Cabletron Systems
Cabling Guide

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Chapter 1

Introduction

Using This Guide

The **Cabletron Systems Cabling Guide** is intended to provide much of the information necessary to allow Network Managers to plan facility network cabling and to ensure that the cabling is usable by the networking devices that will populate the cabling.

This Cabling Guide also provides instructions that may be helpful for connecting Cabletron Systems networking devices to an existing facility cabling infrastructure.

Document Organization

This guide begins with an overview of the important aspects of cabling and cables. The information presented in the initial sections is essential to a complete understanding of the material that is presented in later sections. Following the introductory material, detailed examinations of the standard media and connectors used for Ethernet, Token Ring, and Fiber Distributed Data Interface (FDDI) networks are presented. The closing sections of the document describe some common installation and cable management devices, and explain some methods for testing cables and planning installations.

The remainder of this guide contains charts and tables which supply much of the information that the cable system planning process requires, and an extensive glossary of the terms used within this guide and other Cabletron Systems publications.

The following summarizes the organization of this manual:

Chapter 1, **Introduction**, discusses the use and contents of this guide.

Chapter 2, **Cabling Terms**, defines and explains some of the terminology used throughout this document to describe aspects and components of cabling and installation planning.

Chapter 3, **Relevant Specifications**, details some relevant specifications and standards that apply to the installation of facility network cabling.

Chapter 4, **Ethernet Media**, identifies and discusses several networking cables and their characteristics when used in Ethernet and Fast Ethernet networking environments. The chapter examines the physical characteristics and requirements of both physical cabling and the connectors and ports used with the cabling.

Chapter 5, **Ethernet Network Requirements**, provides a series of test envelopes and installation requirements that Ethernet cabling must meet in order to conform to the Ethernet standard.

Chapter 6, **Full-Duplex Ethernet Network Requirements**, supplies the test characteristics and network limitations of Ethernet networks intended to operate in full-duplex mode.

Chapter 7, **Fast Ethernet Network Requirements**, deals with the cable characteristics and requirements of the Fast Ethernet networking technology, including 100BASE-TX and 100BASE-FX.

Chapter 8, **Full-Duplex Fast Ethernet Network Requirements**, Provides specific information related to the requirements of full-duplex Fast Ethernet network cabling.

Chapter 9, **Token Ring Media**, identifies and details the cables and connectors that may be used in Token Ring network environments.

Chapter 10, **Token Ring Network Requirements**, lists the required performance and test characteristics of Token Ring cabling.

Chapter 11, **FDDI Media**, lists and describes the various cabling types that may be used with Fiber Distributed Data Interface (FDDI) networks.

Chapter 12, **FDDI Network Requirements**, lists the required test characteristics and accepted maximums of cabling used in FDDI network installations.

Chapter 13, **Cabling Devices**, provides a list of several useful tools and accessories that can aid in the installation, management, and control of installed cabling in a facility.

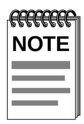
Chapter 14, **Connecting and Terminating**, describes the procedures involved in connecting and disconnecting the standard connectors of each network technology treated in Chapters 4, 9, and 11.

Appendix A, **Charts and Tables**, provides the information contained in the network requirements chapters of this document in a simplified table form. Tables of test requirements and acceptable levels are provided for all media discussed in this document.

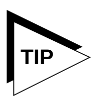
Following the appendix, the Cabletron Systems **Glossary of Terms** may be found.

Document Conventions

Warnings and Notifications

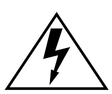


Note symbol. Calls the reader’s attention to any item of information that may be of special importance.



Tip symbol. Used to convey helpful hints concerning procedures or actions that would assist the operator in performing the task in a more timely manner in the future.

Caution symbol. Used to caution against an action that could result in damage to equipment or poor equipment performance.



Warning symbol. Used to warn against an action that could result in personal injury or death and equipment damage.

Formats

References to chapters or sections within this document are printed in **boldface** type.

References to other Cabletron Systems publications or documents are printed in *italic* type.

Additional Assistance

The planning and installation of facility cabling for network operation is a complex and highly specialized process. Due to the different nature of each and every cabling installation and the special problems and concerns raised by any facility, there may be aspects of installation planning that are not covered in this guide.

If you have questions or concerns about your cabling design, or if you require installation personnel to perform the actual installation process, Cabletron Systems maintains a staff of network design personnel and a sizable team of highly-trained cabling and hardware installation technicians. The services of the Networking Services group are available to customers at any time. If you are interested in obtaining design assistance or a network installation plan from the Networking Services group, contact your Cabletron Systems Sales Representative.

In addition to the availability of Networking Services, the Cabletron Systems Technical Support department is available to answer customer questions regarding existing Cabletron Systems networks or planned expansion issues. Contact Cabletron Systems at (603) 335-9400 to reach the Technical Support department with any specific product-related questions you may have.

Related Documentation

The following publications may be of assistance to you in the design process. Several of these documents present information supplied in this Cabling Guide in greater or lesser detail than they are presented here.

- *Cabletron Systems Networking Guide - MMAC-FNB Solutions*
- *Cabletron Systems Ethernet Technology Guide*
- *Cabletron Systems Token Ring Technology Guide*
- *Cabletron Systems FDDI Technology Guide*
- EIA/TIA 568 Specification
- IEEE 802.3 Specifications
- IEEE 802.5 Specifications
- ANSI X3T9.5 Specification

Chapter 2

Cabling Terms

This chapter identifies and defines several terms that are used throughout the text of this manual.

Physical Components

The following terms and definitions deal with the physical makeup of cabling used in Local Area Networks.

Media

Media refers to a type or family of cables. When the term media is used, it indicates a type of cabling, rather than a specific cable. A reference to "fiber optic media" deals with the characteristics of all fiber optic cable types, such as single or multimode fiber optics.

Cable

The term cable, as used in this document, indicates either a specific type of transmission media (i.e., multimode fiber optic cable) or indicates a physical section of that media (i.e., "the installed cable must be no longer than 200 m").

Facility Cabling

Facility cabling, sometimes referred to as building cable or horizontal cable, is the network cabling that is installed in a building or office. It only includes the actual wires that are placed within the walls, conduits, or specific cable channels of the building. The majority of cabling used in a network installation is facility cabling.

Jumper Cabling

Jumper cabling is a term that identifies short, inexpensive cables that are used to make connections between nearby cabling devices. Typically, workstations and network devices are connected to the facility cabling of a site with jumper cables.

Run

A “run” of cabling is a single end-to-end cable path in a networked facility. The cable run typically begins at a network device such as a hub or bridge and ends at a workstation or other end node. The cable run, if calculated, must include all areas on the cable to which signals will travel. On point-to-point media, such as UTP or fiber optics, this will be the same as the measure of cabling between stations. In a shared media environment, however, the measure of a run must include the total length of the shared cable being used, regardless of the distance between stations on that cable.

A cable run includes the facility cabling, jumper cabling, and any passive cable management devices, such as wallplates, patch panels, and punchdown blocks, between the two devices. When a specific type of cabling is referred to when identifying a cable run, the term refers only to the total length of that type of cable in the installation.

As an example, if a thick coaxial cable run is referred to in an installation description, it is concerned with the total length of coaxial cable and does not include the AUI cables used to connect stations to transceivers on the thick coaxial cable. If a UTP cable run is referred to, it includes only the jumper cables, patch panels, wallplates, and facility cabling between the devices in question.

Wire

The wire terms listed below deal with the components that make up a physical cable.

Core

The core of a wire is that portion of the wire upon which the electrical (or light, in the case of fiber optics) signals of network communications travel. In all cases, the term core refers to the transmissive center of the cable or wire in question. The term core is most often used when referring to a cable that has a single transmission path. Cables with multiple transmission paths cannot have an overall core.

Strand

A strand is a metal or glass (in the case of fiber optics) transmission media that is typically surrounded by an insulator. Strands in metallic cables may be made up of either solid lengths of relatively thick wire (solid core) or a bundle of much thinner wires that contact one another throughout the wire (stranded).

Insulator

An insulator is a layer of non-conductive material that protects the core or strands of a cable from both physical damage and from the effects of other strands within a multistranded cable. Insulator also protects the strands or core from the effects of external electrical noise to a small extent.

Shield

A shield is a layer of metal foil or braided screen that protects the core or strands of the cable from interference from outside electrical influences. The shield is wrapped around the core, and is separated from the core by a layer of insulator.

Gauge

The gauge of a wire is an indication of its thickness. Gauge is typically measured in American Wire Gauge (AWG). The lower the AWG number of a strand or core, the thicker it is. The gauge of a wire has an affect on the resistance it presents to electrical signals attempting to travel through it. In general, lower-gauge (thicker) strands allow network communications to travel through them more readily than strands with a higher gauge.

Connector

A connector is a metal, plastic, or composite assembly that is used to simplify the connection of separate lengths of cable or to connect cables to devices. Connectors are only found on cables (ports are located on devices). The terms that follow define important parts of connectors.

Housing (Shell)

The basis of the connector is its housing. A housing is the metal or plastic parts that make up the shape of the connector and determine its characteristics and what ports or other connectors it may be attached to. The purpose of the housing is to separate and organize any strands in the cable being connected and arrange them in a standard fashion for connection to a port or other connector.

If a housing can be assembled and disassembled easily, or is made up of several separate sections, it may be called a shell.

Pin

A pin is an exposed metal prong or wire that is either inserted into a channel or allowed to touch a contact. In this fashion, the pin creates a path for network signals to flow from the connector to the port or device it is connected to.

Pins may be fully exposed, for insertion into a channel, or partially exposed, for connection to a contact. Fully exposed pins will protrude from a housing or insulator. Partially exposed pins are encased on two or three sides by the construction material of the connector housing. An example of a partially exposed pin is that used in the RJ45 modular connector.

Contact

A contact refers to a location where one electrical transmission carrier meets another and creates a link through which electrical signals may be passed. Contacts, when referred to as physical parts of a connector or port, are usually flat, exposed metal surfaces.

Channel

A channel is a hollow cylinder, usually metal, that receives a fully exposed pin. The pin is inserted into the channel, where an electrical contact is made.

The cabling term “channel” should not be confused with the networking term “channel,” which refers to a logical path or group of paths of transmission and reception for network signals.

Gender

The gender of a connector refers to the organization of the pins, contacts, or channels of the connector. Connectors may be identified as male, female, hermaphroditic, or genderless. The most common types of connectors in networking are male and female.

A male connector is one that is inserted into a recessed or hollow port. In the case of some connectors, the determination of male gender is based upon whether the connector makes its networking connection through a pin or a channel. Connectors with pins are considered male.

Female connectors are those that are constructed to accept a male connector. Female connectors typically provide channels into which the pins of male connectors are inserted. A readily available example of male and female connectors is the standard electrical extension cord. The extension cord has a male end, the prongs that are placed in the wall outlet, and a female end, the slots on the opposite end of the cable.

Connections in any gendered cable systems must be made between one male connector and one female connector. The connectors themselves will not allow male/male or female/female connections.

Some connectors are genderless or hermaphroditic. These are connectors that have aspects of both male and female connector types. They may be connected to any other port or connector. The Token Ring MIC connector is perhaps the most common genderless connector in networking.

Keyed

A keyed connector is one that has a housing specifically designed to be connected to a port in a particular orientation. The keyed connector is shaped in such a way that it may only be inserted into the port or connector so that the pins or channels of the housing match up properly.

Threaded

Threaded connectors are designed to be secured to other threaded connectors or ports. They are designed to be screwed together. The threads hold the connectors in place.

Locking

A locking connector is one that snaps into place. Locking connectors are usually keyed, and are often gendered. The locking action holds the connector firmly in place and makes the connection resistant to disconnection due to strain or movement. Locking may be accomplished by a spring clip mechanism or by the use of key pins and locking channels.

Port

A port is a set of pins or channels on a networking or cabling device that are arranged to accept a connector. Ports are constructed much like connectors, and will only accept the connector type they are specifically designed for. Ports may be keyed, gendered, or locking, in the same fashion as connectors.

Jack

A jack is a term that is usually synonymous with port, and indicates a port location. Typically, the term refers to ports located on wallplates or other passive cabling devices.

Test Characteristics

The following section deals with the various important specifications and testing information related to the cabling and connectors used in LAN environments.

