measuring receive-in power for a single-mode coupling link

Make sure the connectors are clean; then assemble the test equipment (using Figure 82 on page 80 or Figure 83 on page 80) as follows:

- Switch on the power meter, and allow approximately 5 minutes for warm-up.
  - Note:** Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.
- Set the power meter to 1300 nm.
- Zero the power meter with darkened sensor.
- Remove the SC duplex connector from the device whose receiver is to be measured. Attach the duplex connector of the splitter (part number 54G3427) labeled "DEVICE TO BE MEASURED" to the open end of the link, using the SC duplex coupler (part number 54G3430).

For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see Figure 83 on page 80).

- Attach the other, unmarked end of the splitter to the device. The splitter is now positioned to measure the optical power coming from the other end of the link into the device receiver.

6. Attach the ST connector adapter (part number 02G6157) to the power meter, and insert the ST connection from the splitter into the power meter.
7. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading.

**Notes:**

- a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical received-in power level. The receiver optical power should be between - 20 dBm and -3 dBm ,  $\pm 0.5$  dBm.
  - b. If the level is within this range and the receiver is not operating properly, the device receiver optical port could be dirty, or the receiver could be defective.
8. Go to “Measuring transmit-out power for a single-mode coupling link” on page 81.

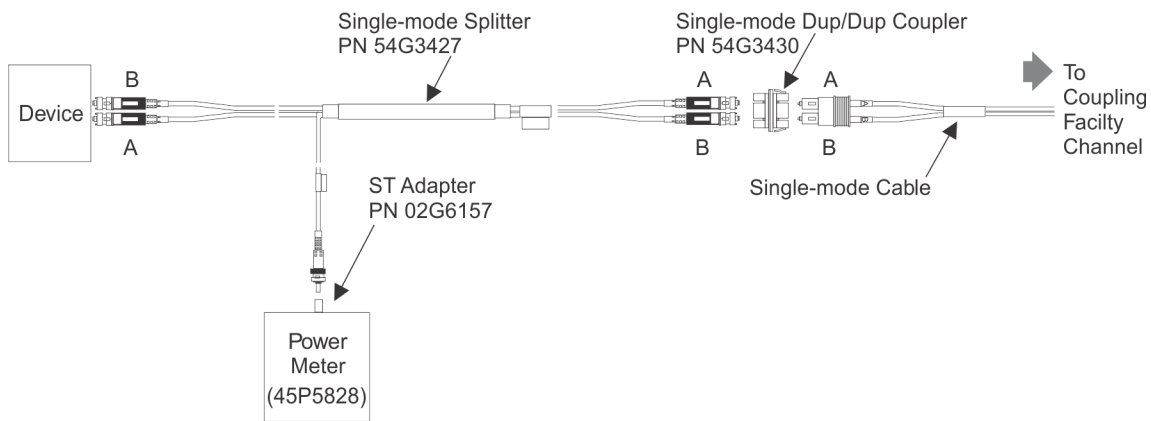


Figure 82. Measuring receive-in power for a single-mode coupling link (ISC Legacy)

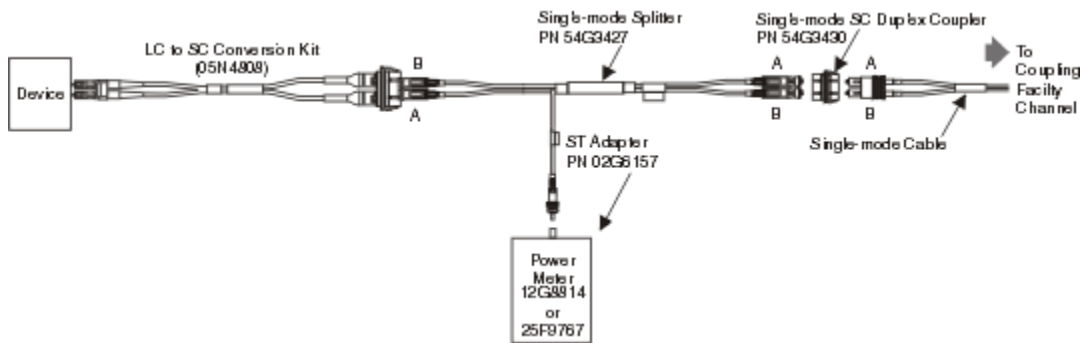


Figure 83. Measuring receive-in power for an ISC3 operating at compatibility mode to ISC legacy link (ISC3 to ISC legacy)

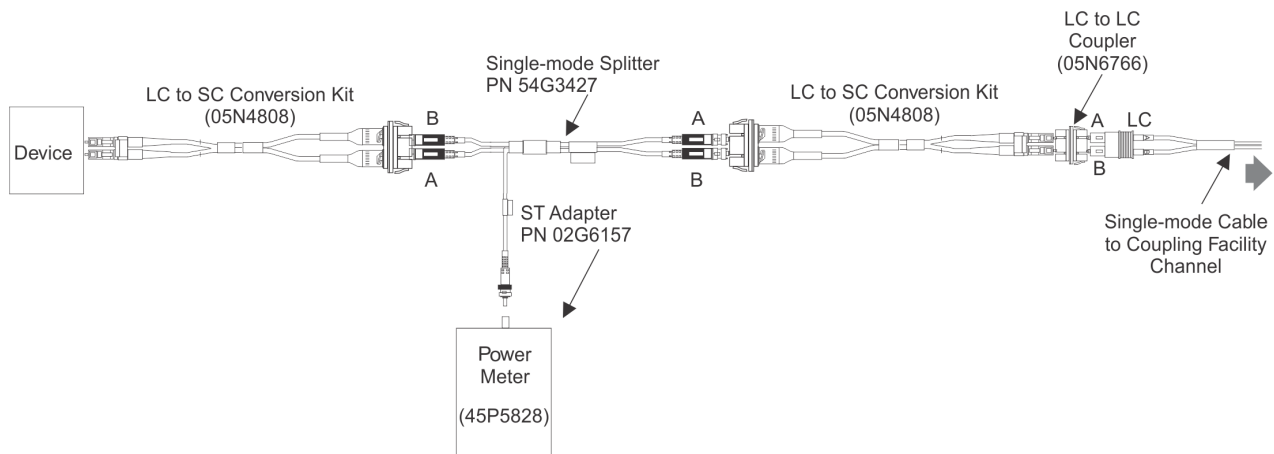


Figure 84. Measuring receive-in power for an ISC3 operating at compatibility mode (ISC3 to ISC3)

## Measuring transmit-out power for a single-mode coupling link

**Note:** The ST connector of the splitter (part number 54G3427) should remain connected to the power meter.

Assemble the test equipment (using [Figure 85 on page 82](#) or [Figure 86 on page 82](#)) as follows:

1. Remove the splitter from the device and the link.
2. Attach the splitter connector marked "DEVICE TO BE MEASURED" to the device, and attach the unmarked splitter connector to the link using the SC duplex coupler (part number 54G3421). For ISC3, connect the LC to SC conversion kit, part number 05N4808, between the splitter and the device (see [Figure 86 on page 82](#)). The splitter is now positioned to measure the transmitter output power of the device.
3. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the link to re-establish transmitting, and for the power meter reading to stabilize before taking a reading.

### Notes:

- a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical received-in power level. The transmitter optical power should be between -11.0 dBm and - 3.0 dBm,  $\pm 0.5$  dBm.
- b. If the level **is** within this range and the link is not operating properly, continue with the link maintenance procedure.

If the level **is not** within this range, the device transmitter optical port could be dirty, or the transmitter could be defective. Clean the transmitter port and repeat the measurement; if the level is still out of range, the transmitter is defective; replace the card with the bad transmitter.

4. Remove the splitter from both the device and the link, and reconnect the link to the device.
5. Have you obtained the transmit and receive levels for both devices?
  - If **Yes**, return to the Fast Path step that directed you here.
  - If **No**, return to [Figure 82 on page 80](#) or [Figure 83 on page 80](#) and repeat the procedure for the other device.

**Note:** The optical power meter reading taken with the splitter represents a percentage of the true optical power in the link, minus some loss associated with the splitter tool. The combined loss is marked on each splitter. To obtain the actual transmit-out power level, add the value given on the splitter to the power meter reading.

This measurement procedure is accurate to within  $\pm 0.5$  dB, because of variations in the splitter's optical connectors.

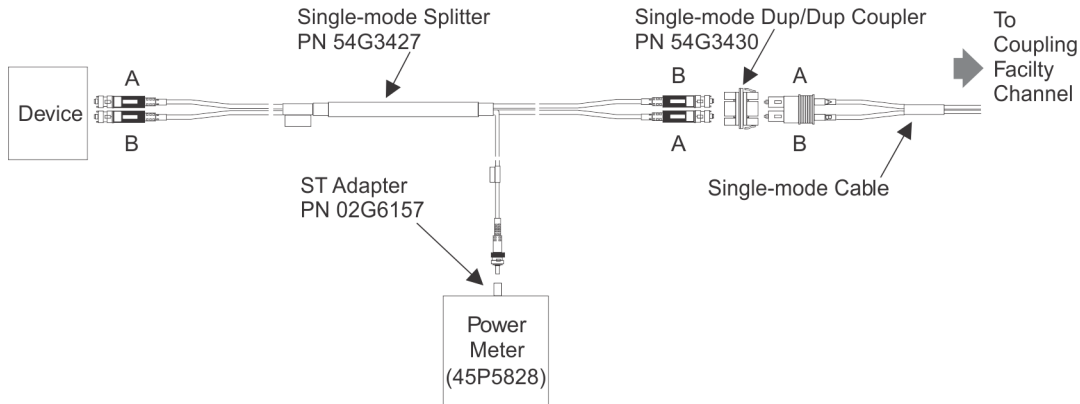


Figure 85. Measuring transmit-out power for a single-mode coupling link

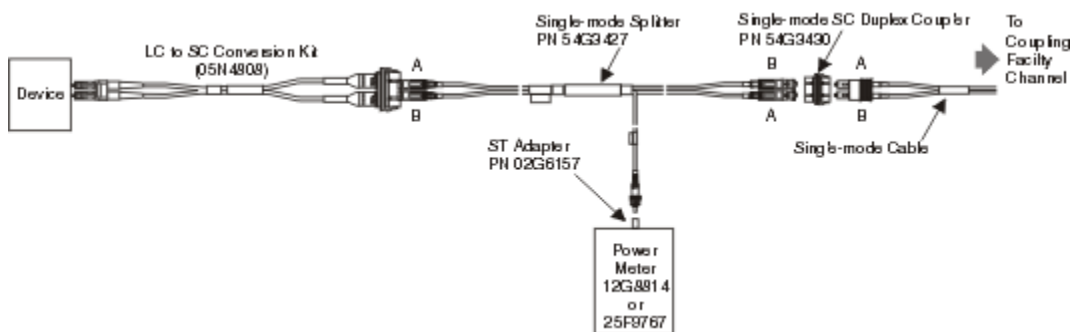


Figure 86. Measuring transmit-out power for an ISC3 operating at compatibility mode to ISC legacy link (ISC3 to ISC legacy)

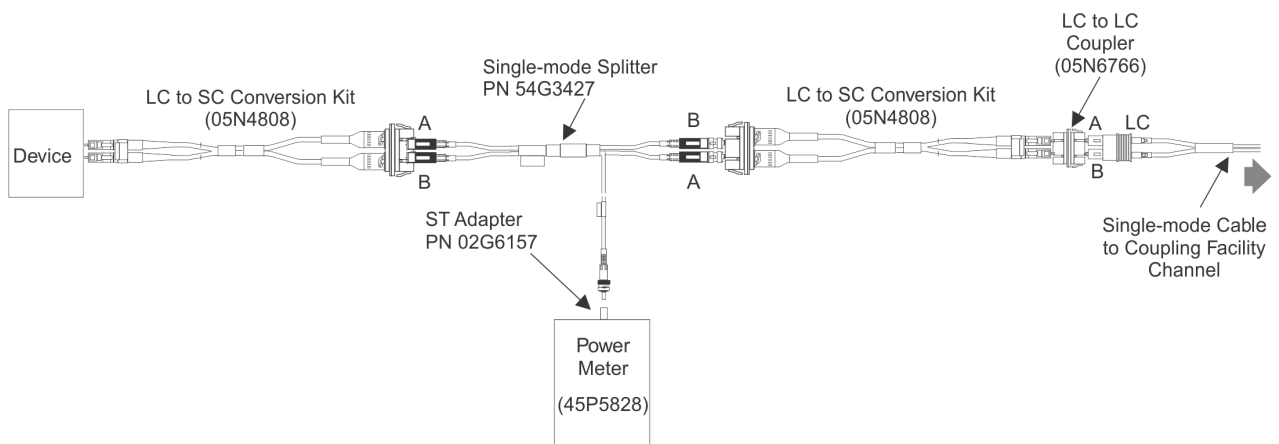


Figure 87. Measuring transmit-out power for an ISC3 operating at compatibility mode for an ISC3 compatibility link (ISC3 to ISC3)

## Isolating link segments using the splitter tool

Coupling facility links operating at 2 Gbit/s (peer mode) do not use Open Fiber Control (OFC). Coupling facility links operating at 1 Gbit/s (compatibility mode) use the laser safety method known as Open Fiber Control (OFC). The transmitters on both ends of the link only function if there is a complete fiber link between both pairs of transmitters and receivers. If the link is opened at any point (such as unplugging a connector or breaking a fiber), both transmitters automatically shut down, as a safety measure. The transmitters will automatically come on within 10 seconds after the link is re-established. To isolate a

segment of the link, it is necessary to use a fiber optic splitter to tap off a small amount of light from an operating link.

Figure 88 on page 83 (multi-mode link) and Figure 89 on page 83 (single-mode link) show how to assemble the test equipment. Within 10 seconds after the link is assembled with the test equipment shown, the laser comes on and the power meter shows the light levels within the link.

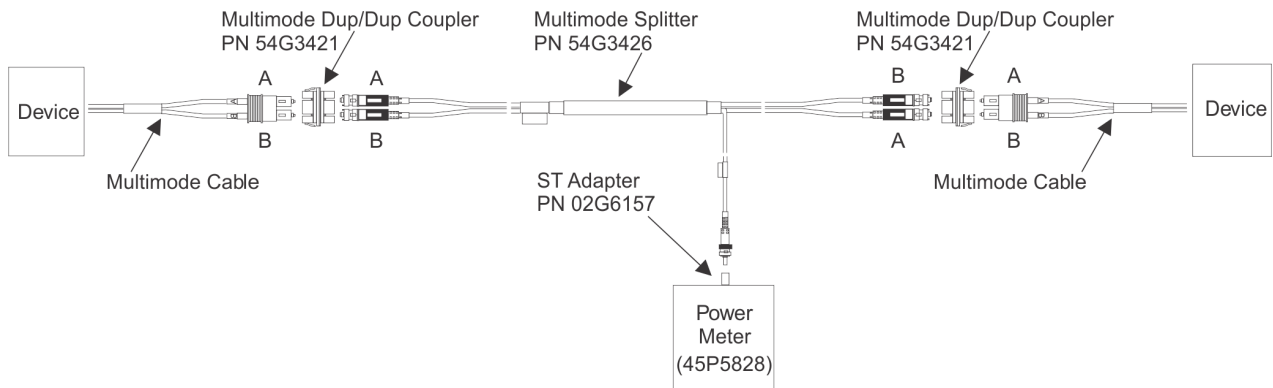


Figure 88. Isolating a link segment using the multi-mode splitter

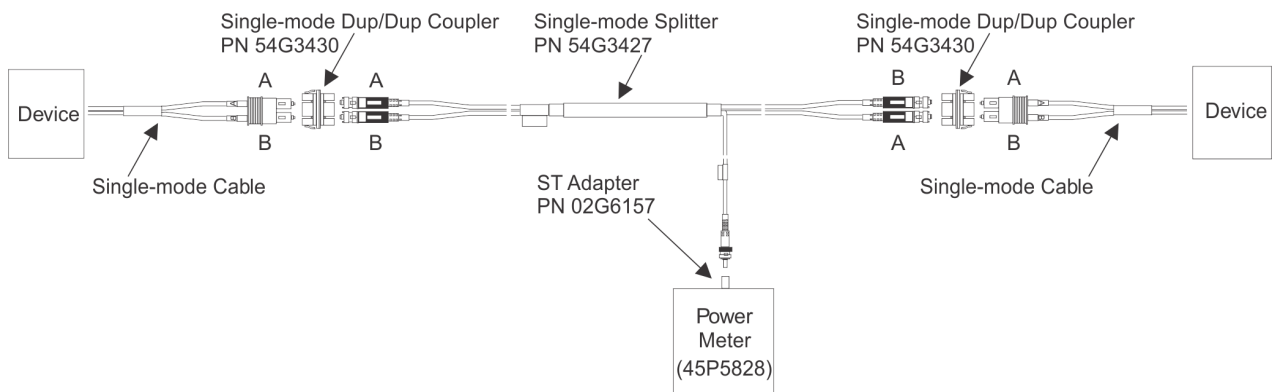


Figure 89. Isolating a link segment using the single-mode splitter

## ETR link multi-mode power level measurement procedures

Some ETR cards require the receive-in signal (timing and pulses) from the 9037 Sysplex Timer to be connected for the transmit-out power to be at the correct level. If the receive-in signal is disconnected during the measurement, the transmit-out number may be significantly lower than it is during normal operation. This is true for z990 and later server ETR cards.

Be sure that you have measured the Receive-In power level using the instructions in “Measuring receive-in power” on page 69 prior to this Transmit-Out measurement. If the Receive-In power level does not meet specification, the Transmit-Out measurement can be incorrect on a functional ETR card.

To make the transmit-out power meter reading on those cards, you must ensure that the transceiver on the ETR card continues to receive light. The ETR card generally connects to the ETR channel via an MT-RJ-to-ESCON duplex adapter cable (Figure 28 on page 11). If this is not the case, you must use the appropriate adapters to make sure the receive-in signal is connected to the ETR card transceiver during the transmit-out power level measurement.

### Measuring transmit-out power for an ETR link

Make sure the connectors are clean. Then assemble the test equipment (using Figure 90 on page 84) as follows:

1. Switch on the power meter, and allow approximately 5 minutes for warm-up.

**Note:** Some instruments have a power-on hold (POH) pushbutton to prevent automatic power-off.

2. Set the power meter to 1300 nm.
3. Zero the power meter with darkened sensor.
4. The ESCON duplex connector has two ST simplex connectors. Disconnect the transmit side ST connector only.

**Note:** Ensure that you have disconnected the transmit side by checking the Loss of Light LED on the card.

5. Connect the transmit side ST connector to the power meter using [Figure 90 on page 84](#).
6. Observe the power meter display. Be sure to wait at least 10 seconds after completing the connections for the transmit-out power level to stabilize and for the power meter reading to stabilize before taking a reading.

**Notes:**

- a. Each optical splitter is labeled with the total splitter loss in dB. Add this value to the power meter reading to obtain the actual optical received-in power level. this level should be between -20.5 dBm and -15.0 dBm,  $\pm 0.5$
  - b. If the level is **within** this range and the link is not operating properly, continue with the link maintenance procedure.
  - c. If the level is **not within** this range, the device transmitter optical port could be dirty, or the transmitter could be defective. Clean the transmitter port and repeat the measurement. If the level is still out of range, the transmitter is defective and you must replace the card with the bad transmitter.
7. Disconnect the ST connector from the power meter and reconnect it to the ESCON Duplex connector.
  8. Have you obtained the transmit and receive levels for both devices?
    - If **Yes**, return to the Fast Path step that directed you here.
    - If **No**, use the device in [Figure 70 on page 71](#) for the ETR card receive level and refer to *Maintenance Information for the 9037 Model 002 Sysplex Timer, SY27-2641*, to measure the 9037 Sysplex Timer device.

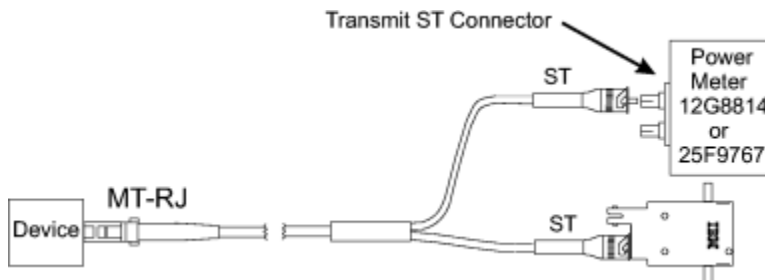


Figure 90. Measuring transmit-out power for an ETR link



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## Appendix D. Measurement Conversion Tables

### English-to-Metric conversion table

---

English value	Multiplied by	Equals metric value
Fahrenheit	$(^{\circ}\text{F} - 32) \times 0.556$	Celsius
Inches	2.54	Centimeters (cm)
Inches	25.4	Millimeters (mm)
Feet	0.305	Meters (m)
Miles	1.61	Kilometers (km)
Pounds	0.45	Kilograms (kg)
Pounds	4.45	Newtons (N)

### Metric-to-English conversion table

---

English value	Multiplied by	Equals metric value
Celsius	$(^{\circ}\text{C} \times 1.8) + 32$	Fahrenheit
Centimeters (cm)	0.39	Inches
Millimeters (mm)	0.039	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.621	Miles
Kilograms (kg)	2.20	Pounds
Newtons (N)	0.225	Pounds



# Appendix E. Work Sheets

The work sheets in this appendix may be copied and should be kept as a permanent account record.