Impedance

Impedance is the resistance that a conductive cable offers to the transmission of current. Impedance is measured in ohms (Ω). Cables with high Impedance values are highly resistant to the transmission of electrical signals. Some network operation specifications and network devices require the use of cabling with specific impedance levels and will not work properly with cabling having significantly higher or lower values.

Crosstalk

Crosstalk is electrical interference between wires in a multi-stranded cable, such as Unshielded Twisted Pair (UTP) cabling. Crosstalk occurs when a cable strand or group of strands absorb signals from other wires that they are adjacent to. Crosstalk can be caused by a break in the insulation or shielding that separates wires from one another in a bundle.

Noise

In regards to network cabling, the term noise refers to electrical noise, electrical signals that are spontaneously introduced onto a cable due to that cables proximity to noise sources. Typical sources of electrical noise include lighting fixtures, electric motors, and transformers.

Delay

The term delay, when applied to network cabling, typically refers to the propagation delay of the segment or network. As signals in both electrically conductive cables and fiber optic cables travel through the transmission media at a fraction of the speed of light, there is an appreciable delay between the transmission of a signal on one end of a cable and the reception of the same signal on the other end. Network delay is typically measured in microseconds (µs). One microsecond is equal to 1/1,000,000 of a second.

Attenuation

Attenuation is the reduction of signal strength in a cable as a result of absorption or dispersion of the electrical or optical impulse traveling through the cable. The effect of attenuation is a gradual decrease in the power or clarity of a signal after it traverses a length of cabling. The measure of the attenuation of a cable is expressed in decibels (dB).

There are two different measures of attenuation that are important from a networking point of view. The first is the attenuation characteristics of a cable. These are estimates of the expected attenuation that a signal will suffer for passing through a given length of the cable. Expected attenuation values are expressed in dB/m, dB/km, or dB/ft.

The second measure of attenuation is that which is determined by testing a length of cable to determine its total attenuation. Total attenuation takes into account all components of the cable run and is expressed as a total measure of signal loss in decibels from one end of the cable to the other.

Chapter 3

Relevant Specifications

This chapter presents and examines a number of networking specifications and how they are related to planning and installing network cabling.

Just as there are specifications that deal with the tested aspects of installed cabling and their fitness for use with a particular networking technology, there are also standards that deal with the construction of cables and the methods by which they may be installed. These higher-level cabling standards involve such things as the pairing and insulating of cables within a multi-wire cable, the labeling of cable jackets, and the allowable proximity of cables of certain types to other cables or electrical equipment.

These higher-level specifications are out of the purview of this Cabling Guide, and are not covered in detail within this document. Some of the aspects treated by the higher-level specifications are discussed in the sections which follow, as they impact or affect the use or selection of cabling materials in certain facilities or for use with individual networking standards.

EIA/TIA

The EIA/TIA specifications deal with the recommended methods and practices for constructing, installing, and terminating wiring. There are several different EIA/TIA specifications which cover different aspects of wiring. EIA/TIA specification number 568 is the one that network installers are most commonly interested in, as it deals with the installation of networking and telephony and networking cable.

The construction specifications of the EIA/TIA specification are important only when selecting a specific type of cable. The EIA/TIA construction specification used in the manufacture of that cable determines the construction and tested characteristics of the cable, the organization and quality of its components, and what applications it is suited for.

The installation procedures of the EIA/TIA help to ensure that care is taken to avoid cabling situations that are possibly hazardous or which can result in degradation of the operating quality of the installed cable.

The EIA/TIA 568 specification details the minimum distance that cables may be located away from sources of electrical noise, what types of power cables or other telephony cabling the cables being installed may be next to, how the connectors must be installed, and other aspects which affect the overall usability of the cable for a particular purpose.

Full copies of the EIA/TIA 568 specification may be obtained from a technical document seller or ordered directly from the Electronics Industries Association/Telecommunications Industry Association.

Universal Service Order Code (USOC)

The USOC specification is similar to many EIA/TIA specifications, including EIA/TIA 568. The USOC specification describes, among other things, the construction and installation characteristics of a type of twisted pair cable. The USOC specification deals with the same aspects of the installation process as the EIA/TIA specifications, but provides slightly different guidelines.

Originally, the specification was drafted by the Bell System, and copies of the USOC specification may be obtained from technical booksellers or those Regional Bell Operating Companies (RBOCs) which provide specifications to customers.

National Electrical Code (NEC)

The National Electrical Code or NEC is an overall specification to which all facility wiring of any kind in the United States of America must be held. As the NEC is a higher-level standard than either the EIA/TIA or USOC specifications, the two lower-level specifications are designed to be automatically in accordance with the NEC.

Ethernet Media

This chapter examines the physical characteristics and requirements of both physical cabling and the connectors and ports used with the cabling in Ethernet , Full-Duplex Ethernet, and Fast Ethernet environments.

Cabling Types

Attachment Unit Interface (AUI)

Attachment Unit Interface cable (referred to hereafter as AUI cable) is a shielded, multistranded cable that is used to connect Ethernet network devices to Ethernet transceivers. AUI cable should be used for no other purpose. AUI cable is available in two basic types: standard AUI and office AUI.

AUI cable is made up of four individually shielded pairs of wire surrounded by an overall cable shielding sheath. The doubled shielding makes AUI cable more resistant to electrical signal interference than other, lighter cables, but increases the signal attenuation suffered over long distances.

AUI cables are connected to other devices through DB15 connectors. The connectors of an AUI cable run from Male to Female at all times. Any transceiver cable that uses a Male/Male or Female/Female configuration is a non-standard cable, and should be avoided.

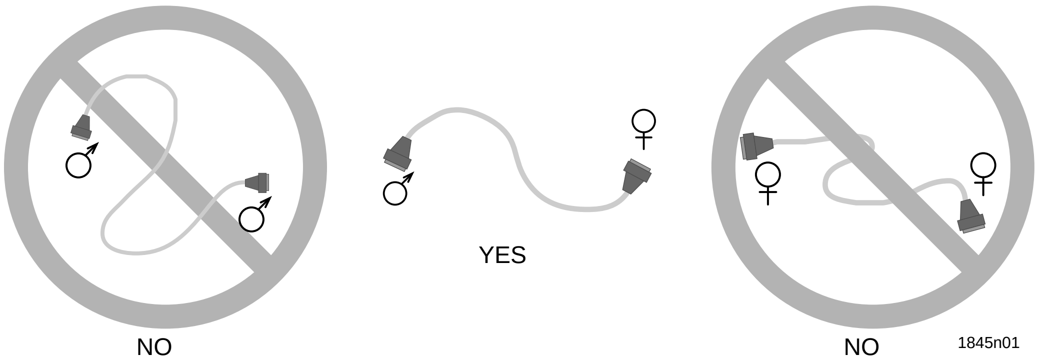


Figure 4-1. AUI Cable Configurations

The reason for the configuration of AUI cables as Male to Female only is due to their intended use. AUI cables are designed to attach transceivers to workstations or other active network equipment. Transceivers require power to operate, and that power is supplied either by an external power supply or by a pair of wires dedicated to power in the cable. A Male/Male or Female/Female AUI cable does not correctly supply power and grounding to the transceiver. If you use a Female/Female AUI cable between two transceiver devices, both transceivers will try to draw power from each other. Neither is capable of providing this power. Therefore, this configuration will not function. Likewise, two AUI device ports should never be directly attached without using transceivers.

NOTE

If you find yourself in need of a gender changer to connect a device with AUI cable, you are doing something wrong.

Standard

The gauge of the internal wires that make up the cable determines the thickness and relative flexibility of the AUI cable. Standard AUI cable (containing pairs of AWG 20 or 22 wire) is capable of reaching a maximum distance of 50 meters between transceivers and the network device, but is thick, (0.420 inch) and somewhat inflexible.

Standard AUI cables, due to their bulk, are typically used in environments that require the 50 meter distances that standard AUI cables can provide. In situations where the workstations or networking equipment are close to the transceivers they are to be connected to, Office AUI cable, being more easily managed and more flexible, is often used.

Office

Office AUI cable is a thinner cable that is more convenient to use on many environments than standard AUI. This lighter-gauge AUI cable is made up of four pairs of AWG 28 wire, which is thinner (at 0.26 inch) and much more easily flexed, but can only be run to a maximum distance of 16.5 meters.

Office AUI cable is intended to be used in places where standard AUI cable would be cumbersome and inflexible. Typically, office AUI is used in locations where a large number of workstations are concentrated in a single area.

Coaxial Cable

Coaxial cable is a cabling type where two or more separate materials share a common central axis. While several types of networking cables could be identified as having coaxial components or constructions, there are only two cable types that can support network operation using only one strand of cabling with a shared axis. These are commonly accepted as the coaxial cables, and are divided into two main categories: thick and thin coaxial cable.

Thick Coaxial Cable

Thick coaxial cable (also known as thick Ethernet cable, “thicknet,” or 10BASE5 cable), is a cable constructed with a single solid core, which carries the network signals, and a series of layers of shielding and insulator material. The shielding of thick coaxial cable consists of four stages. The outermost shield is a braided metal screen. The second stage shield, working inward, is usually a metal foil, but in some brands of coaxial cable may be made up of a second screen. The third stage consists of a second braided shield followed by the fourth stage, a second foil shield. The various shields are separated by non-conductive insulator materials.

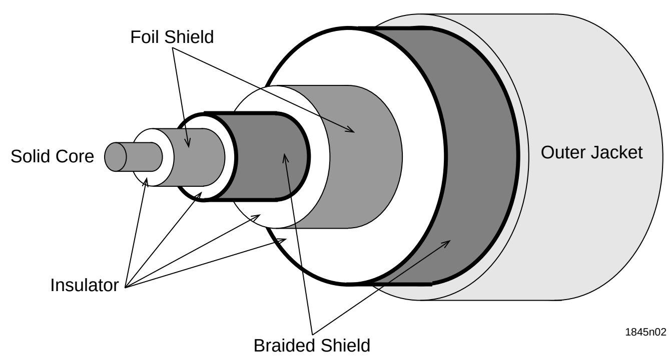


Figure 4-2. Thick Coaxial Cable Diagram

Thick coaxial cable is a media used exclusively in Ethernet installations, commonly as a backbone media. Transceivers are connected to the cable at specified distances from one another, and standard transceiver cables connect these transceivers to the network devices.

Due to the extensive shielding, thick coaxial cable is highly resistant to electrical interference by outside sources such as lighting, machinery, etc. Because of the bulkiness (typically 0.405 inch in diameter or thicker) and limited flexibility of the cable, thick coaxial cable is primarily used as a backbone media and is placed in cable runways or laid above ceiling tiles to keep it out of the way.

Thick coaxial cable is designed to be accessed as a shared media. Multiple transceivers can be attached to the thick coaxial cable at multiple points on the cable itself. A properly installed length of thick coaxial cable can support up to 100 transceivers.

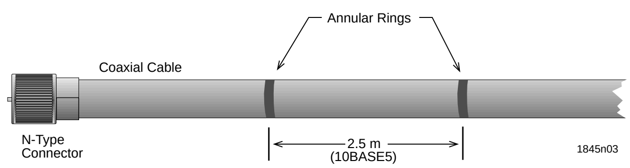


Figure 4-3. Annular Rings

Multiple transceivers on a thick coaxial cable must be spaced at least 2.5 meters from any neighboring transceivers or terminators. Thick coaxial cable is often bright yellow or orange in color. The outer jacket will frequently be marked with annular rings, dark red or black sections of jacketing that are spaced 2.5 meters from one another. These annular rings are a useful guide for ensuring that terminators and transceivers are spaced not less than 2.5 m from one another.

Thin Coaxial Cable

Thin coaxial cable (also known as thin Ethernet cable, “thinnet,” “cheapernet,” RG-58 A/U, BNC or 10BASE2 cable) is a less shielded, and thus less expensive, type of coaxial cabling. Also used exclusively for Ethernet networks, thin coaxial cable is smaller, lighter, and more flexible than thick coaxial cable. The cable itself resembles (but is not identical to) television coaxial cable.