<b>Device 1</b> Type _____ Serial _____ Port _____	<div style="border: 1px solid black; padding: 5px; display: inline-block;">           Customer Name _____            Date _____         </div>	<b>Device 2</b> Type _____ Serial _____ Port _____
-------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------

**P0** \_\_\_\_\_ dBm

Fiber 1	Fiber 2
<b>P1</b> Reference Level    _____ dBm	<b>P1</b> Reference Level    _____ dBm
<b>L</b> Maximum Link Loss    _____ dB	<b>L</b> Maximum Link Loss    _____ dB
<b>F1</b> Maximum Acceptable Receive Level at <b>A1</b> _____ dBm	<b>F2</b> Maximum Acceptable Receive Level at <b>A2</b> _____ dBm

# Cable Administration Work Sheet

							Machine Type Ser # Port #	Product Information	1
							Strain Relief Used? (Y/N)		
							Vendor	Jumper Cable Information	2
							Length (meter or ft)		
							Loss (dB or dB/km) and Bandwidth (Mhz *km) Specifications		
							Modified? If yes, Loss Measurement Fiber 1/Fiber 2		
							Connector Types		
							Stack Storage? (Y/N)		
							From Label Fiber 1/Fiber 2 M/T Serial		
							Path ID/Segment ID		
							To Label Fiber 1/Fiber 2		
							Cable Manufacturer and Fiber Core Size ( $\mu\text{m}$ )		
							Installer		
							Length (km or ft)		
							Attenuation Specification (dB/km) or Loss Measurement (dB)		
							Bandwidth Specifications (Mhz*km)		
							# of Splices and Type		
							Connector Type(s) and Panel(s)		
							OTDR Print? If Yes, ID		
							From Panel ID Fiber 1/Fiber 2		
							Path ID and Segment ID		
							To Panel ID Fiber 1/Fiber 2		
							Date Tested	Loss Measurement	4
							End-End Link Verification Loss (dB)		
								Service Comments	5

Figure 91. Example of a cable administration work sheet

Table 7. Jumper cable power levels

Link/fiber type	Cable length in meters (Ft.)	Level at <b>C1</b> / <b>D2</b>	Level at <b>C2</b> / <b>D1</b>
<b>ESCON, ATM, FDDI, FICON, and GbE</b>			
Multi-mode	4 to 73 (12 to 240)	-22.0 dBm	-29.0 dBm
Multi-mode	74 to 146 (243 to 479)	-22.1 dBm	-28.9 dBm
Multi-mode	147 to 219 (482 to 719)	-22.2 dBm	-28.8 dBm
Multi-mode	220 to 292 (722 to 958)	-22.4 dBm	-28.6 dBm
Multi-mode	293 to 365 (961 to 1198)	-22.5 dBm	-28.5 dBm
Multi-mode	366 to 438 (1201 to 1437)	-22.6 dBm	-28.4 dBm
Multi-mode	439 to 500 (1440 to 1640)	-22.7 dBm	-28.3 dBm
<b>Coupling link, FICON SX, GbE SX</b>			
Multi-mode	7 (21)	-6.0 dBm	-15.0 dBm
Multi-mode	13 (33)	-6.1 dBm	-14.9 dBm
Multi-mode	22 (66)	-6.2 dBm	-14.8 dBm
Multi-mode	31 (93)	-6.3 dBm	-14.7 dBm
Multi-mode	46 (138)	-6.4 dBm	-14.6 dBm
Multi-mode	61 (183)	-6.5 dBm	-14.5 dBm
<b>ESCON, ATM, FICON LX, GbE LX, Coupling Facility</b>			
Single-mode	7 (21)	-11.0 dBm	-20.0 dBm
Single-mode	13 (33)	-11.1 dBm	-19.9 dBm
Single-mode	22 (66)	-11.2 dBm	-19.8 dBm
Single-mode	31 (93)	-11.3 dBm	-19.7 dBm
Single-mode	46 (138)	-11.4 dBm	-19.6 dBm
Single-mode	61 (183)	-11.5 dBm	-19.5 dBm
<b>Note:</b> ESCON channels using the FICON connector may use FICON cables with the values described above.			

## MAP work sheet: link configuration 1

Device 1

Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_

Customer Name _____
Date _____

Device 2

Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_



[P0] \_\_\_\_\_ dBm

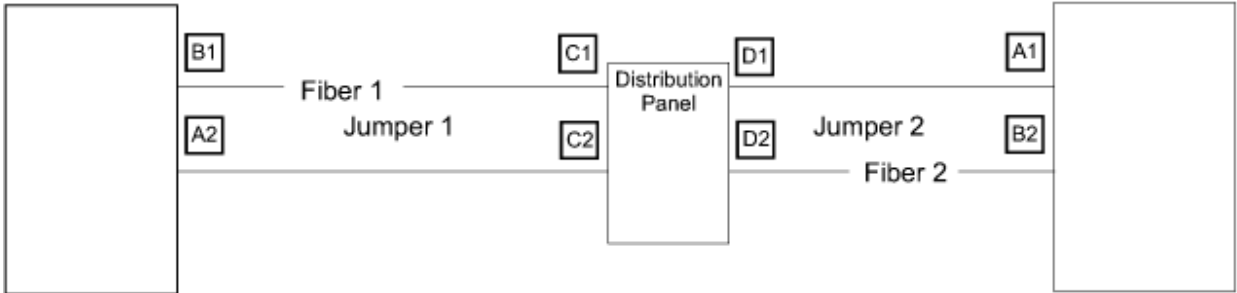
Fiber 1		Fiber 2	
[P1] Reference Level	_____ dBm	[P1] Reference Level	_____ dBm
[L] Maximum Link Loss	_____ dB	[L] Maximum Link Loss	_____ dB
	(-) _____		(-) _____
[F1] Maximum Acceptable Receive Level at [A1]	_____ dBm	[F2] Maximum Acceptable Receive Level at [A2]	_____ dBm

# MAP work sheet: link configuration 2

Device 1  
 Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_

Customer Name \_\_\_\_\_  
 Date \_\_\_\_\_

Device 2  
 Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_



P0 \_\_\_\_\_ dBm

Fiber 1		Fiber 2	
P1	Reference Level _____ dBm	P1	Reference Level _____ dBm
L	Maximum Link Loss _____ dB	L	Maximum Link Loss _____ dB
	(-) _____		(-) _____
F1	Maximum Acceptable Receive Level at A1 _____ dBm	F2	Maximum Acceptable Receive Level at A2 _____ dBm
P1	Reference Level _____ dBm	P1	Reference Level _____ dBm
L	Maximum Link Loss _____ dB	L	Maximum Link Loss _____ dB
	(-) _____		(-) _____
F1	Maximum Acceptable Receive Level at A1 _____ dBm	F2	Maximum Acceptable Receive Level at A2 _____ dBm

## MAP work sheet: link configuration 3

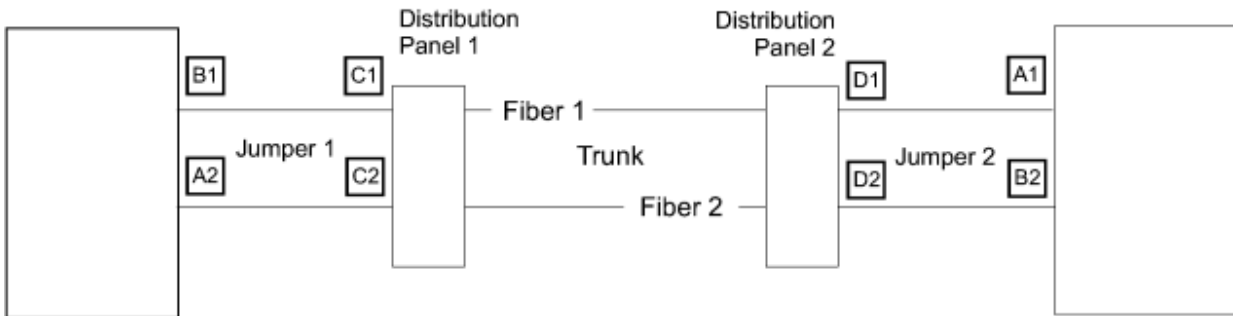
Device 1

Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_

Customer Name \_\_\_\_\_  
 Date \_\_\_\_\_

Device 2

Type \_\_\_\_\_  
 Serial \_\_\_\_\_  
 Port \_\_\_\_\_



[P0] \_\_\_\_\_ dBm

Fiber 1		Fiber 2	
[P1] Reference Level	_____ dBm	[P1] Reference Level	_____ dBm
[L] Maximum Link Loss	_____ dB	[L] Maximum Link Loss	_____ dB
	(-) _____		(-) _____
[F1] Maximum Acceptable Receive Level at [A1]	_____ dBm	[F2] Maximum Acceptable Receive Level at [A2]	_____ dBm
[Px] Reference Level	_____ dBm	[Px] Reference Level	_____ dBm
[J1] Maximum Link Loss	_____ dB	[J2] Maximum Link Loss	_____ dB
	(-) _____		(-) _____
[G1] Maximum Acceptable Receive Level at [C1]	_____ dBm	[G2] Maximum Acceptable Receive Level at [D2]	_____ dBm
[Py] Reference Level	_____ dBm	[Py] Reference Level	_____ dBm
[J2] Maximum Link Loss	_____ dB	[J1] Maximum Link Loss	_____ dB
	(-) _____		(-) _____
[H1] Maximum Acceptable Receive Level at [A1]	_____ dBm	[H2] Maximum Acceptable Receive Level at [A2]	_____ dBm



## Fast path work sheet: all link configurations

**Device 1**

Type \_\_\_\_\_

Serial \_\_\_\_\_

Port \_\_\_\_\_

Customer Name \_\_\_\_\_

Date \_\_\_\_\_

**Device 2**

Type \_\_\_\_\_

Serial \_\_\_\_\_

Port \_\_\_\_\_

[C1] - \_\_\_\_\_ dBm    [C2] - \_\_\_\_\_ dBm

[D1] - \_\_\_\_\_ dBm    [D2] - \_\_\_\_\_ dBm

---

[B1] Device 1 Transmit Level \_\_\_\_\_ dBm

[A1] Device 2 Receive Level \_\_\_\_\_ dB

[B2] Device 2 Transmit Level \_\_\_\_\_ dBm

[A2] Device 1 Receive Level \_\_\_\_\_ dB

(-) \_\_\_\_\_

Fiber 1 Link Loss \_\_\_\_\_ dBm

(-) \_\_\_\_\_

Fiber 2 Link Loss \_\_\_\_\_ dBm

*Table 8. Maximum link loss when using the device as a transmitter*

Fiber type	Maximum loss	Maximum length	Trunk size
Multi-mode (1300 nm)	8 dB	2.0 km (1.24 miles)	62.5 μm
Multi-mode (1300 nm)	8 dB	2.0 km (1.24 miles)	50.0 μm
Multi-mode (1300 nm)	8 dB	3.0 km (1.86 miles)	62.5 μm
multi-mode (850 nm)	8 dB	1.0 km (0.62 miles)	50.0 μm
Single-mode (1270 - 1340 nm)	14.0 dB	20 km (12.4 miles)	9 to 10 μm
Single-mode Coupling link (1270 - 1355 nm)	7.0 dB	3.0 km (1.86 miles)	9 to 10 μm
multi-mode (850 nm)	6.0 dB	550 meter (0.31 miles)	50 μm or 62.5 μm

## Multi-mode calculated link loss work sheet

### A. Calculating the multi-mode component mean loss

Connection loss multiplied by the number of connections in the link:

\_\_\_\_\_ - μm-to-\_\_\_\_\_ - μm \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB  
 connection:

### A. Calculating the multi-mode component mean loss

\_\_\_\_\_ - μm-to-\_\_\_\_\_ - μm connection: \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB

Splice loss multiplied by total number of splices in the link: \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB

Jumper cable loss multiplied by the combined length of the jumper cables: \_\_\_\_\_ dB/km x \_\_\_\_\_ km = \_\_\_\_\_ dB

Trunk loss per kilometer multiplied by the total trunk length (in km): \_\_\_\_\_ dB/km x \_\_\_\_\_ km = \_\_\_\_\_ dB

(+) \_\_\_\_\_

(For FDDI only, add 2.0 dB system loss to this value.)

**Total component mean loss** \_\_\_\_\_ dB

### B. Calculating the multi-mode component variance loss

Connection variance multiplied by the number of connections in the link:

\_\_\_\_\_ - μm-to-\_\_\_\_\_ - μm connection: \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>

\_\_\_\_\_ - μm-to-\_\_\_\_\_ - μm connection: \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>

Splice variance multiplied by total number of splices in the link: \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>

Jumper cable loss multiplied by the combined length of the jumper cables: \_\_\_\_\_ dB/km x \_\_\_\_\_ km = \_\_\_\_\_ dB<sup>2</sup>

(+) \_\_\_\_\_

(For FDDI only, add 0.04 dB<sup>2</sup> system loss to this value.)

**Total component variance loss** \_\_\_\_\_ dB<sup>2</sup>

### C. Calculating the total multi-mode link loss

Total component mean loss: \_\_\_\_\_ dB

Square root of total component variance loss multiplied by 3:  $\sqrt{\text{_____ dB}^2}$  = \_\_\_\_\_ dB x 3 = \_\_\_\_\_ dB

High order mode loss (ESCON only): \_\_\_\_\_ dB

50.0-μm trunk = 1.5 dB (+) \_\_\_\_\_

62.5-μm trunk = 1.0 dB

**Note:** Maximum allowable link loss for different type links is given in Table A-1 on page A-2. **Calculated link loss** \_\_\_\_\_ dB

## Single-mode calculated link loss work sheet

### A. Calculating the single-mode component mean loss

Connection loss multiplied by the number of connections in the link: \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB

### A. Calculating the single-mode component mean loss

Splice loss multiplied by total number of \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB  
 splices in the link:

Jumper cable loss multiplied by the \_\_\_\_\_ dB/km x \_\_\_\_\_ km = \_\_\_\_\_ dB  
 combined length of the jumper cables:

Trunk loss per kilometer multiplied by the \_\_\_\_\_ dB/km x \_\_\_\_\_ km = \_\_\_\_\_ dB  
 total trunk length (in km):

(+) \_\_\_\_\_

**Total component mean loss** \_\_\_\_\_ dB

### B. Calculating the single-mode component variance loss

Connection variance multiplied by the \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>  
 number of connections in the link:

Splice variance multiplied by total number of \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>  
 splices in the link:

(+) \_\_\_\_\_

**Total component variance loss** \_\_\_\_\_ dB<sup>2</sup>

### C. Calculating the total single-mode link loss

Total component mean loss: \_\_\_\_\_ = \_\_\_\_\_ dB

Square root of total component variance loss multiplied by 3:  $\sqrt{\text{_____} + 0.05 \text{ dB}^2}$  = \_\_\_\_\_ dB x 3 = \_\_\_\_\_ dB

Jumper assembly loss plus excess connector loss: \_\_\_\_\_ = 0.50 dB

(+) \_\_\_\_\_

**Calculated link loss** \_\_\_\_\_ dB

## Calculating the loss in a multi-mode link

This chapter describes how to calculate the maximum allowable loss for an fiber optic link that uses multi-mode components. It shows an example of a multi-mode ESCON link and includes a completed work sheet that uses values based on the link example. The same procedures may be used to calculate the link loss for a coupling link, ATM, FDDI, FICON, or GbE link. Note that the jumper and trunk losses for a multi-mode coupling link will be larger than for a multi-mode ESCON link of the same length. This is because all ESCON, ATM, FDDI, FICON, and GbE links operate at 1300 nm wavelength, while multi-mode coupling links operate at 780 nm, and the fiber loss is greater at 780 nm. Be sure to use the fiber loss corresponding to the proper wavelength for multi-mode links; refer to the ESCON and coupling link physical layer documents for more information.

Each link has a loss (attenuation) whose value depends on the loss induced by each cable, connector, and splice. This value, when calculated, cannot be greater than the maximum link loss (see [Table 4 on page 61](#)).

Use the following explanation and refer to the configuration example ([Figure 92 on page 98](#)) and the work sheet example ([Table 9 on page 98](#)). Although actual values should be used if possible, this example uses the typical loss values shown in [Table 5 on page 64](#).

## Completing a loss work sheet for a multi-mode link

Use Section A of the Link Loss Work Sheet to calculate the total component mean loss, Section B to calculate the component variance loss, and Section C to calculate the total link loss.

### Dispersion

Dispersion in an optical system is the spreading of information pulses over the fiber with distance. The maximum distance at which the incoming signal pulses are still separated well enough for correct detection is the point at which the link becomes dispersion limited. Fibers are available from vendors in different sizes and characteristics. Dispersion is not a factor for 62.5/125- $\mu\text{m}$  fiber with a modal bandwidth of 500 MHz $\cdot$ km for distances up to 2 km. Dispersion can become a consideration for other fiber sizes as distances approach the FDDI 2-km maximum. Most FDDI products have been designed to meet the FDDI maximum specification for 62.5/125- $\mu\text{m}$  fiber. For greater distances or for fiber that does not meet the FDDI specification, contact the device manufacturer.

Dispersion is not a limiting factor for ESCON, GbE, ATM, or FICON links.

### Link limitations

#### FDDI multi-mode link

The following link conditions should be met, on a FDDI link, when using the work sheets provided:

- If 50- $\mu\text{m}$  jumper cables are used in the design, all link segments of the design should use only 50- $\mu\text{m}$  fiber.
- A connection from 100- to 50- $\mu\text{m}$  fiber is not supported, because of excessive attenuation.
- A connection from 62.5- to either 50- or 100- $\mu\text{m}$  fiber and subsequently back to 62.5- $\mu\text{m}$  fiber should be made only once within the link.
- Splices should be made only to fibers with the same core diameters.

#### ESCON, GbE, ATM, or FICON link

An ESCON, GbE, ATM, or FICON link should use either single-mode or multi-mode fiber throughout and not convert from one fiber type to another. Although the ANSI FICON does not include the use of long wavelength (1300 nm) lasers in multi-mode fiber, IBM will support 50.0  $\mu\text{m}$  and 62.5  $\mu\text{m}$  multi-mode fiber as well as 4.0  $\mu\text{m}$  single-mode fiber as specified in Refer to the *Fiber Channel Connection (FICON I/O Interface Physical Layer, SA24-7172)*.

### Loss calculation

Each link has a specific calculated loss value that depends on the loss induced by each cable, connector, and splice. This calculated value combined with other parameters cannot be greater than the maximum link loss. Maximum link loss specifications are given in [Table 4 on page 61](#).

### Section A: Calculating the multi-mode component mean loss

The fiber cable manufacturer should provide either the component mean (average) loss or worst-case specification data. If the mean value is not available, use the worst-case specification data to complete Section A. If the manufacturer's data is not available, use the typical component loss values from [Table 5 on page 64](#).

**Connections:** Multiply the average connection loss value by the total number of connections in the link. Connections to coupling link-capable, FICON-capable, or ESCON-capable devices are included in the device specification and should **not** be included in the connection calculation.

**Note:** A link consisting of one IBM duplex-to-duplex jumper cable is considered to have no connections when calculating the link loss.

**Splice Loss:** Multiply the splice loss value by the total number of link splices. If the link has both mechanical and fusion splices, calculate the losses separately, then enter the total on the work sheet.

**Jumper Cable Loss:** Multiply the combined length of the jumper cables in kilometers by the jumper cable loss per kilometer.

**Trunk Cable Loss:** Multiply the total length of the trunk cable in kilometers by the cable loss per kilometer.

## Section B: Calculating the multi-mode component variance loss

The fiber cable manufacturer should provide the values used to determine variance loss. This loss, attributable to manufacturing tolerances or installation methods (or both), is induced by connections and splices.

- If the manufacturer's data is not available, use the typical component loss values from [Table 5 on page 64](#).
- If the manufacturer has provided only worst-case specification data, it includes the variance loss. Enter a value of zero on the work sheet for the Total Component Variance Loss.
- If the manufacturer provides a standard deviation ( $\sigma$ ) value, use the square of this value to determine the component variance loss. For example, if  $\sigma$  equals 0.24, then enter a value of 0.06 (0.24 squared) on the worksheet for the Total Component Variance Loss.

**Connections:** Multiply the connection variance value by the total number of connections in the link. Connections to ESCON-capable devices are included in the device specification and **should not** be included in the connection calculation.

**Splice Variance:** Multiply the splice variance value by the total number of splices in the link.

- For FDDI links only, include the system variance of 0.04 dB<sup>2</sup>.

## Section C: Calculating the total multi-mode link loss

The total calculated link loss includes the following values:

- All calculated component mean losses.
- Three times the square root of the sum of the calculated component variances.
- The higher-order mode loss. This loss, induced by the connectors and the first few hundred meters of each link, is assigned a constant value, depending on the trunk fiber size. This loss should only be included for an ESCON link.
  - For 50.0- $\mu$ m trunk fiber, use 1.5 dB.
  - For 62.5- $\mu$ m trunk fiber, use 1.0 dB.
- The FDDI system loss, for FDDI links only; this value is 2.0 dB and includes extinction ratio penalty, higher order mode losses and retiming penalty for an FDDI link.

## Loss calculation example for a multi-mode ESCON link

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Figure 92 on page 98 shows a link example consisting of:

- Jumper Cable 1 (IBM duplex-to-duplex, multi-mode, 13 meters).
- Jumper Cable 2 (IBM duplex-to-duplex, multi-mode, 77 meters)  
(combined jumper cable length = 90 meters or 0.09 km).
- 1.5 km of 50- $\mu$ m trunk cable (bandwidth = 800 MHz•km).
- One 62.5- $\mu$ m-to-50.0- $\mu$ m physical-contact connection (in each fiber).
- One 50.0- $\mu$ m-to-62.5- $\mu$ m physical-contact connection (in each fiber).
- Six 50- $\mu$ m mechanical splices (in each fiber).
- Trunk cable connectors are ST (physical contact).