Thin coaxial cable is made up of a single outer copper shield that may be braided or foil, a layer beneath that of non-conductive dielectric material, and a stranded center conductor. This shielding makes thin coaxial cable resistant to electromagnetic interference as the shielding of thick coaxial cable does, but does not provide the same extent of protection. Thin coaxial cable, due to its less extensive shielding capacity, can be run to a maximum length of 185 meters (606.7 ft).

Building Network Coax (BNC) connectors crimp onto a properly prepared cable end with a crimping tool. To prevent signal reflection on the cable, 50 Ohm terminators are used on unconnected cable ends.

As with thick coaxial cable, thin coaxial cable allows multiple devices to connect to a single cable. Up to 30 transceivers may be connected to a single length of thin coaxial cable, spaced a minimum of 0.5 meter from one another. This minimum spacing requirement keeps the signals from one transceiver from interfering with the operation of others. The annular rings on the thin coaxial cable are placed 0.5 meter apart, and are a useful guide to transceiver placement.

Unshielded Twisted Pair (UTP)

Unshielded Twisted Pair cabling (referred to here as UTP, but also may be termed copper wire, 10BASE-T wire, Category 3, 4, or 5 Ethernet wire, telephone cable, or twisted pair without shielded or unshielded qualifier) is commonly made up of two, four, or 25 pairs of 22, 24, or 26 AWG unshielded copper solid or stranded wires. These pairs of wires are twisted together throughout the length of the cable, and are broken up into transmit and receive pairs. In each pair, one wire carries the normal Ethernet transmission, while its associated wire carries a copy of the transmission that has been inverted.

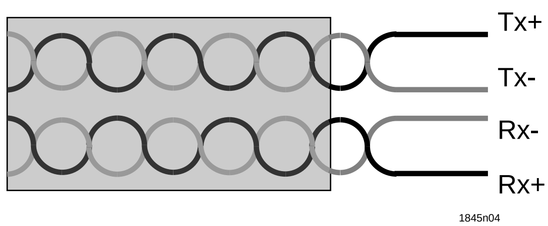


Figure 4-4. UTP Cable Pair Association

The twisting of associated pairs helps to reduce the interference of the other strands of wire throughout the cable. This is due to the method of transmission used with twisted pair transmissions.

In any transceiver or Network Interface Card (NIC), the network protocol signals to be transmitted are in the form of changes of electrical state. The means by which the ones and zeroes of network communications are turned into these signals is called encoding. In a twisted pair environment, once a transceiver has been given an encoded signal to transmit, it will copy the signal and invert the polarity of that signal (see Figure 4-5). The result of this inverted signal is a mirror opposite of the original signal.

Both the original and the inverted signal are then transmitted, the original signal over the TX+ wire, the inverted signal over the TX - wire. As these wires are the same length and of the same construction, the signal travels (propagates) at the same rate through the cable. Since the pairs are twisted together, any outside electrical interference that affects one member of the pair will have the same effect on the other member of that pair.

The transmissions travel through the cable, eventually reaching a destination transceiver. At this location, both signals are read in. The original signal is unchanged, but the signal that had previously been inverted is reverted to the original state. When this is done, it returns the encoded transmission to its original state, but reverses the polarity of any signal interference that the encoded transmission may have suffered.

Once the inverted transmission has been returned to the normal encoded state, the transceiver adds the two signals together. As the encoded transmissions are now identical, there is no change to the data content. Line noise spikes, however, are combined with noise spikes of their exact opposite polarity, causing them to cancel one another out.

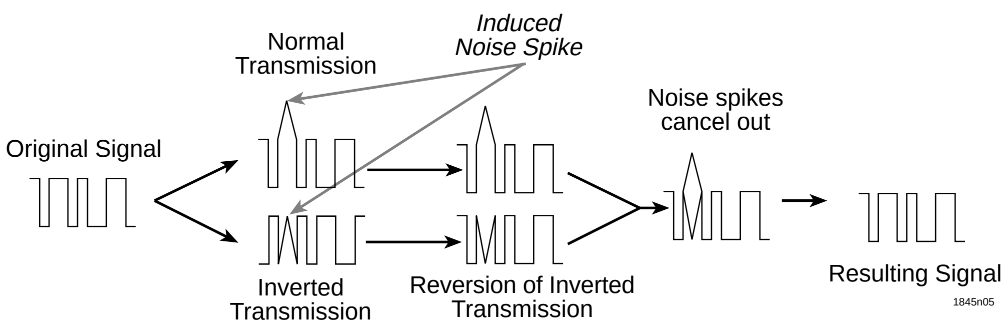


Figure 4-5. UTP Signal Equalization

The UTP cable used in network installations is the same type of cable used in the installation of telephone lines within buildings. UTP cabling is differentiated by the quality category of the cable itself, which is an indicator of the type and quality of wire used and the number of times the wires are twisted around each other per foot. The categories range from Category 1 to Category 5, with Category 5 cabling being of the highest quality.

The wires that make up a length of UTP cable are numbered and color coded. These color codes allow the installer of the networking cable to determine which wires are connected to the pins of the RJ45 ports or patch panels. The numbering of the wires in EIA/TIA standard cables is based on the color of the insulating jacket that surrounds the core of each wire.

The association of pairs of wire within the UTP cable jacket are decided by the specifications to which the cable is built. There are two main specifications in use around the world for the production of UTP cabling: EIA/TIA 568A and the EIA/TIA 568B. The two wiring standards are different from one another in the way that the wires are associated with one another at the connectors.

The arrangement of the wires in the two EIA/TIA specifications does not affect the usability of either type of connector style for 10BASE-T purposes. As the arrangement of the wires into pairs and the twisting of the pairs throughout the cable remain the same regardless of the EIA/TIA specification being used, the two specifications can be considered equivalent. As the specifications terminate the wires into different arrangements, care must be taken to keep all the cables at a facility terminated to the same EIA/TIA standard. Failure to do so can result in the mis-association of wires at the connectors, making the cabling unable to provide a connection between Ethernet devices. The arrangement of the wires and pairs in the two EIA/TIA specifications is discussed in the **UTP Cable** portion of the **Connector Types** section of this chapter.

Keep in mind that the selection of an EIA/TIA wiring scheme determines the characteristics of Wallplates, Patch Panels, and other UTP interconnect hardware you add to the network. Most manufacturers supply hardware built to both of these specifications. The more common of the two specifications in 10BASE-T applications is EIA/TIA 568A.

Four-Pair Cable

The typical single UTP cable is a polyvinyl chloride (PVC) or plenum-rated plastic jacket containing four pairs of wire. The majority of facility cabling in current and new installations is four-pair cable of this sort. The dedicated single connections made using four-pair cable are easier to troubleshoot and replace than the alternative, bulk multipair cable such as 25-pair cable.

The jacket of each wire in a four-pair cable will have an overall color: brown, blue, orange, green, or white. In a four-pair UTP cable (the typical UTP used in networking installations) there is one wire each of brown, blue, green, and orange, and four wires whose overall color is white. The white wires are distinguished from one another by periodically placed (usually within 1/2 inch of one another) rings of the other four colors.

Wires with a unique base color are identified by that base color: blue, brown, green, or orange. Those wires that are primarily white are identified as white/<color>, where <color> indicates the color of the rings of the other four colors in the white insulator.

The 10BASE-T and 100BASE-TX standards are concerned with the use of two pairs, Pair 2 and Pair 3 (of either EIA/TIA 568 specification). The 10BASE-T and 100BASE-TX standards configure devices to transmit over Pair 3 of the EIA/TIA 568A specification (Pair 2 of EIA/TIA 568B), and to receive from Pair 2 of the EIA/TIA 568A specification (Pair 3 of EIA/TIA 568B). The use of the wires of a UTP cable is shown in Table 4-1.

Table 4-1. 10BASE-T/100BASE-TX Four-Pair Wire Use

Wire Color	EIA/TIA Pair	Ethernet Signal Use	
		568A	568B
White/Blue (W-BL)	Pair 1	Not Used	
Blue (BL)			
White/Orange (W-OR)	Pair 2	RX+	TX+
Orange (OR)		RX-	TX-
White/Green (W-GR)	Pair 3	TX+	RX+
Green (GR)		TX-	RX-
White/Brown (W-BR)	Pair 4	Not Used	
Brown (BR)			

NOTE

Do not split pairs in a twisted pair installation. While you may consider combining your voice and data cabling into one piece of horizontal facility cabling, the Crosstalk and interference produced by this practice greatly reduces the viability of the cable for either application. The use of the pairs of cabling in this fashion can also prevent the future usage of advanced networking technologies such as FDDI TP-PMD and 100BASE-T4, that require the use of all four pairs in a twisted pair cable.

Twenty-Five Pair Cable

UTP cabling in large installations requiring several cable runs between two points is often 25-pair cable. This is a heavier, thicker form of UTP. The wires within the plastic jacket are of the same construction, and are twisted around associated wires to form pairs, but there are 50 individual wires twisted into 25 pairs in these larger cables. In most cases, 25-pair cable is used to connect wiring closets to one another, or to distribute large amounts of cable to intermediate distribution points, from which four-pair cable is run to the end stations.

As with four-pair cable, the wires within a 25-pair cable are identified by color. The jacket of each wire in a 25-pair cable has an overall color: violet, green, brown, blue, red, orange, yellow, gray, black, and white. In a 25-pair UTP cable all wires in the cable are identified by two colors. The first color is the base color of the insulator, while the second is the color of narrow bands painted onto the base color. These identifying rings are periodically placed on the wire, and repeat at regular intervals. When a wire is identified in a 25-pair cable, it is identified first by its base color, and then further specified by the color of the bands or rings.

As a 25-pair cable can be used to make up to 12 connections between Ethernet stations (two wires in the 25-pair cable are typically not used), the wire pairs need to be identified not only as transmit or receive pairs, but what other pair they are associated with. There are two ways of identifying sets of pairs in a 25-pair cable. The first is based on the connection of a 25-pair cable to a specific type of connector designed especially for it, the RJ21 connector. The second is based on connection to a punchdown block, a cable management device typically used to make the transition from a single 25-pair cable to a series of four-pair cables easier.

For further information on the RJ21 connector, refer to the **Connector Types** section later in this chapter. A description of punchdown blocks may be found in Chapter 13, **Cabling Devices**, and details of the punchdowns may be found in the **Connector Types** section later in this chapter.

Table 4-2. 25-Pair Cable Pair Mapping

Port Number	Wire Use	Wire Color	RJ21 Pin Number	Punchdown In Number	Punchdown Out Number
1	RX +	White/Blue	26	A1	B1
	RX -	Blue/White	1	A2	B2
	TX +	White/Orange	27	A3	B3
	TX -	Orange/White	2	A4	B4
2	RX +	White/Green	28	A5	B5
	RX -	Green/White	3	A6	B6
	TX +	White/Brown	29	A7	B7
	TX -	Brown/White	4	A8	B8
3	RX +	White/Gray	30	A9	B9
	RX -	Gray/White	5	A10	B10
	TX +	Red/Blue	31	A11	B11
	TX -	Blue/Red	6	A12	B12

Table 4-2. 25-Pair Cable Pair Mapping (Continued)

Port Number	Wire Use	Wire Color	RJ21 Pin Number	Punchdown In Number	Punchdown Out Number
4	RX +	Red/Orange	32	A13	B13
	RX -	Orange/Red	7	A14	B14
	TX +	Red/Green	33	A15	B15
	TX -	Green/Red	8	A16	B16
5	RX +	Red/Brown	34	A17	B17
	RX -	Brown/Red	9	A18	B18
	TX +	Red/Gray	35	A19	B19
	TX -	Gray/Red	10	A20	B20
6	RX +	Black/Blue	36	A21	B21
	RX -	Blue/Black	11	A22	B22
	TX +	Black/Orange	37	A23	B23
	TX -	Orange/Black	12	A24	B24
7	RX +	Black/Green	38	A25	B25
	RX -	Green/Black	13	A26	B26
	TX +	Black/Brown	39	A27	B27
	TX -	Brown/Black	14	A28	B28
8	RX +	Black/Gray	40	A29	B29
	RX -	Gray/Black	15	A30	B30
	TX +	Yellow/Blue	41	A31	B31
	TX -	Blue/Yellow	16	A32	B32
9	RX +	Yellow/Orange	42	A33	B33
	RX -	Orange/Yellow	17	A34	B34
	TX +	Yellow/Green	43	A35	B35
	TX -	Green/Yellow	18	A36	B36

Table 4-2. 25-Pair Cable Pair Mapping (Continued)

Port Number	Wire Use	Wire Color	RJ21 Pin Number	Punchdown In Number	Punchdown Out Number
10	RX +	Yellow/Brown	44	A37	B37
	RX -	Brown/Yellow	19	A38	B38
	TX +	Yellow/Gray	45	A39	B39
	TX -	Gray/Yellow	20	A40	B40
11	RX +	Violet/Blue	46	A41	B41
	RX -	Blue/Violet	21	A42	B42
	TX +	Violet/Orange	47	A43	B43
	TX -	Orange/Violet	22	A44	B44
12	RX +	Violet/Green	48	A45	B45
	RX -	Green/Violet	23	A46	B46
	TX +	Violet/Brown	49	A47	B47
	TX -	Brown/Violet	24	A48	B48
Unused Pair	N/A	-	25	N/A	N/A
	N/A	-	50	N/A	N/A

Crossovers

The 10BASE-T and 100BASE-TX specifications require that some UTP connections be crossed over. Crossing over is the reversal of the transmit and receive pairs at opposite ends of a single cable. Each cable that swaps the location of the transmit and receive pairs at only one end is called a crossover cable. Those cables that maintain the same pin numbers for transmit and receive pairs at both ends are called straight-through cables.

The 10BASE-T and 100BASE-TX specifications are designed around connections from networking hardware to end user stations being made through straight-through cabling. Because of this, the transmit wires of a networking device such as a standalone hub or repeater connect to the receive pins of a 10BASE-T or 100BASE-TX end station.

If two similarly-designed network devices are connected using a straight-through cable, the transmit pins of one device are connected to the transmit pins of the other device. In effect, the two devices will both attempt to transmit on the same pair of the cable between them.

To overcome this, a crossover must be placed between two like devices on a network, forcing the transmit pins of one device to connect to the receive pins of the other device. When two like devices are being connected to one another using UTP cabling, an odd number of crossover cables, preferably one, must be part of the cabling between them.

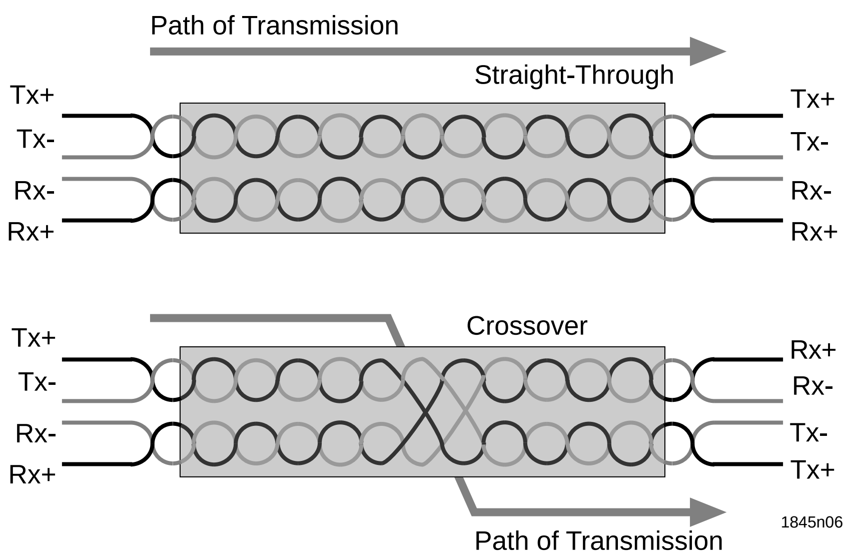


Figure 4-6. Straight-Through vs. Crossover Cables

UTP Cable Quality

UTP cabling is produced in a number of overall quality levels, called Categories. The requirements of networking limit UTP cabling for Ethernet to Categories 3, 4, and 5. Any of these cable Categories can be used in an Ethernet installation, provided that the requisite IEEE 802.3 specifications regarding the cables are met.

Category 3

UTP cabling that is built to the Category 3 specification consists of two or more pairs of solid 24 AWG copper strands. Each strand, approximately 0.02 inch thick, is surrounded by a layer of insulation. The characteristics of the insulation are determined by the fire resistant construction of the cable (plenum cable is thicker and made with slightly different material than normal PVC cabling).

The individual wires are twisted into pairs. The twisted pairs of cable are laid together within an outer jacket, that may be low-smoke PVC plastic or a plenum-rated insulating material. The outer jacket surrounds, but does not adhere to, the wire pairs that make up the cable.

Category 3 UTP cabling must not produce an attenuation of a 10 MHz signal greater than 98 dB/km at the control temperature of 20° C.

Category 4

Category 4 UTP cabling is constructed in the same manner as the Category 3 cabling discussed previously. Category 4 UTP is constructed using copper center strands of 24 or 22 AWG. The resulting wire pairs are then covered by a second layer of insulating jacketing. Higher-quality materials and a closer association of the twisted pairs of wire improve the transmission characteristics of the cable in comparison to Category 3 cabling.

Category 4 UTP cabling must not produce an attenuation of a 10 MHz signal greater than 72 dB/km at the control temperature of 20° C.

Category 5

Category 5 UTP cabling is manufactured in the same fashion as Category 3 cable, but the materials used are of higher quality and the wires that make up the pairs are more tightly wound than those in lower Category classes. This closer association helps to reduce the likelihood that any one member of a pair may be affected by external noise sources without the other member of the pair experiencing the same event. Only Category 5 cable may be used in 100BASE-TX networks.

Category 5 UTP consists of 2 or more pairs of 22 or 24 AWG wire. Category 5 cable is constructed and insulated such that the maximum attenuation of a 10 MHz signal in a cable run at the control temperature of 20° C is 65 dB/km. A cable that has a maximum attenuation higher than 65 dB/km does not meet the Category 5 requirements.

Fiber Optics

Fiber optic cable is a high performance media constructed of glass or plastic that uses pulses of light as a transmission method. Because fiber optics do not utilize electrical charges to pass data, they are free of interference due to proximity to electrical fields. This, combined with the extremely low rate of signal degradation and dB loss makes fiber optics able to traverse extremely long distances. The actual maximums are dependent upon the architecture being used, but distances upwards of 2 kilometers (1.2 miles) are not uncommon.

Glass optical fiber is made up of a glass strand, the core, that allows for the easy transmission of light, the cladding, a less transmissive glass layer around the core that helps keep the light within the core, and a plastic buffer that protects the cable.

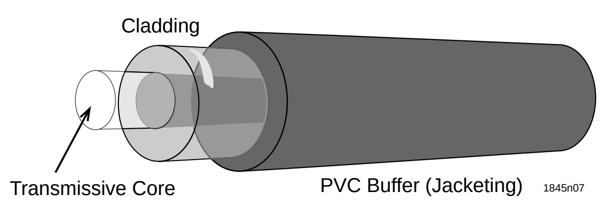


Figure 4-7. Fiber Optic Cable Construction (multimode)

There are two basic types of fiber optics, multimode and single mode. The names come from the types of light used in the transmission process. Multimode fiber uses inexpensive Light Emitting Diodes (LEDs) that produce light of a single color. Due to the nature of the LED, the light produced is made up of a number of differing wavelengths of light, fired outward from the center of the LED. Not all the rays of light enter the fiber, and those that do often do so at an angle, which reduces the amount of distance the signal can effectively cover. Single mode fiber optics use lasers to achieve greater maximum distances. Since light from a laser is all of the same wavelength, and travels in a coherent ray, the resulting signal tends to be much clearer at reception than an LED signal under the same circumstances.

Fiber optics of both types are measured and identified by a variety of means. The usual means of referring to a fiber optic cable type is to identify if it is single mode or multimode, and to describe the thickness of each strand. Fiber optics are very thin, and the diameter of each strand is measured in microns (µm). Two measurements are important in fiber optic identification; the diameter of the core, where signals travel, and the diameter of the cladding, which surrounds the core. Thus, fiber optic measurements will usually provide two numbers separated by the "/" symbol. The first number is the diameter, in microns, of the core. The second is the diameter of the cladding. Thus, a 62.5/125 multimode cable is a type of fiber optic cabling with a 62.5 micron core and 125 micron cladding, which is commonly used by LED driven transmitting devices.

In much the same way that UTP cabling is available in two-, four-, 25-, and 50-pair cables, strands of fiber optic cabling are often bound together with other strands into multiple strand cables. These multiple strand cables are available with anywhere from two to 24 or more strands of fiber optics, all gathered together into one protective jacket.

TIP

Cabletron Systems recommends that customers planning to install fiber optic cabling not install any facility fiber optics (non-jumper cabling) containing fewer than six strands of usable optical fiber. The minimum number of strands needed to make an end-to-end fiber optic link between two network devices is **two** (using the Ethernet network architecture). In the event that a strand within the cable is damaged during installation or additional fiber pairs become desired along the cable path, the availability of extra strands of optical fiber will reduce the likelihood that a new cable must be pulled. The existing, unused pairs of optical fiber can be terminated and used immediately.

Multimode

Multimode fiber optic cabling is designed and formulated to allow the propagation of many different wavelengths, or modes, of light. Multimode fiber optics are the most commonly encountered fiber type in Ethernet installations, due to their lower cost compared to other fiber types.

Multimode fiber optics may be terminated with any type of fiber optic connector; SMA, ST, FDDI MIC, or the new and not currently standardized SC connector.

Single Mode

Single mode fiber optics are designed specifically to allow the transmission of a very narrow range of wavelengths within the core of the fiber. As the precise wavelength control required to accomplish this is performed using lasers, which direct a single, narrow ray of light, the transmissive core of single mode fiber optics is typically very small (8 to 10 μm). Single mode fiber is more expensive to produce than multimode fiber, and is typically used in long-haul applications.

Due to the very demanding tolerances involved in connecting two transmissive media with diameters approximately one-quarter as thick as a sheet of paper, single mode fiber optics require very precise connectors that will not move or shift over time. For this reason, single mode fiber optics should only be terminated with locking, preferably keyed, connectors. Fiber optic connector types such as the ST, SC, or FDDI MIC connector all meet the requirements of single mode fiber optics, if installed and tested properly.

Connector Types

AUI

AUI cabling is always connected with DB15 ports and connectors. The use of any other type of connector for AUI cable is a violation of the IEEE 802.3 specification and is considered nonstandard.

DB15

The DB15 connector (male or female) provides 15 pins or channels (depending on gender). For identification, these pins are numbered from 1 to 15. To identify the number of a pin, look at the front of the connector, holding the DB15 as shown in Figure 4-8, below, keeping the longer edge of the D-shaped connector up.

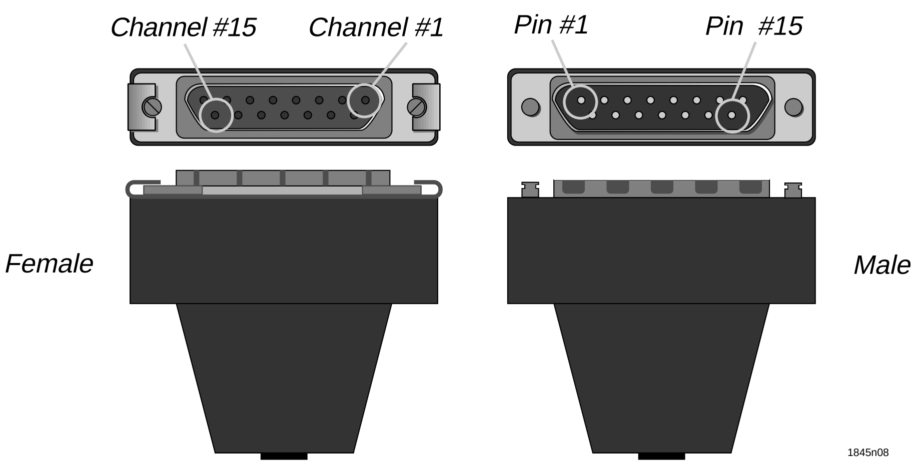


Figure 4-8. DB15 Connectors

The channel located at the upper right-hand corner of the female DB15 connector is identified as channel 1. The numbering continues across the top of the connector, to channel 8 at the upper left-hand corner. The channels from 9 to 15 are the seven channels at the bottom of the connector, from the lower right-hand corner (9) to the lower left-hand corner (15). The male DB15 connector reverses the left-right order of numbering, placing pin 1 at the upper left-hand corner, then following the path across and down to pin 15 at the lower right-hand corner.