**Note:** The example of a completed Calculated Link Loss Work Sheet (Table 9 on page 98) uses Table 5 on page 64, which lists typical values for currently used components. Use Table 5 on page 64 **only** if the manufacturer's specifications are not available.

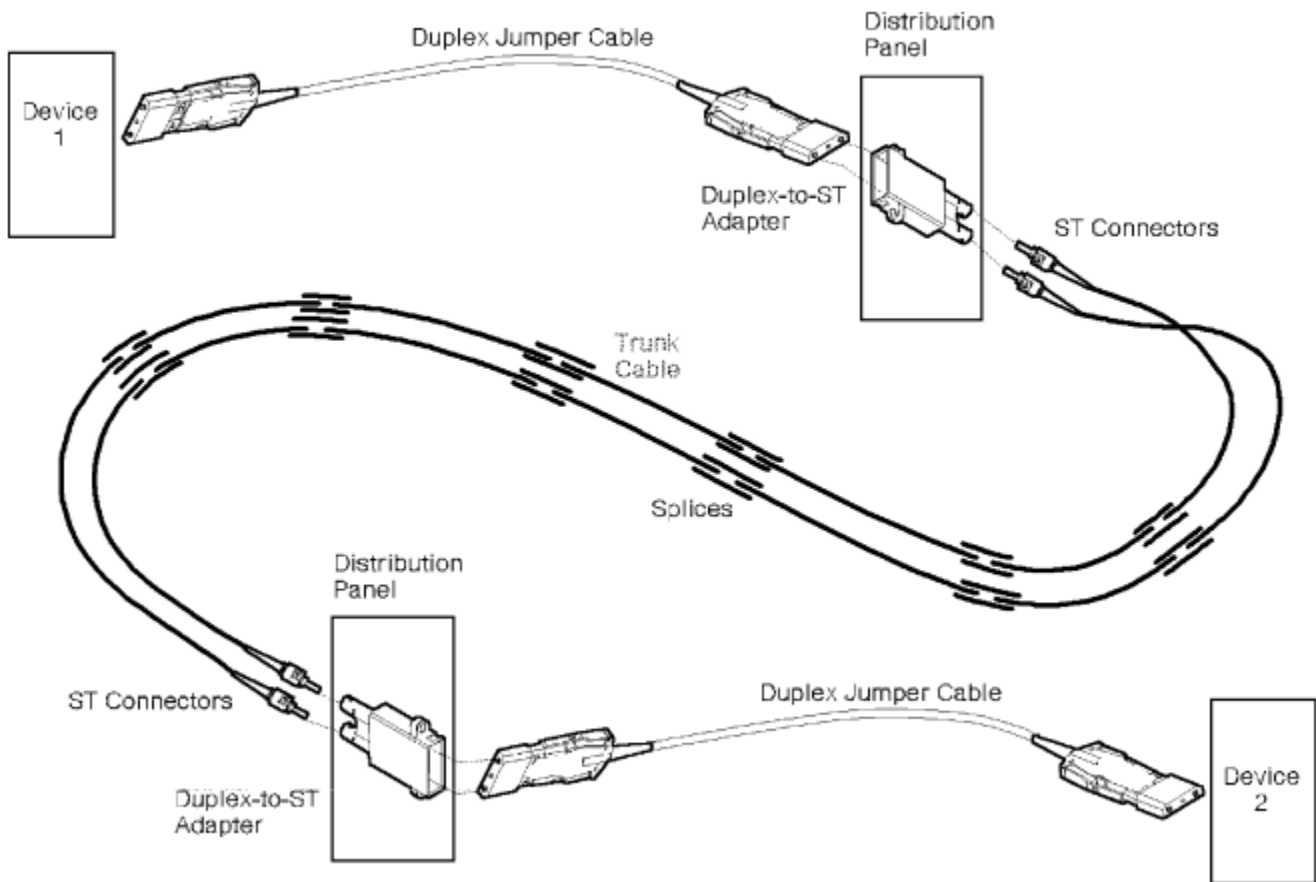


Figure 92. Example of a multi-mode ESCON link

Table 9. Example of a completed calculated link loss work sheet for a multi-mode link. This example was completed for an ESCON link.

**A. Calculating the multi-mode component mean loss**

Connection loss multiplied by the number of connections in the link:

62.5 - μm-to- 50.0 - μm connection: 2.10 dB x 1 = 2.10 dB

50.0 - μm-to- 62.5 - μm connection: 0 dB x 1 = 0 dB

\_\_\_\_\_ - μm-to- \_\_\_\_\_ - μm connection: \_\_\_\_\_ dB x \_\_\_\_\_ = \_\_\_\_\_ dB

Splice loss multiplied by total number of splices in the link: 0.15 dB x 6 = 0.90 dB

Jumper cable loss multiplied by the combined length of the jumper cables: 1.75 dB/km x 0.09 km = 0.16 dB

Trunk loss per kilometer multiplied by the total trunk length (in km): 0.90 dB/km x 1.5 km = 1.35 dB

Table 9. Example of a completed calculated link loss work sheet for a multi-mode link. This example was completed for an ESCON link. (continued)

**A. Calculating the multi-mode component mean loss**

(For FDDI only, add 2.0 dB system loss to this value.)	Total component mean loss	(+)	_____
			__4.51__ dB

**B. Calculating the multi-mode component variance loss**

Connection variance multiplied by the number of connections in the link:

__62.5__ - μm-to-__50.0__ - μm	__0.12__ dB <sup>2</sup>	x	__1__	=	__0.12__ dB <sup>2</sup>
__50.0__ - μm-to-__62.5__ - μm	__0.01__ dB <sup>2</sup>	x	__1__	=	__0.01__ dB <sup>2</sup>
connection:					
_____ - μm-to-_____ - μm	_____ dB <sup>2</sup>	x	_____	=	_____ dB <sup>2</sup>
Splice variance multiplied by total number of splices in the link:	__0.01__ dB <sup>2</sup>	x	__6__	=	__0.06__ dB <sup>2</sup>

(For FDDI only, add 0.04 dB <sup>2</sup> system loss to this value.)	Total component variance loss	(+)	_____
			__0.19__ dB <sup>2</sup>

**C. Calculating the total multi-mode link loss**

Total component mean loss: = \_\_4.51\_\_ dB

Square root of total component variance loss multiplied by 3:  $\sqrt{0.19 \text{ dB}^2}$  = \_\_0.44\_\_ dB x 3 = \_\_1.32\_\_ dB

High order mode loss (ESCON only): = \_\_1.5\_\_ dB

50.0-μm trunk = 1.5 dB

62.5-μm trunk = 1.0 dB

**Note:** Maximum allowable link loss for different type links is given in Table A-1 on page A-2. **Calculated link loss** \_\_7.3\_\_ dB

**Loss calculation for an FDDI multi-mode link**

Figure 93 on page 100 shows a link example consisting of:

- Jumper Cable 1: IBM FDDI-to-IBM FDDI, physical contact, 62.5 μm, 12 m.
- Jumper Cable 2: ST-to-ST, physical contact, 62.5 μm, 12 m.
- Jumper Cable 3: IBM FDDI-to-IBM FDDI, physical contact, 62.5 μm, 12 m.
- 2.0 km of 62.5-μm trunk cable
  - The first trunk segment is 100 m.
  - The second trunk segment is 1.9 km.
- Seven 62.5 μm mechanical splices
  - Two splices are included to allow for possible future repair.
  - Five splices are already in the fiber.

- Trunk cable connectors are ST (physical contact).

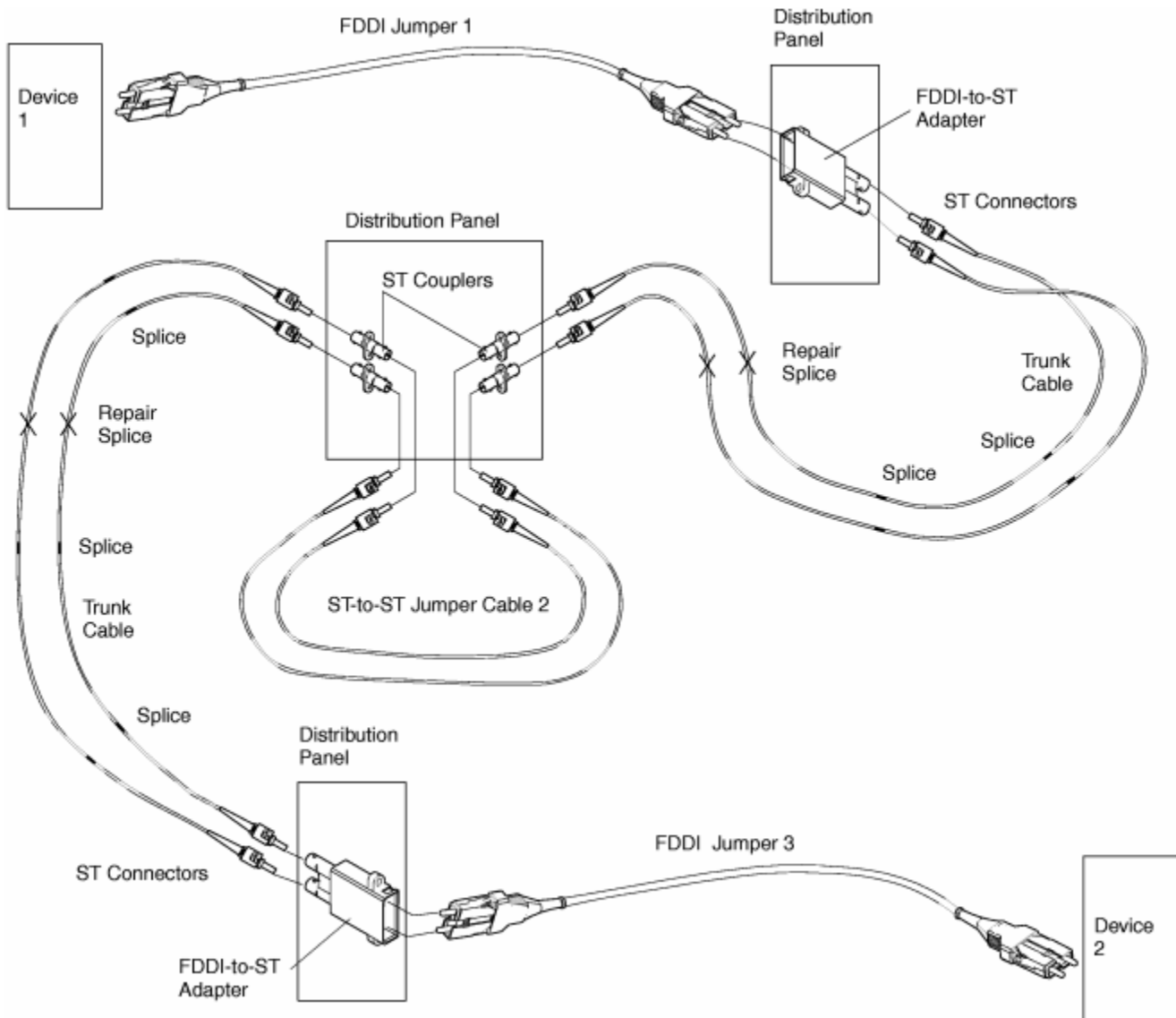


Figure 93. Typical FDDI link and components

**Note:** The example of a completed Calculated Link Loss Work Sheet (Table 10 on page 100) uses Table 5 on page 64, which lists typical values for currently used components.