The wires of an AUI cable are connected to different locations (pins or channels) of the male and female DB15 connectors. The differing organizations are called “pinouts.” The standard Ethernet DB15 pinout is discussed below.

Table 4-3. AUI Pinouts

AUI Connector Pin	Wire Function
1	Logic Ref
2	Collision +
3	Transmit +
4	Logic Ref
5	Receive +
6	Power Return
7	No Connection
8	Logic Ref
9	Collision -
10	Transmit -
11	Logic Ref
12	Receive -
13	Power (+12 Vdc)
14	Logic Ref
15	No Connection

Coaxial Cable

The connectors available for coaxial cabling are dependent upon the type of coaxial cabling in question. Thick coaxial cable may be tapped into without breaking the continuity of the cable or may be physically cut and re-connected. Thin coaxial cable cannot support the non-intrusive tap style, and must be split and connected to a junction device at each point where a connection is to be made.

N-Type

N-Type connectors are used for the termination of thick coaxial cables and also for the connection of transceivers to the cable. When used to provide a transceiver tap, the coaxial cable is broken at an Annular Ring and two N-Type connectors are attached to the resulting bare ends. These N-Type connectors, once in place, are screwed onto a barrel housing. The barrel housing contains a center channel that the signals of the cable are passed across, and a pin or cable that contacts this center channel, providing access to and from the core of the coaxial cable. The pin that contacts the center channel is connected to the transceiver assembly and provides the path for Ethernet transmission and reception.

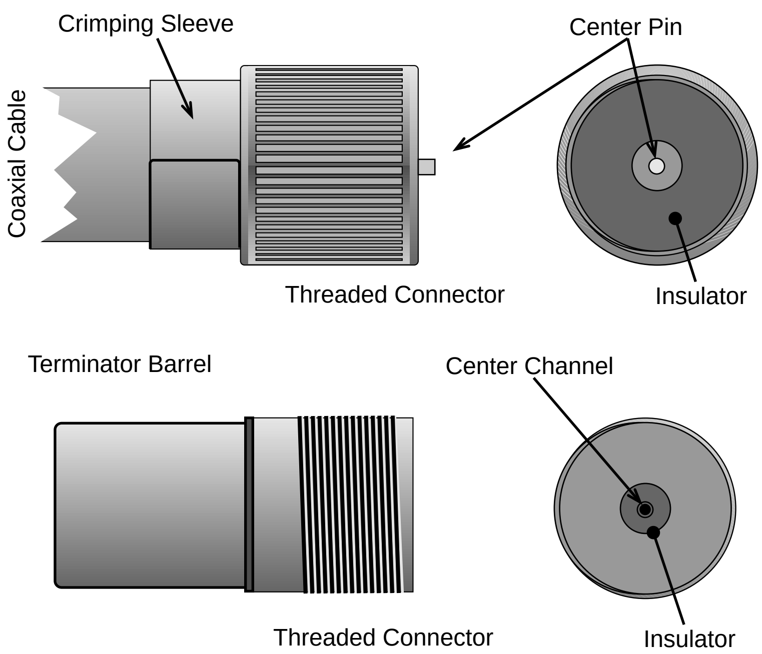


Figure 4-9. N-Type Connector and Terminator

Thick coaxial cables require termination with N-Type connectors. As the coaxial cable carries network transmissions as voltage, both ends of the thick coaxial cable must be terminated with N-Type connectors and terminators to keep the signal from reflecting throughout the cable, which would disrupt network operation. The terminators used for thick coaxial cable are 50 Ohm (Ω) terminators. These terminators are screwed into an N-Type connector placed at the end of a run of thick coaxial cabling.

Non-Intrusive

Tapping a thick coaxial cable may be done without breaking the cable itself. The non-intrusive, or “vampire” tap (Figure 4-10), inserts a solid pin through the thick insulating material and shielding of the coaxial cable. The solid pin reaches in through the insulator to the core wire where signals pass through the cable. By contacting the core, the pin creates a tap. The signals travel through the pin to and from the core.

Non-Intrusive taps are made up of saddles, which bind the connector assembly to the cable, and tap pins, which burrow through the insulator to the core wire. Non-Intrusive connector saddles are clamped to the cable to hold the assembly in place, and usually are either part of, or are easily connected to, an Ethernet transceiver assembly.

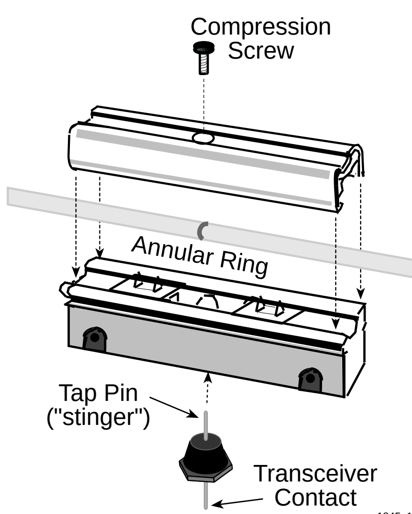


Figure 4-10. Non-Intrusive Tap and Cable Saddle

The non-intrusive tap’s cable saddle is then inserted into a transceiver assembly (Figure 4-11). The contact pin, that carries the signal from the tap pin’s connection to the coaxial cable core, makes a contact with a channel in the transceiver housing. The transceiver breaks the signal up and carries it to a DB15 connector, to which an AUI cable may be connected.

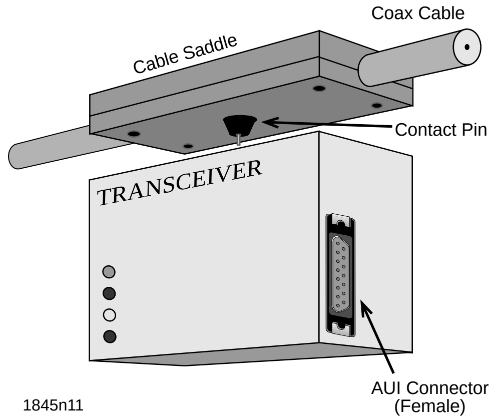


Figure 4-11. Cable Saddle and Transceiver Assembly

BNC

The BNC connector, used in 10BASE2 environments, is an intrusive connector much like the N-Type connector used with thick coaxial cable (described above). The BNC connector (shown in Figure 4-12) requires that the coaxial cable be broken at an annular ring to make the connection. Two BNC connectors are either screwed onto or crimped to the resulting bare ends. Cabletron Systems recommends the use of the crimp-on BNC connectors for more stable and consistent connections. BNC connectors use the same pin-and-channel system to provide a contact that is used in the thick coaxial N-Type connector.

BNC Male connectors are attached to BNC female terminators or T-connectors (Figure 4-13). The outside metal housing of the BNC male connector has two guide channels that slip over corresponding locking key posts on the female BNC connector. When the outer housing is placed over the T-connector or terminator locking keys and turned, the connectors will snap securely into place.

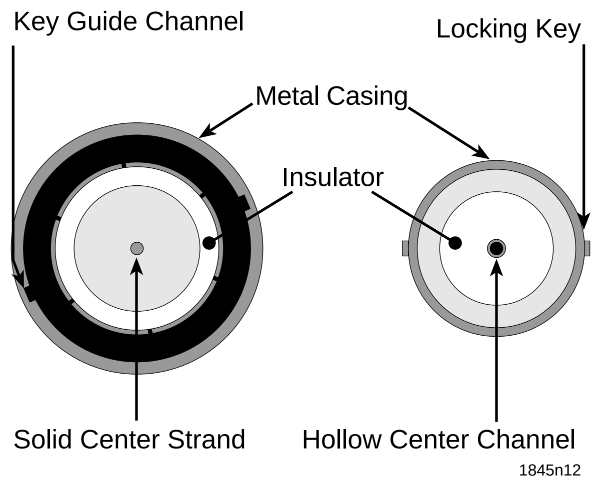


Figure 4-12. BNC connectors

T-Connector

Connections from the cable to network nodes are typically made using T-connectors, which provide taps for additional runs of coaxial cable to workstations or network devices. T-connectors, as shown in Figure 4-13, below, provide three BNC connections, two of which attach to Male BNC connectors on the cable itself and one of which is used for connection to the Female BNC connection of a transceiver or Desktop Network Interface Card (DNI or NIC) on a workstation.

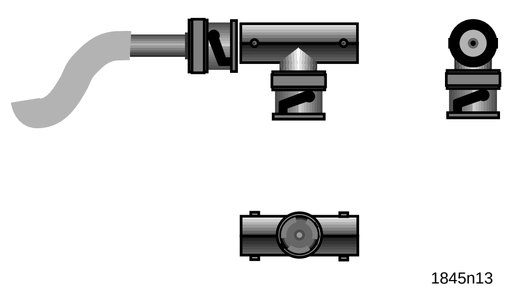


Figure 4-13. Thin Coax T-Connector

NOTE

T-connectors should be attached directly to the BNC connectors of Network Interface Cards or other Ethernet devices. The single solid strand connector of a T-connector should not be attached to a coaxial jumper cable of any length.

UTP Cable

RJ45

The RJ45 connector is a modular, plastic connector that is often used in UTP cable installations. The RJ45 is a keyed connector, designed to be plugged into an RJ45 port only in the correct alignment. The connector is a plastic housing that is crimped onto a length of UTP cable using a custom RJ45 die tool. The connector housing is often transparent, and consists of a main body, the contact blades or "pins," the raised key, and a locking clip and arm.

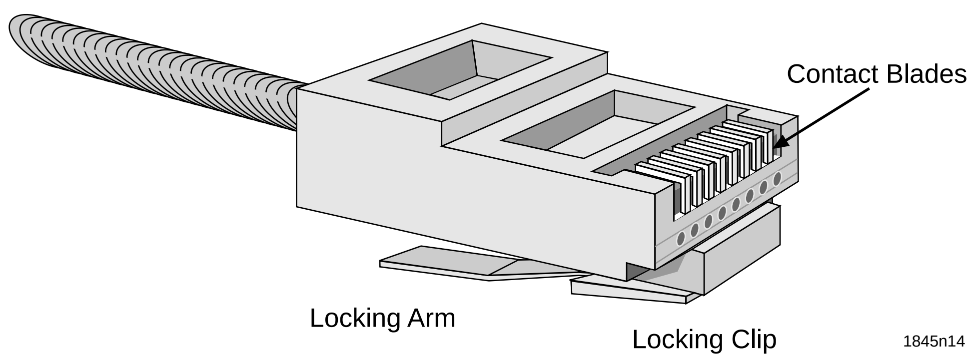


Figure 4-14. RJ45 Connector

The locking clip, part of the raised key assembly, secures the connector in place after a connection is made. When the RJ45 connector is inserted into a port, the locking clip is pressed down and snaps up into place. A thin arm, attached to the locking clip, allows the clip to be lowered to release the connector from the port. For a complete discussion of connecting and disconnecting RJ45 connectors, refer to Chapter 14, **Connecting and Terminating**.

RJ45 connectors for UTP cabling are available in two basic configurations; stranded and solid. These names refer to the type of UTP cabling that they are designed to connect to. The blades of the RJ45 connector end in a series of points that pierce the jacket of the wires and make the connection to the core. Different types of connections are required for each type of core composition.

A UTP cable that uses stranded core wires will allow the contact points to nest among the individual strands. The contact blades in a stranded RJ45 connector, therefore, are laid out with their contact points in a straight line. The contact points cut through the insulating material of the jacket and make contact with several strands of the core.

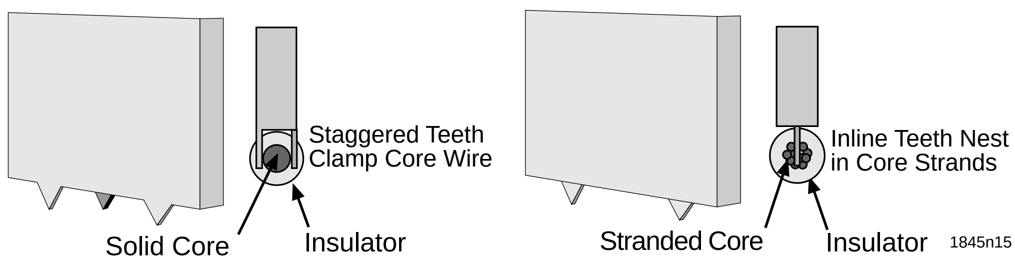


Figure 4-15. Solid and Stranded RJ45 Blades

The solid UTP connector arranges the contact points of the blades in a staggered fashion. The purpose of this arrangement is to pierce the insulator on either side of the core wire and make contacts on either side. As the contact points cannot burrow into the solid core, they clamp the wire in the middle of the blade, providing three opportunities for a viable connection.

The contact pins and their associated wires are organized into what is known as a pinout. The pinout of a connector or port is the layout of the wires or cables coming into the connector. The pinout used in any connector is dependent upon the wiring specification to which the cable is constructed. The 10BASE-T standard requires that all the cables used in the network end in connectors with particular pinouts. The pinout form required by the 10BASE-T standard is the EIA/TIA 568A specification.

The EIA/TIA 568A specification orders the pairs in a four-pair cable into the pinout shown in Figure 4-16, below. The RJ45 connector in Figure 4-16 is being viewed from the contact blade end, with the locking clip up.

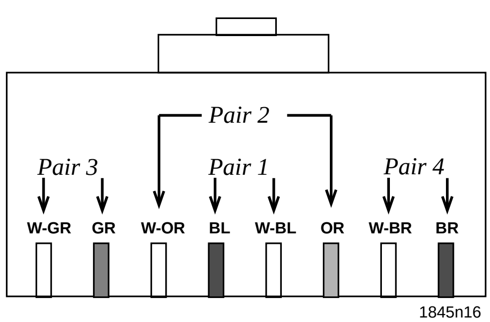


Figure 4-16. EIA/TIA 568A Pair Association

The EIA/TIA 568B specification reverses the arrangement of Pair 1 and Pair 2, but does not change the association of pairs within the cable. The Universal Service Order Code, or USOC, a standard used for Token Ring network installations or some telephone wiring, uses a different pair association than EIA/TIA 568A. The USOC standard will cause a split pair condition in an IEEE 10BASE-T environment, causing a loss of network functionality. For further information on the differences between the standards, refer to the USOC and EIA/TIA specifications.

RJ21 (Telco)

The RJ21 or "Telco" connector is another standard 10BASE-T connector type. The RJ21 connector is a D-shaped metal or plastic housing that is wired and crimped to a UTP cable made up of 50 wires, a 25-pair cable. The RJ21 connector can only be plugged into an RJ21 port. The connector itself is sizable, and the cables that it connects to are often quite heavy, so the RJ21 relies on a tight fit and good cable management practices to keep itself in the port. Some devices may also incorporate a securing strap that wraps over the back of the connector and holds it tight to the port.

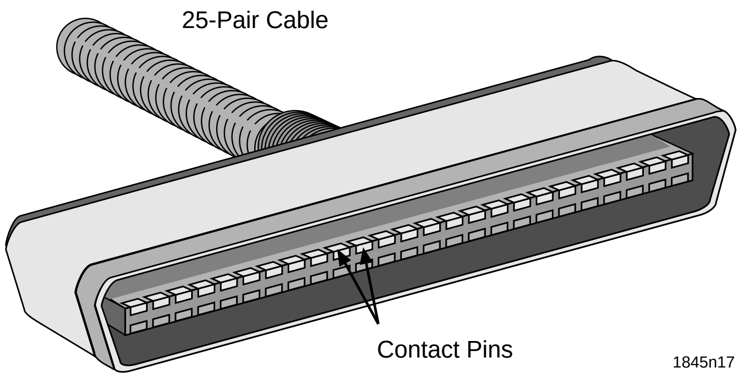


Figure 4-17. The RJ21 Connector

The RJ21 is used in locations where 25-pair cable is being run either to stations or to an intermediary cable management device such as a patch panel or punchdown block. Due to the bulk of the 25-pair cable and the desirability of keeping the wires within the insulating jacket as much as possible, 25-pair cable is rarely run directly to Ethernet stations.

The RJ21 connector, when used in a 10BASE-T environment, must use the EIA/TIA 568A pinout scheme. The numbers of the RJ21 connector's pins are detailed in Figure 4-18, below. The actual association of the wire colors into pairs and the organization that these pairs may use to connect to a punchdown block are discussed in the **Cabling Types** portion of this chapter.

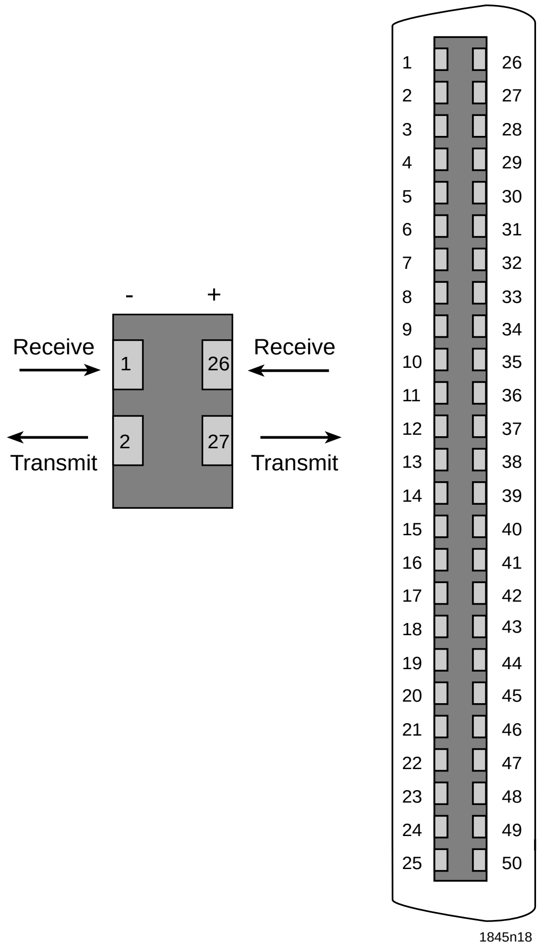


Figure 4-18. RJ21 Pinout Mapping for 10BASE-T

Punchdown Blocks

While not strictly a connector type, the punchdown block is a fairly common component in many Ethernet 10BASE-T installations that use 25-pair cable. The punchdowns are bayonet pins to which UTP wire strands are connected. The bayonet pins are arranged in 50 rows of four columns each. The pins that make up the punchdown block are identified by the row and column they are members of. Each of the four columns is lettered A, B, C, or D, from leftmost to rightmost. The rows are numbered from top to bottom, one to 50. Thus, the upper left hand pin is identified as A1, while the lower right hand pin is identified as D50.

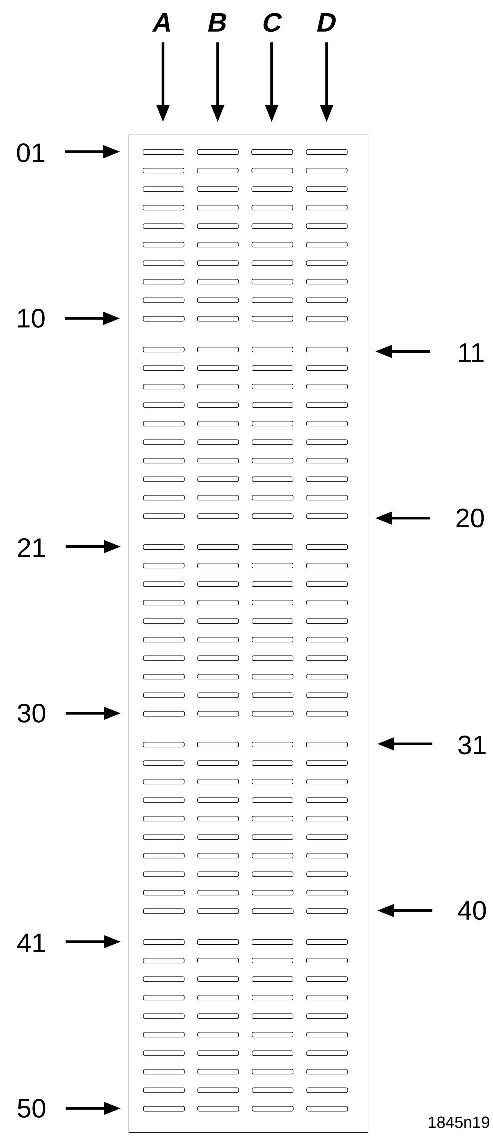


Figure 4-19. Punchdown Block Mapping for UTP Cabling

Fiber Optics

As both multimode and single mode fiber optics use the same standard connector in the Ethernet 10BASE-FL and FOIRL specifications, both cabling types are treated in the section that follows. The recommended connector for 100BASE-FX networks is discussed in the closing pages of this section.

NOTE The 10BASE-F specification is broken up into three main categories; 10BASE-FP Passive Fiber Optic Star, 10BASE-FB Active Fiber Optic Backbone, and 10BASE-FL Active Fiber Optic Link. Cabletron Systems produces Ethernet products that comply with the 10BASE-FL specification.

Straight-Tip

The 10BASE-FL standard and FOIRL specification for Ethernet networks define one style of connector as being acceptable for both multimode and single mode fiber optic cabling - the Straight-Tip or ST connector (note that ST connectors for single mode and multimode fiber optics are different in construction and are not to be used interchangeably). Designed by AT&T, the ST connector replaces the earlier Sub-Miniature Assembly or SMA connector. The ST connector is a keyed, locking connector that automatically aligns the center strands of the fiber optic cabling with the transmission or reception points of the network or cable management device it is connecting to.

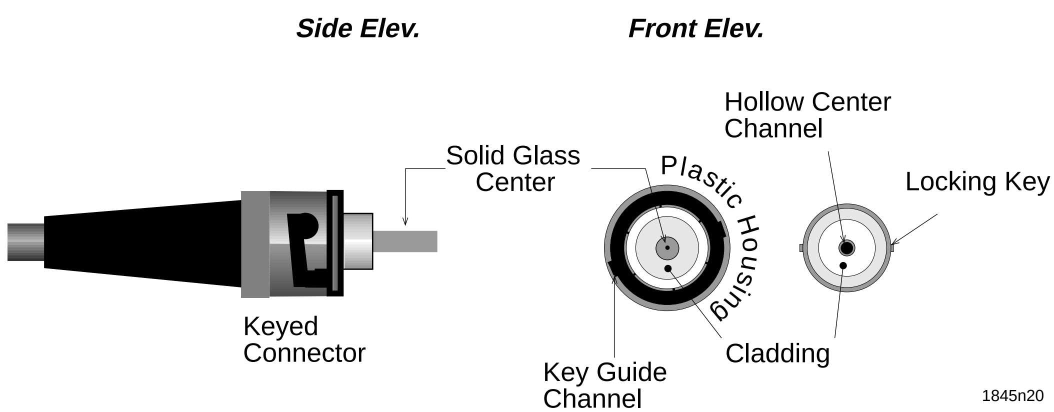


Figure 4-20. ST Connectors

The key guide channels of the male ST connector allow the ST connector to only be connected to a female ST connector in the proper alignment. The alignment keys of the female ST connector ensure the proper rotation of the connector and, at the end of the channel, lock the male ST connector into place at the correct attitude. An integral spring helps to keep the ST connectors from being crushed together, damaging the fiber optic cables. For a complete discussion of connecting and disconnecting ST connectors, refer to Chapter 14, **Connecting and Terminating**.

SC Connector

The SC connector is a gendered connector that is recommended for use in Fast Ethernet networks that incorporate multimode fiber optics adhering to the 100BASE-FX specification. It consists of two plastic housings, the outer and inner. The inner housing fits loosely into the outer, and slides back and forth with a travel of approximately 2 mm (0.08 in).