Table 10. Example of a completed calculated link loss work sheet for an FDDI link

### A. Calculating the multi-mode component mean loss

Connection loss multiplied by the number of connections in the link:

$$\underline{62.5} \text{ } \mu\text{m-to-} \underline{62.5} \text{ } \mu\text{m} \text{ connection: } \underline{0.4} \text{ dB} \times \underline{4} = \underline{1.6} \text{ dB}$$

$$\text{ } \mu\text{m-to-} \text{ } \mu\text{m} \text{ connection: } \text{ } \text{ dB} \times \text{ } = \text{ } \text{ dB}$$

$$\text{Splice loss multiplied by total number of splices in the link: } \underline{0.15} \text{ dB} \times \underline{7} = \underline{1.05} \text{ dB}$$



Table 10. Example of a completed calculated link loss work sheet for an FDDI link (continued)

**A. Calculating the multi-mode component mean loss**

Jumper cable loss multiplied by the combined length of the jumper cables:  $\underline{1.75}$  dB/km x  $\underline{0.036}$  km =  $\underline{0.06}$  dB

Trunk loss per kilometer multiplied by the total trunk length (in km):  $\underline{1.0}$  dB/km x  $\underline{2.0}$  km =  $\underline{2.0}$  dB

(+) \_\_\_\_\_

(For FDDI only, add 2.0 dB system loss to this value.)

**Total component mean loss**  $\underline{4.71}$  dB

**B. Calculating the multi-mode component variance loss**

Connection variance multiplied by the number of connections in the link:

$\underline{62.5}$  -  $\mu$ m-to- $\underline{50.0}$  -  $\mu$ m  $\underline{0.02}$  dB<sup>2</sup> x  $\underline{4}$  =  $\underline{0.08}$  dB<sup>2</sup>

\_\_\_\_\_ -  $\mu$ m-to-\_\_\_\_\_ -  $\mu$ m connection: \_\_\_\_\_ dB<sup>2</sup> x \_\_\_\_\_ = \_\_\_\_\_ dB<sup>2</sup>

Splice variance multiplied by total number of splices in the link:  $\underline{0.01}$  dB<sup>2</sup> x  $\underline{7}$  =  $\underline{0.07}$  dB<sup>2</sup>

(+) \_\_\_\_\_

(For FDDI only, add 0.04 dB<sup>2</sup> system loss to this value.)

**Total component variance loss**  $\underline{0.15}$  dB<sup>2</sup>

**C. Calculating the total FDDI multi-mode link loss**

System loss (2.0 dB): = 2.0 dB<sup>2</sup>

Total component mean loss: =  $\underline{4.71}$  dB

Square root of total component variance loss plus system variance loss (0.04 dB) multiplied by 3:  $\sqrt{0.15+0.04}$  dB<sup>2</sup> =  $\underline{0.436}$  dB x 3 =  $\underline{1.31}$  dB

(+) \_\_\_\_\_

**Note:** Maximum allowable link loss for different type links is given in Table A-1 on page A-2. **Calculated link loss**  $\underline{8.02}$  dB

**Calculating the loss in a single-mode link**

This chapter describes how to calculate the maximum allowable loss for an ESCON link that uses single-mode components. It shows an example of a single-mode ESCON link and includes a completed work sheet that uses values based on the link example. The same procedure can be used to calculate the loss for a single-mode coupling link.

Each link has a loss (attenuation) whose value depends on the loss induced by each cable, connector, and splice. This value, when calculated, cannot be greater than the maximum link loss (see Table 4 on page 61).

Use the following explanation and refer to the configuration example (Table 10 on page 100) and the work sheet example (Table 11 on page 104). Although actual values should be used if possible, this example uses the typical loss values shown in Table 5 on page 64.

## Completing a loss work sheet for a single-mode link

Use Section A of the Link Loss Work Sheet to calculate the total component mean loss, Section B to calculate the component variance loss, and Section C to calculate the total link loss.

### Section A: Calculating the single-mode component mean loss

The fiber cable manufacturer should provide either the component mean (average) loss or worst-case specification data. If the mean value is not available, use the worst-case specification data to complete Section A. If the manufacturer's data is not available, use the typical component loss values from [Table 5 on page 64](#).

**Connections:** Multiply the average connection loss value by the total number of connections in the link. Connections to coupling link-capable or ESCON-capable devices are included in the device specification and **should not** be included in the connection calculation.

#### Notes:

1. A link consisting of one IBM duplex-to-duplex jumper cable is considered to have no connections when calculating the link loss.
2. The ESCON XDF Adapter kit does **not** add connection loss to the link.

**Splice Loss:** Multiply the splice loss value by the total number of link splices. If the link has both mechanical and fusion splices, calculate the losses separately, then enter the total on the work sheet.

**Note:** Because a single-mode link can be up to 20 kilometers (12.4 miles) and fiber cable is available in reels of from 1 to 7 kilometers (0.62 to 4.35 miles), single-mode trunk cable could require "reel-to-reel" splicing. If this loss is included in the trunk cable loss, **do not** include it in the splice loss calculation. If not certain about whether to include this value, contact your marketing representative.

**Jumper Cable Loss:** Multiply the combined length of the jumper cables in kilometers by the jumper cable loss per kilometer.

**Trunk Cable Loss:** Multiply the total length of the trunk cable in kilometers by the cable loss per kilometer.

### Section B: Calculating the single-mode component variance loss

The fiber cable manufacturer should provide the values used to determine variance loss. This loss, attributable to manufacturing tolerances or installation methods (or both), is induced by connections and splices.

- If the manufacturer's data is not available, use the typical component variance loss values from [Table 5 on page 64](#).
- If the manufacturer has provided only worst-case specification data, it includes the variance loss. Enter a value of zero on the work sheet for the Total Component Variance Loss.
- If the manufacturer provides a standard deviation ( $\sigma$ ) value, use the square of this value to determine the component variance loss. For example, if  $\sigma$  equals 0.24, then enter a value of 0.06 (0.24 squared) on the worksheet for the Total Component Variance Loss.

**Connections:** Multiply the connection variance value by the total number of connections in the link. Connections to coupling link-capable or ESCON-capable devices are included in the device specification and **should not** be included in the connection calculation.

**Note:** The ESCON XDF Adapter kit does **not** add connection loss to the link.

**Splice Variance:** Multiply the splice variance value by the total number of splices in the link.

### Section C: Calculating the total single-mode link loss

The total calculated link loss includes the following values:

- All calculated component mean losses.

- Three times the square root of the sum of the calculated component variances plus the jumper assembly variance loss (0.05 dB)
- The jumper assembly loss and the excess connector loss. For a 9- $\mu$ m trunk cable, these values are:
  - Jumper assembly loss = 0.3 dB
  - Excess connector loss = 0.2 dB.

### Loss calculation example for a single-mode link

Figure 94 on page 103 shows a link example consisting of:

- Jumper Cable 1 (IBM duplex-to-duplex, single-mode, 92 meters).
- Jumper Cable 2 (IBM duplex-to-duplex, single-mode, 122 meters) (combined jumper cable length = 214 meters or 0.21 km).
- 19.76 km of 9- $\mu$ m trunk cable.
- Two physical-contact ST connections (in each fiber).
- Two mechanical splices (in each fiber).

**Note:** The example of a completed Calculated Link Loss Work Sheet (Table 11 on page 104) uses Table 5 on page 64, which lists typical values for currently used components. Use Table 5 on page 64 **only** if the manufacturer's specifications are not available.

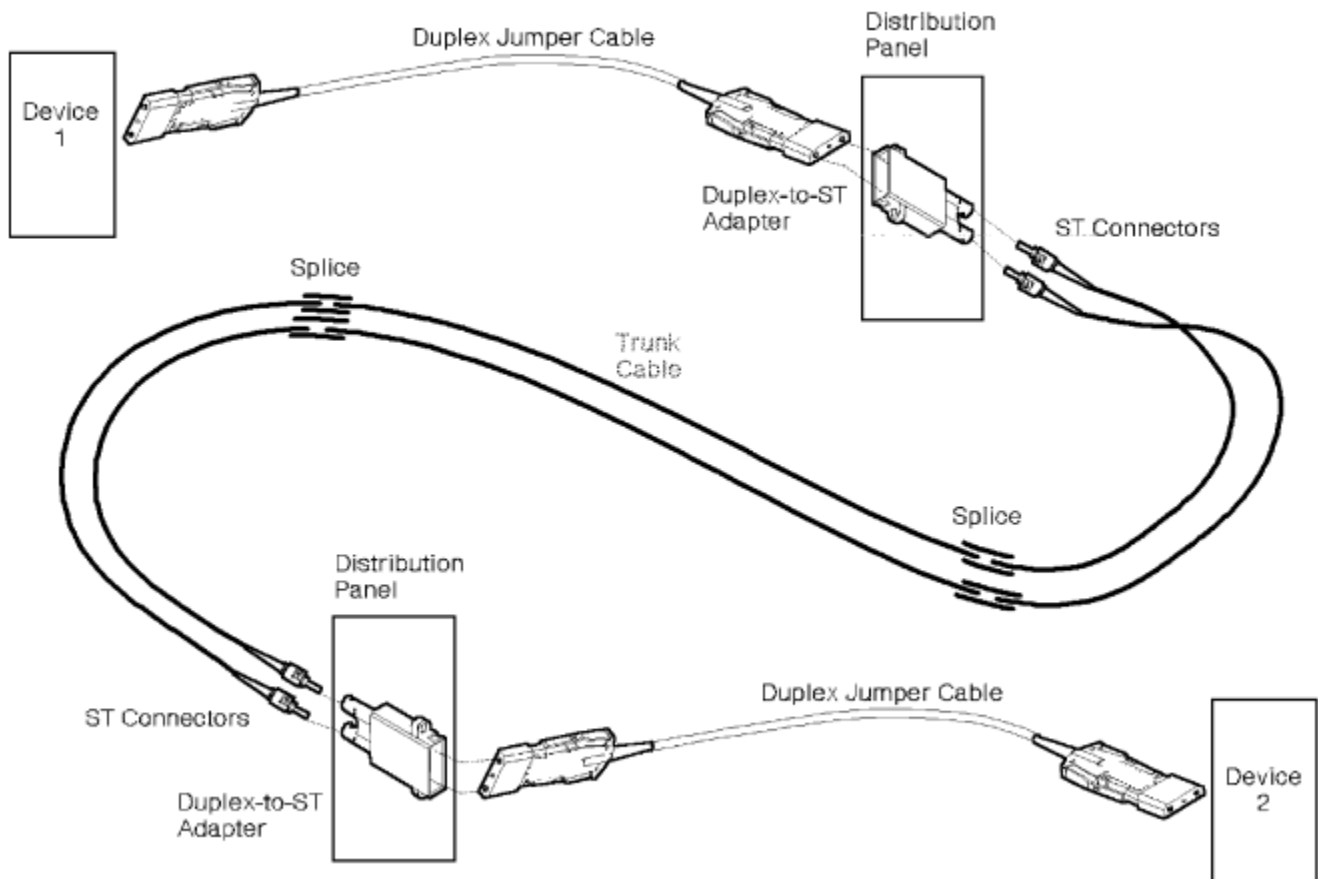


Figure 94. Example of a single-mode ESCON link

Table 11. Example of a completed calculated link loss work sheet for a single-mode link. This example was completed for an ESCON link.