The inner housing ends in two floating ferrules, which are very similar to the floating ferrules used in the FDDI MIC connector. The 100BASE-FX specification requires very precise alignment of the fiber optic strands in order to make an acceptable connection. In order to accomplish this, SC connectors and ports each incorporate "floating" ferrules that make the final connection between fibers. These floating ferrules are held in place relatively loosely. This arrangement allows the ferrules to move slightly when making a connection. This small amount of movement manages to accommodate the subtle differences in construction found from connector to connector and from port to port.

The sides of the outer housing are open, allowing the inner housing to act as a latching mechanism when the connector is inserted properly in an SC port.

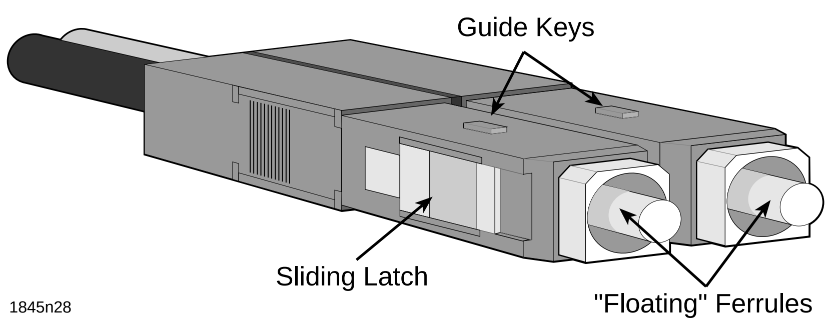


Figure 4-21. Fast Ethernet SC Connector

Chapter 5

Ethernet Network Requirements

This chapter provides test parameters and specification requirements for Ethernet network cabling.

10BASE-T

All Cabletron Systems 10BASE-T products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 10BASE-T products may be affected.

Cable Type

10BASE-T network operations are more demanding than normal telephony, and thus require specific, high-quality cabling in order to function properly. The 10BASE-T specification for Ethernet networks requires UTP cabling of Category 3, 4, or 5. Categories of UTP cabling below Category 3 may not meet the quality requirements of the networking specification, and may therefore be unable to meet the tested characteristics listed below.

The Category of cabling used in a network installation is dependent upon all the components that make up the cabling run. If an installation utilizes Category 5 cabling, and the wallplates and patch panels to which that cabling is connected are Category 3 compliant, the cable does not meet the EIA/TIA end-to-end specifications for a Category 5 installation.

Insertion Loss (Attenuation)

The maximum allowable insertion loss for any 10BASE-T station on the Ethernet network is 11.5 dB at frequencies from 5 to 10 MHz. This calculation must take all cabling devices in the cable path into account. A typical insertion loss test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

The insertion loss characteristics of a cable are one of the main determinants of link length allowed by the Ethernet and 10BASE-T specifications. As long as a UTP cable does not exceed the total insertion loss of 11.5 dB, it may be any length up to 200 m (656 ft). The 200 meter maximum total length is based on the total allowable propagation delay in the network, and cannot be exceeded.

NOTE

As longer cables are more susceptible to other limiting factors, Cabletron Systems does not recommend the installation of 10BASE-T cabling over 100 m in length.

Impedance

Cabletron Systems 10BASE-T equipment requires that 10BASE-T cables in the Ethernet network have an impedance within the range of 75 - 165 Ω. Typical UTP cables used in Ethernet environments have an impedance between 85 to 150 Ω.

Jitter

Jitter may be caused by intersymbol interference and reflection of signal. Networking technologies that rely on particular timing or clocking schemes may be affected by jitter due to excessive signal reflection. Any 10BASE-T cable installation should not exceed 5.0 ns of jitter. If a cable run meets the 10BASE-T impedance requirements (detailed above), jitter should not be a concern.

Delay

The maximum propagation delay allowable on a 10BASE-T segment is 1 microsecond (μs). If an Ethernet signal is unable to traverse the entire length of an installed UTP cable run within 1 μs, Out of Window (OOW) errors will occur due to excessive delays between transmission of signals and notification of collisions. This propagation delay requirement limits UTP cabling to a total maximum length of 200 m (656 ft).

NOTE

As longer cables are more susceptible to other limiting factors, Cabletron Systems does not recommend the installation of 10BASE-T cabling over 100 m in length.

Crosstalk

Crosstalk is electrical interference between wires. Crosstalk occurs when a cable strand absorbs signals from other wires that it is adjacent to. Excessive crosstalk can be caused by a break in the insulation or shielding that separates wires from one another in a bundle.

Ethernet UTP cables should be checked for Near-End Crosstalk, or NEXT, at installation. The allowable amount of NEXT for a UTP cable is dependent upon the type of cable used in the installation.

25-Pair Cable

The acceptable amount of NEXT between pairs in a 25-pair cable is at least 60 dB for a 10 MHz link.

Four-Pair Cable

The acceptable amount of NEXT between pairs in a four-pair cable is not less than 60 dB for a 10 MHz link.

Noise

As “noise” is not a readily quantified and tested aspect of installed cables, there are no hard and fast rules for the amount of acceptable cable noise on a 10BASE-T segment. If a cable that meets all other requirements for 10BASE-T operation is experiencing an unusual number of errors, the introduction of noise may be a problem.

If you suspect noise of causing signal degradation, examine the cable or cables in question. If they are near possible sources of outside noise, such as lighting fixtures, electric motors, or transformers, reroute the cable.

Other Considerations

UTP cabling, due to the small gauge of the wires it is constructed out of, is susceptible to changes in attenuation due to heat. In an installation that exceeds the control temperature of 20° C (68° F), the attenuation of PVC jacketed UTP cabling that is within the 11.5 dB limitations may fall outside the acceptable range. In installations where UTP cables are expected to be subjected to temperatures of 40° C (104° F) or greater, the use of plenum-jacketed cabling is recommended. The thicker insulating jacket of a plenum-rated cable reduces the susceptibility of that cable to heat-induced changes in attenuation characteristics.

The IEEE 802.3 10BASE-T specification requires that all 10BASE-T devices support UTP cables of not less than 100 m (328 ft) in length. This requirement does not factor in losses due to connectors, patch panels, punchdown blocks, or other cable management hardware, which introduce additional loss.

For each connector or other intrusive cable management device in the total link, subtract 12 m (39.4 ft) from the total allowable link length.

Length

The 10BASE-T standard specifies that any 10BASE-T compliant device must be capable of transmitting an Ethernet signal not less than 100 m (328 ft) over a UTP cable segment that meets the minimum quality values listed above. As long as all specifications are met for the entire length of the cable, UTP cable segments can be run up to a maximum allowable length of 200 m (656 ft).

NOTE

As longer cables are more susceptible to noise and other limiting factors, Cabletron Systems does not recommend the installation of 10BASE-T cabling over 100 m in length.

10BASE-F (Multimode)

All Cabletron Systems 10BASE-F and FOIRL products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 10BASE-F products may be affected.

Cable Type

10BASE-F network devices require specific types of cabling. 10BASE-F multimode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following types of multimode fiber optics:

- 50/125 µm
- 62.5/125 µm
- 100/140 µm

Attenuation

Multimode fiber optic cables must be tested for attenuation with a fiber optic attenuation test set. The test set must be configured to determine attenuation of the cable at a wavelength of 850 nm. The attenuation test will confirm or deny that the cable falls within an acceptable level. The acceptable level of attenuation for a cable is dependent upon the type of multimode fiber optic cable being tested. The acceptable levels of attenuation for the types of multimode fiber optic cabling supported by Cabletron Systems products are listed in Table 5-1 below:

Table 5-1. Multimode Fiber Optic Attenuation Limits

Cable Type	Maximum Attenuation
50/125 µm	13.0 dB
62.5/125 µm	16.0 dB
100/140 µm	19.0 dB

Insertion Loss

The 10BASE-F specification allows for a total dB loss of 10 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

As fiber optic cabling is often used to make connections between Ethernet repeaters or hubs, the 10BASE-F specification allows a multimode fiber optic link to be configured such that the total propagation delay for the link is less than or equal to 25.6 µs one-way. Keep in mind, however, that propagation delay must be calculated for the entire network. If there are more stations than the one connected by your fiber optic link, you must also calculate the propagation delay for the longest of those station links.

If there is any signal path whose total one-way propagation delay exceeds 25.6 µs, the Ethernet network is out of specifications, and error conditions may result. To eliminate propagation delay problems, incorporate some form of segmentation, such as bridging or routing, into the network to separate the problem signal paths from one another.

Length

The 10BASE-F specification limits a multimode fiber optic cable segment to 2 km or less. Assuming that a fiber optic cable meets all other limitations for 10BASE-F usage, it is possible to extend a multimode fiber optic link to an absolute maximum of 2 km. At a length of more than 2 km, the propagation delay introduced by the multimode fiber optic cable segment may exceed the 25.6 μs limit of the Ethernet specification and cause excessive OOW errors. Cabletron Systems does not recommend the installation or use of any multimode fiber optic cable segment that exceeds 10BASE-F limitations of 2 km.

Older networking equipment for fiber optic connections may be built to the FOIRL specification. FOIRL devices will support a multimode fiber optic link of up to 1 km.

Ethernet FOIRL (Single Mode)

All Cabletron Systems FOIRL products require that installed single mode fiber optic facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the FOIRL products may be affected.

Cable Type

FOIRL network devices require specific types of cabling. FOIRL single mode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following types of single mode fiber optics:

- 8/125 μm
- 12/125 μm

Some Cabletron Systems single mode fiber optic devices may be connected to multimode fiber optic cabling with measurements of 62.5/125 μm, but the greater optical loss characteristics of multimode fiber optics will limit the maximum distance of the single mode fiber optic signal to approximately 2 km.

Attenuation

Single mode fiber optic cabling must be tested with a fiber optic attenuation test set configured to determine attenuation of the cable at a wavelength of 1300 nm. The acceptable level of attenuation for a single mode fiber optic is less than or equal to 10.0 dB for any given link.

Insertion Loss

The FOIRL specification allows for a total loss of 10 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

If there is any signal path in the overall network whose total one-way propagation delay exceeds 25.6 µs, the Ethernet network is out of specifications, and error conditions may result. To eliminate propagation delay problems, incorporate some form of segmentation, such as bridging or routing, into the network to separate the problem signal paths from one another.

Length

The FOIRL specification limits single mode fiber optic cabling links to a total of 1 km or less. If a single mode fiber optic cable is used to form a link between two bridges and shares no connection with other Ethernet stations, the total segment length may reach up to 5 km, assuming all other requirements for a FOIRL network are met. At lengths over 5 km, propagation delays for the fiber optic link exceed the 25.6 µs limit of Ethernet networks. Cabletron Systems does not recommend the installation or use of any single mode fiber optic cable segment that exceeds the FOIRL limitations of 1 km.

10BASE2

All Cabletron Systems 10BASE2 products require that installed thin coaxial cables and related cabling hardware meet the following minimum specifications. If a network installation does not comply with the following specifications, operation of the 10BASE2 products may be affected.

Cable Type

Cabletron Systems 10BASE2 products are designed to be connected to 50 Ohm RG-58 A/U type coaxial cable. If Cabletron Systems products are connected to other types of thin coaxial cable, the 10BASE2 networks will be subject to errors and poor performance.

Termination

All 10BASE2 cables must be terminated at both ends of the cable with 50 Ohm terminators. Some 10BASE2 network equipment is capable of performing internal termination. If a network device supports internal termination, and that device is located at one end of the 10BASE2 cable, no external terminators need to be added to the cable segment.

Connectors/Taps

10BASE2 cables may only be terminated with BNC connectors. Connectors on the 10BASE2 cable must be spaced more than 0.5 m (1.64 ft) from any other connector or tap in the cable. If connectors are located closer to one another than this minimum, signal reflection may occur, causing network errors and a loss of performance.

One segment of 10BASE2 thin coaxial cable can support no more than 30 stations. When planning a thin coaxial cable segment that will connect to a bridge, repeater, or hub, keep in mind that one connection must be reserved for the network device, leaving a maximum of 29 stations that may be connected to one segment.

Connections from T-connectors to network devices may not be made through thin coaxial jumper cables; connections must be made from the T-connector directly to the device.

Grounding

Each thin coaxial cable segment should be connected to earth ground at only one point. The connection to a ground should not be made through the BNC ports of a network device or T-connector unless the connection to the ground is made through the BNC terminator at the end of the cable. The grounding wire must be connected to the outer metal shield of the coaxial cable and should be no longer than 10 m (32.8 ft). If insulated, grounding wires should be green in adherence with accepted wiring practice.