**A. Calculating the single-mode component mean loss**

Connection loss multiplied by the number of connections in the link:	<u>0.35</u> dB	x	<u>2</u>	=	<u>0.706</u> dB
Splice loss multiplied by total number of splices in the link:	<u>0.15</u> dB	x	<u>2</u>	=	<u>0.30</u> dB
Jumper cable loss multiplied by the combined length of the jumper cables:	<u>0.8</u> dB/km	x	<u>0.21</u> km	=	<u>0.17</u> dB
Trunk loss per kilometer multiplied by the total trunk length (in km):	<u>0.5</u> dB/km	x	<u>19.76</u> km	=	<u>9.88</u> dB
				(+)	_____
				<b>Total component mean loss</b>	<u>11.05</u> dB

**B. Calculating the single-mode component variance loss**

Connection variance multiplied by the number of connections in the link:	<u>0.06</u>	x	<u>2</u>	=	<u>0.12</u> dB <sup>2</sup>
Splice variance multiplied by total number of splices in the link:	<u>0.01</u> dB <sup>2</sup>	x	<u>2</u>	=	<u>0.02</u> dB <sup>2</sup>
				(+)	_____
				<b>Total component variance loss</b>	<u>0.14</u> dB <sup>2</sup>

**C. Calculating the total single-mode link loss**

Total component mean loss:		=	<u>11.05</u> dB
Square root of total component variance loss plus system variance loss (0.04 dB) multiplied by 3:	$\sqrt{0.14 + 0.05 \text{ dB}^2}$	=	<u>0.436</u> dB x 3 = <u>1.31</u> dB
Jumper assembly loss plus excess connector loss:		=	0.50 dB
		(+)	_____
		<b>Calculated link loss</b>	<u>12.86</u> dB

---

# Appendix F. Fiber optic cleaning procedures

## Introduction

---

With increasing speeds of optical connections, the cleanliness of the connections assumes greater importance in ensuring maximum performance and error free transmission. Due to the tighter tolerances associated with state of the art optics, levels of contamination that were acceptable at lower speeds may not be at higher speeds. Most issues can be avoided by adhering to the following best practices

- When cables or connectors are not in use, use "clean" dust covers provided.
- Ensure that the cable length and type used is suitable for the speed and application.
- Clean optical connections and fiber prior to connection or reconnection.
- Ensure cables are properly seated within the connector.

Kits are commercially available for cleaning and inspecting these connections. IBM also offers services that will ensure optimal condition of the network.

Fiber optic server interfaces include:

- Enterprise Systems Connection (ESCON)
- Fibre Connection (FICON)
- IntraSystem Coupling (ISC)
- OSA - Express (Gbe) Gigabit Ethernet
- External Time Reference (ETR)
- Host Channel Adapter LR 1x (HCA-O LR)
- Host Channel Adapter SR 12x (HCA-O SR)
- RoCE
- Integrated Coupling Adapter (ICA 24x)
- zHyperLink Express

Each requires connectivity planning for different fiber types and new fiber optic connectors. Similarly, connectivity requirements for every I/O device must be known because their connectors may not be the same as the connectors on a server, director, or switch. Fiber optic technology is evolving rapidly with new standards, small form factor connectors, and enhanced fiber types. IBM offers a full range of services for optical cabling.

Although there are a multitude of fiber optic connectors, the components of those connectors are virtually the same: the ferrule (male), the end-surface, and the coupler (female). This publication contains the cleaning procedures for those fiber optic components.

### **Terms associated with Fiber Optic cabling include:**

1. Long wavelength laser (LX)
2. Short wavelength laser (SX)
3. Single Mode (SM)
4. Multimode (MM)
5. Mode Conditioning Patch cabling (MCP)
6. Fiber Optic SubAssembly (FOSA)
7. Fibre Channel Standard (FCS)
8. Multi-Fiber Push-on (MPO)

9. Transmitter Receiver Shell (TRS)
10. Small Form Factor (SFF)
11. Small Form Pluggable (SFP)
12. Process Plug / Dust Cover
13. Dust Cap

## Precautions

---

Please use the following precautions when handling fiber optic equipment:

- Make sure the cable cutouts in the floor tiles have the appropriate protective edging.
- Route the cables away from any sharp edges or projections that could cut the outer jacket.
- Do not route the cables near unprotected steam or refrigeration lines.
- Do not coil the cable to less than a 96.0 mm (3.78 in.) diameter.
- Do not bend the cable to less than a 50.8 mm (2.0 in.) radius.
- Do not pull cables into position; place them.
- Do not grasp the cable with pliers.
- Do not attach a pull rope or wire to the connectors.
- **Always clean the connectors before installing, attaching, or replugging them to reduce link loss.**
- **Do not remove the protective plugs or protective covers until you are ready to clean the connectors and attach the cables to a device.**
- **Always leave the protective plugs and protective covers on unused ports and cable connectors.**
- Connect the cable carefully to prevent damage to the connector housing or the fiber optic ferrules.
- Before inserting the connector, make sure the connector and receptacle keying are aligned.

## Materials required

---

The following fiber optic cleaning materials are available through the IBM Tools Catalog <http://pokgsa.ibm.com/~tstesc/public/>, or are part of the ship group.

### Item

#### IBM part number

#### Alcohol pads

59P4739

#### Cleaning kit

45P5948

#### LC Port Cleaning Tool

54Y4392

#### MPT/MPO Fiber Optic Trunk Connector Cleaner

43W3044

#### Air Pump (Ship Group)

45D2645

#### Fiber Optic Cleaning Wipes

45P5945

#### Fiber Scope

00P7031 or equivalent

**Note:** Included in the Cleaning Kit are 18 lint free cloths, 10 Microswabs, and 10 foam swabs.

## General cleaning procedures

---

Before performing any of the following procedures, read the statements in “Safety” on page vii.

- End-faces on fiber optic connectors must be free of dust and other debris which could interfere with signal quality.
- To facilitate cleaning, refer to “Materials Required” for the tool recommended for the application.
- Compressed gas (ref CO2), filtered dry air or Air pump 45D2645 may be used to remove dust. Compressed air is not recommended due to possible oil contamination.

**Note:** If air is used, keep the air nozzle approximately 50 millimeters (2 inches) from the component and continue blowing into the component for 5 seconds.

- Dust caps applied over the connector end-face should always be used on unplugged connectors.
- The ONLY acceptable solution for cleaning dust covers is isopropyl alcohol. Do NOT use water for cleaning.

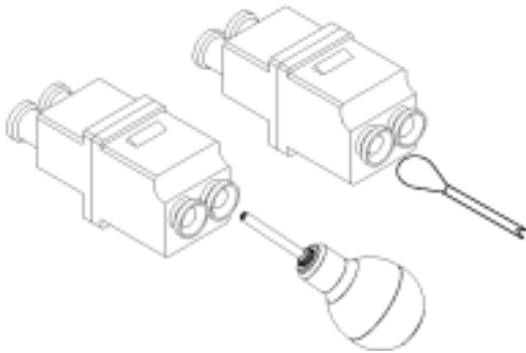
## Couplers

---

This procedure is used to clean any duplex coupler.

- Blow out any debris using Air Pump 45D2645
- Clean the inside of the coupler with a swab saturated with isopropyl alcohol. Swabs can be found in Cleaning Kit PN 46G6844, alcohol pads PN 59P4739

**Note:** Always check the area you have just cleaned to be sure it is free of lint or cotton fuzz.

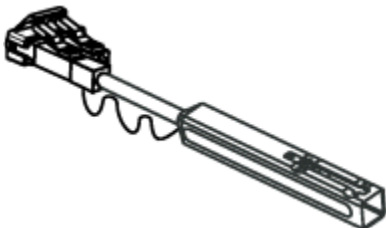


## Wrap plug

---

For LC wrap plugs:

1. The port cleaning tool (54Y4392) comes with an adapter for cleaning LC connectors. Follow the instructions included with the tool.



For non-LC wrap plugs:

1. Place a clean cloth (from Cleaning kit 46G6844) on a flat surface

2. Hold the wrap plug against the cloth at a 90% angle
3. Slide the end face of the wrap plug against the cloth. Approx one centimeter.
4. Install dust caps on wrap plug after usage

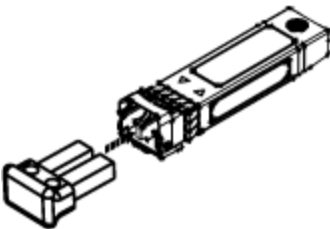


## Protective plug

---

This procedure is used to clean any protective plug. Before performing this procedure, complete the appropriate procedure for cleaning the coupler or SFP into which the protective plug will be inserted.

1. Gently wipe each arm of the protective plug at least 5 times with an alcohol pad using a pinch and twist motion.
2. Wait 5 seconds for the alcohol to dry
3. Immediately insert the protective plug into the SFP assembly.



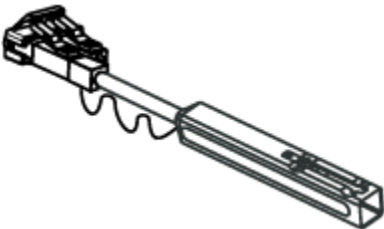
## Fiber optic cable connector cleaning procedure

---

Use this general procedure to clean any fiber optic cable connector. Repeat these steps as necessary.

For LC cables:

1. The port cleaning tool (54Y4392) comes with an adapter for cleaning LC cable connectors (end face). Follow the instructions included with the tool.



For non-LC cables:

1. Place a clean cloth (from Cleaning kit 46G6844) on a flat surface
2. Hold the connector against the cloth at a 90% angle
3. Slide the end face of the connector against the cloth. Approx one centimeter.
4. Immediately plug the cleaned cable connector, or install dust caps if not used.

**Duplex connector:**



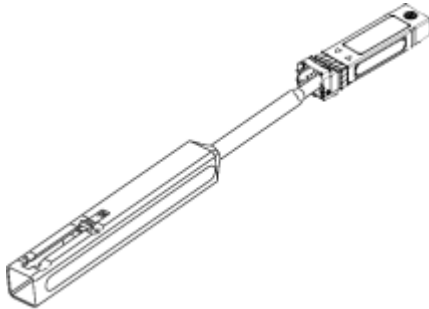


## Small form pluggable (SFP) transceiver

Use this general procedure to clean fiber optic SFP transceivers..

**Note:** The optical ports of a transceiver should be cleaned when contamination is suspected due to reduced optical performance or when non-approved practices have been observed (I.e. Plugging a wrap or cable that has not been cleaned first).

1. Clean the inside of the optical port with an LC Port Cleaning Tool: 54Y4392. Two "clicks" of this tool in both ports has been shown effective at cleaning most types of debris.



**Note:** Always check the area you have just cleaned to be sure it is free of lint or cotton fuzz.

## MPO Transceiver

**Note:** The optical ports of a MPO transceiver should be cleaned when contamination is suspected due to reduced optical performance or when non-approved practices have been observed (ie. Plugging a wrap or cable that has not been cleaned first). This transceiver provides a parallel, multi-mode communication path on Host Channel Adapters.

1. Remove cable from transceiver
2. Blow air over the transceivers using Air Pump 45D2645
3. Clean MPO connector (refer to Fiber Optic Cable Connector Cleaning Procedure)
4. Re-plug cable and re-test

## Common connectors

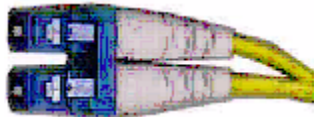
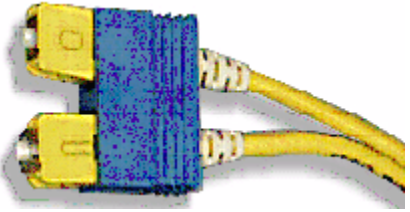




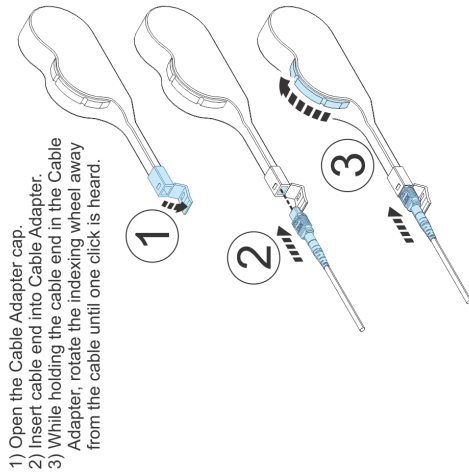
<i>Table 12. common connectors</i>	
Description	Connector
LC Duplex used for FICON Express® LX, FICON Express SX, and ISC-3	

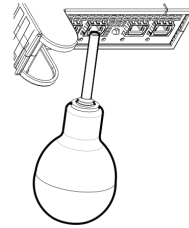
Table 12. common connectors (continued)

Description	Connector
SC Duplex used for OSA Express ATM SM, OSA Express ATM MM, FDDI, OSA Express Gigabit LX and OSA Express Gigabit SX	
ESCON Duplex used for both ESCON and ETR	
MTRJ (Multimode)	
SCDC (Single mode and multimode)	
MTP Connector used for high density fiber optic cabling on IBM eServer™ systems, storage systems, switches, and directors	

## Cleaning Procedure for MPO cables and Transceivers



- 1) Open the Cable Adapter cap.
- 2) Insert cable end into Cable Adapter.
- 3) While holding the cable end in the Cable Adapter, rotate the indexing wheel away from the cable until one click is heard.



Use Air Bulb to blow dust out of the port.

Optional: Clean Dry Air

Note: Clean Dry Air (CDA) is free of dust, water, and oil. Large laboratory facilities often have filter/compressor combinations for this purpose.

## References:

- Maintenance Information for Fiber Optic Links:**  
(SY27-7694-00)  
<https://www.304.ibm.com/servers/resourceLink/svc03100.nsf?OpenDatabase>
- IBM Tools Catalog:**  
<http://pokgsa.ibm.com/~tstesc/public/>
- Link to SSR material:**  
[http://pokgsa.ibm.com/home/r/o/rosowers/web/public/system\\_z/index.html](http://pokgsa.ibm.com/home/r/o/rosowers/web/public/system_z/index.html)

## Tools:

43W3044	MPT/MPO Fiber Optic Trunk Connector Cleaner (Tool Catalog)
54Y4392	1.25mm Fiber Cleaner (Tool Catalog)
45P5945	Fiber Optic Cleaning Wipes (Tool Catalog)
45P5948	Fiber Cleaning Kit (Tool Catalog)
45D2645	Air Pump (Ship Group)
00P7031	Fiber microscope (Tool Catalog) or equivalent

## Best Practices:

- Always clean the connectors before installing, attaching or plugging them to reduce Link Loss
- Do not remove the protective plugs/covers until you are ready to clean the connectors and attach the cable to the device.
- Always leave the protective plugs/covers on unused ports and cable connectors

## Interesting Facts:

- The core diameter of single mode fiber is 9 microns or about the size of pollen or dust.
- Smallest size of an object recognizable to the naked eye is ~55-75 microns.

## Remember!

- Use dust covers on cables and transceivers
- Do not touch the end of fiber optic cables

## Definitions:

- SFP: Small Form Pluggable
- MPO: Multi-fiber Push On

# Fiber Optic Connection Care





## Preventive Maintenance of Fiber Optic Cables and Optics Modules

The end of a fiber optic cable and the inner surface of an optical module lens are surfaces that should be properly cleaned and maintained to ensure optimum reliability and system performance.

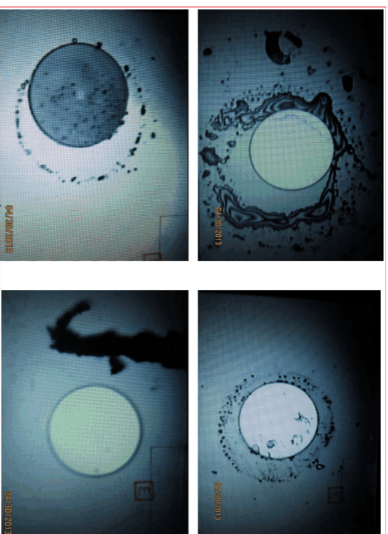
Contaminated cable connectors often transfer contaminants and particulates into the optical module into which they are inserted.

Dust covers prevent contamination and should be used whenever a cable is not connected. It is therefore important to have a source of clean dust covers for cables and optical transceivers.

**In industry studies the #1 cause of link failure is a contaminated or dirty connector or fiber.**

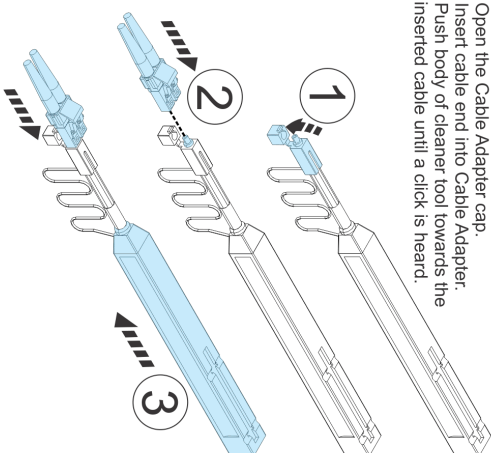
Examples of transceiver contamination due to poor cable handling procedures.

Oils from skin and fibers from clothing are common contaminants.

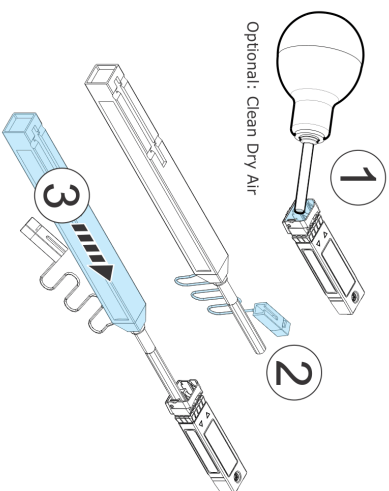


## Cleaning Procedure for LC cables and Optical SFPs

- 1) Open the Cable Adapter cap.
- 2) Insert cable end into Cable Adapter.
- 3) Push body of cleaner tool towards the inserted cable until a click is heard.



- 1) Use the Air Pump to blow debris out of the target port.
- 2) Remove the Cable Adapter from the LC Cleaner.
- 3) Insert the LC Cleaner into the port to be cleaned then push the LC Cleaner body towards the port until a single click is heard.



Optional: Clean Dry Air

---

## Appendix G. Notices

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

Properly shielded and grounded cables and connectors must be used in order to meet FCC emission limits. IBM is not responsible for any radio or television interference caused by using other than recommended cables and connectors or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

This 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.

### **Industry Canada Compliance Statement**

This Class A digital apparatus complies with Canadian ICES-003.

### **Avis de conformité à la réglementation d'Industrie Canada**

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European Community contact:  
IBM Deutschland GmbH  
Technical Regulations, Department M372  
IBM-Allee 1, 71139 Ehningen, Germany  
Tele: +49 (0) 800 225 5423 or +49 (0) 180 331 3233  
email: [halloibm@de.ibm.com](mailto:halloibm@de.ibm.com)

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(一社) 電子情報技術産業協会 高調波電流抑制対策実施  
要領に基づく定格入力電力値： Knowledge Centerの各製品の  
仕様ページ参照

For products less than or equal to 20 A per phase, the following statement applies:

高調波電流規格 JIS C 61000-3-2 適合品

For products greater than 20 A, single-phase, the following statements apply:

高調波電流規格 JIS C 61000-3-2 準用品

本装置は、「高圧又は特別高圧で受電する需要家の高調波抑制対策ガイドライン」対象機器（高調波発生機器）です。

回路分類：6（単相、PFC回路付）

換算係数：0

For products greater than 20 A per phase, three-phase, the following statements apply:

高調波電流規格 JIS C 61000-3-2 準用品

本装置は、「高圧又は特別高圧で受電する需要家の高調波抑制対策ガイドライン」対象機器（高調波発生機器）です。

回路分類：5（3相、PFC回路付）

換算係数：0

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在这种情况下, 可能需要用户对其  
干扰采取切实可行的措施。

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電話：0800-016-888

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New Orchard Road  
Armonk, New York 10504  
Tel: 914-499-1900

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Generelle Informationen:

**Das Gerät erfüllt die Schutzanforderungen nach EN 55024 und EN 55032 Klasse A.**

#### **Electromagnetic Interference (EMI) Statement - Russia**

**ВНИМАНИЕ! Настоящее изделие относится к классу А.  
В жилых помещениях оно может создавать радиопомехи, для  
снижения которых необходимы дополнительные меры**



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