Length

10BASE2 specifications allow thin coaxial cable segments to be no longer than 185 m (606.7 ft). The use of longer cable segments can cause excessive error conditions and poor network operation.

10BASE5 (Coaxial Cable)

The IEEE 802.3 10BASE5 specification details the use of thick coaxial cabling and Attachment Unit Interface (AUI) cables. If a thick coaxial cable network does not meet the requirements listed here, operation of the 10BASE5 networking components may be adversely affected.

Cable Type

Cabletron Systems 10BASE5 transceivers are designed to be connected to IEEE 802.3-compliant 50 Ω thick coaxial cable with a core gauge of 12 AWG. If Cabletron Systems products are connected to other types of thin coaxial cable, the 10BASE5 network may be subject to errors and poor performance.

Termination

All 10BASE5 cables must be terminated at both ends of the cable with 50 Ω terminators. Any time an N-Type barrel connector or intrusive tap is removed from the thick coaxial cable segment, the segment or segments resulting from the cable split must be either reconnected or terminated at the resulting ends. Failure to terminate a thick coaxial cable segment can cause reflection of signal and the creation of excessive error conditions.

Connectors/Taps

10BASE5 cables may be terminated with intrusive (N-Type) connectors or tapped by coring through the cable to the transmissive core wire. Termination of the cable segment must be accomplished with intrusive connectors. Connectors or taps on the 10BASE5 cable must be spaced no less than 2.5 m (8.2 ft) from one another or the cable termination. If connectors are located closer to one another than this minimum, a loss of network performance may result.

One segment of 10BASE5 cabling can support up to 100 taps or intrusive connectors. This number does not count the terminating connectors at each end of the cable as taps.

Grounding

Each thick coaxial cable segment should be connected to earth ground at only one point. The connection to a ground should not be made through an N-Type connector unless the connection to the ground is made through the N-Type terminator at the end of the cable. The grounding wire must be connected to the outer metal shield of the coaxial cable and should be no longer than 10 m (3.28 ft). If insulated, grounding wires should be green in adherence with accepted wiring practice.

Length

10BASE5 specifications allow a thick coaxial cable segment to be no longer than 500 meters (1,646 ft). The use of longer cable segments can cause excessive error conditions and poor network performance.

Chapter 6

Full-Duplex Ethernet Network Requirements

This chapter provides test parameters and specification requirements for Full-Duplex Ethernet network cabling.

Full-Duplex 10BASE-T

All Cabletron Systems Full-Duplex 10BASE-T products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 10BASE-T products may be affected.

Note that Full-Duplex Ethernet links are dependent upon dedicated links from one Ethernet switch to another Ethernet switch or from one Ethernet switch to a single workstation. Both the end devices must be capable of operating in full-duplex mode.

Cable Type

Network operations using 10BASE-T are more demanding than normal telephony, and thus require specific, high-quality cabling in order to function properly. The 10BASE-T specification for Ethernet networks requires UTP cabling of Category 3, 4, or 5. Categories of UTP cabling below Category 3 may not meet the quality requirements of the networking specification, and may therefore be unable to meet the tested characteristics listed below.

The Category of cabling used in a network installation is dependent upon all the components that make up the cabling run. If an installation utilizes Category 5 cabling, and the wallplates and patch panels to which that cabling is connected are Category 3 compliant, the cable will not meet the EIA/TIA end-to-end specifications for a Category 5 installation.

Insertion Loss (Attenuation)

The maximum allowable insertion loss for any 10BASE-T station on the Ethernet network is 11.5 dB at frequencies from 5 to 10 MHz. This calculation must take all cabling devices in the cable path into account. A typical insertion loss test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

The insertion loss characteristics of a cable are one of the main determinants of link length allowed by the Ethernet and 10BASE-T specifications. As long as a UTP cable does not exceed the total insertion loss of 11.5 dB, it may be any length up to 200 m (656 ft). The 200 meter maximum total length is based on the total allowable propagation delay in the network, and cannot be exceeded.

NOTE

As longer cables are more susceptible to other limiting factors, Cabletron Systems does not recommend the installation of 10BASE-T cabling over 100 m in length.

Impedance

Cabletron Systems 10BASE-T equipment requires that 10BASE-T cables in the Ethernet network have an impedance within the range of 75 to 165 Ω. Typical UTP cables used in Ethernet environments have an impedance between 85 and 150 Ω.

Jitter

Jitter may be caused by intersymbol interference and reflection of signal. Networking technologies that rely on particular timing or clocking schemes may be affected by jitter due to excessive signal reflection. Any 10BASE-T cable installation should not exceed 5.0 ns of jitter. If a cable run meets the 10BASE-T impedance requirements (detailed above), jitter should not be a concern.

Delay

As Full-Duplex Ethernet operation eliminates the possibility of collisions occurring, total media length for a Full-Duplex link is determined by signal strength, noise, and jitter. Delay is not a factor in Full-Duplex Ethernet network cabling design.

Crosstalk

Crosstalk is electrical interference between wires. Crosstalk occurs when a cable strand absorbs signals from adjacent wires. Excessive crosstalk can be caused by a break in the insulation or shielding that separates wires from one another in a bundle.

Ethernet UTP cables should be checked for Near-End Crosstalk, or NEXT, at installation. The allowable amount of NEXT for a UTP cable is dependent upon the type of cable used in the installation.

25-Pair Cable

The acceptable amount of NEXT between pairs in a 25-pair cable is at least 60 dB for a 10 MHz link.

Four-Pair Cable

The acceptable amount of NEXT between pairs in a four-pair cable is not less than 60 dB for a 10 MHz link.

Noise

As "noise" is not a readily quantified and tested aspect of installed cables, there are no hard and fast rules for the amount of acceptable cable noise on a 10BASE-T segment. If a cable that meets all other requirements for 10BASE-T operation is experiencing an unusual number of errors, the introduction of noise may be a problem.

If you suspect that noise is causing signal degradation, examine the cable or cables in question. If they are near possible sources of outside noise, such as lighting fixtures, electric motors, or transformers, reroute the cable.

Other Considerations

Due to the small gauge of the wires which make up UTP cabling, it is susceptible to changes in attenuation due to heat. If the temperature at the installation site exceeds the control temperature of 20°C (68°F), the attenuation of PVC jacketed UTP cabling that is within the 11.5 dB limitations may fall outside the acceptable range. In installations where UTP cables are expected to be subjected to temperatures of 40° C (104° F) or greater, the use of plenum-jacketed cabling is recommended. The thicker insulating jacket of a plenum-rated cable reduces the susceptibility of that cable to heat-induced changes in attenuation characteristics.

The IEEE 802.3 10BASE-T specification requires that all 10BASE-T devices support UTP cables of not less than 100 m (328 ft) in length. This requirement does not factor in losses due to connectors, patch panels, punchdown blocks, or other cable management hardware, which introduce additional loss.

For each connector or other intrusive cable management device in the total link, subtract 12 m (39.4 ft) from the total allowable link length.

Length

The 10BASE-T standard specifies that any 10BASE-T compliant device must be capable of transmitting an Ethernet signal not less than 100 m (328 ft) over a UTP cable segment that meets the minimum quality values listed above. As long as all specifications are met for the entire length of the cable, UTP cable segments can be run up to a maximum allowable length of 200 m (656 ft).

NOTE

As longer cables are more susceptible to noise and other limiting factors, Cabletron Systems does not recommend the installation of 10BASE-T cabling over 100 m in length.

10BASE-F (Multimode)

All Cabletron Systems 10BASE-F and FOIRL products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 10BASE-F products may be affected.

Cable Type

Networking devices built to the 10BASE-F standard require specific types of cabling. The 10BASE-F multimode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following types of multimode fiber optics:

- 50/125 µm
- 62.5/125 µm
- 100/140 µm

Attenuation

Multimode fiber optic cables must be tested for attenuation with a fiber optic attenuation test set. The test set must be configured to determine attenuation of the cable at a wavelength of 850 nm. The attenuation test will confirm or deny that the cable falls within an acceptable level. The acceptable level of attenuation for a cable is dependent upon the type of multimode fiber optic cable being tested. The acceptable levels of attenuation for the types of multimode fiber optic cabling supported by Cabletron Systems products are listed in Table 6-1 below:

Table 6-1. Multimode Fiber Optic Attenuation Limits

Cable Type	Maximum Attenuation
50/125 µm	13.0 dB
62.5/125 µm	16.0 dB
100/140 µm	19.0 dB

Insertion Loss

The 10BASE-F specification allows for a total dB loss of 10.0 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

As is the case with Full-Duplex 10BASE-T operation, Full-Duplex 10BASE-F operation eliminates the possibility of collisions on a network link. Again, for interoperability with the half-duplex 10BASE-F specifications, Cabletron Systems recommends that a 10BASE-F link not exceed 5 km in length or 25.6 µs of total one-way propagation delay.

Length

The 10BASE-F specification limits a multimode fiber optic cable segment to 2 km or less. Assuming that a fiber optic cable meets all other limitations for 10BASE-F usage, it is possible to extend a multimode fiber optic link to an absolute maximum of 2 km. At a length of more than 2 km, the propagation delay introduced by the multimode fiber optic cable segment may exceed the 25.6 µs limit of the Ethernet specification and cause excessive OOW errors. Cabletron Systems does not recommend the installation or use of any multimode fiber optic cable segment that exceeds 10BASE-F limitations of 2 km.

Older networking equipment for fiber optic connections may be built to the FOIRL specification. FOIRL devices will support a multimode fiber optic link of up to 1 km.

Ethernet FOIRL (Single Mode)

All Cabletron Systems FOIRL products require that installed single mode fiber optic facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the FOIRL products may be affected.

Cable Type

FOIRL network devices require specific types of cabling. FOIRL single mode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following types of single mode fiber optics:

- 8/125 µm
- 12/125 µm

Some Cabletron Systems single mode fiber optic devices may be connected to multimode fiber optic cabling with measurements of 62.5/125 µm, but the greater optical loss characteristics of multimode fiber optics will limit the maximum distance of the single mode fiber optic signal to approximately 2 km. Connecting single mode devices to multimode fiber optic cabling is not recommended and is not compliant with the FOIRL specification.

Attenuation

Single mode fiber optic cabling must be tested with a fiber optic attenuation test set configured to determine attenuation of the cable at a wavelength of 1300 nm. The acceptable level of attenuation for a single mode fiber optic is less than or equal to 10.0 dB for any given link.

Insertion Loss

The FOIRL specification allows for a total loss of 10.0 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

If there is any signal path in the overall network whose total one-way propagation delay exceeds 25.6 µs, the Ethernet network is out of specifications, and error conditions may result. To eliminate propagation delay problems, incorporate some form of segmentation, such as bridging or routing, into the network to separate the problem signal paths from one another.

Length

The FOIRL specification limits single mode fiber optic cabling links to a total of 1 km or less. If a single mode fiber optic cable is used to form a link between two bridges and shares no connection with other Ethernet stations, the total segment length may reach up to 5 km, assuming all other requirements for a FOIRL network are met. At lengths over 5 km, propagation delays for the fiber optic link exceed the 25.6 µs limit of Ethernet networks. Cabletron Systems does not recommend the installation or use of any single mode fiber optic cable segment that exceeds the FOIRL limitations.

Chapter 7

Fast Ethernet Network Requirements

This chapter provides test parameters and specification requirements for Fast Ethernet network cabling.

100BASE-TX

All Cabletron Systems 100BASE-TX products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 100BASE-TX products may be affected.

Cable Type

The operation of a 100BASE-TX network is more demanding than that of standard Ethernet, and high-quality cables are required. The 100BASE-TX specification for Fast Ethernet networks requires UTP cabling Category 5. Categories of UTP cabling below Category 5 may not meet the quality requirements of the networking specification, and may therefore be unable to meet the tested characteristics listed below.

The Category of cabling used in a network installation is dependent upon all the components that make up the cabling run. If an installation utilizes Category 5 cabling, and the wallplates and patch panels to which that cabling is connected are Category 3 compliant, the cable does not meet the EIA/TIA end-to-end specifications for a Category 5 installation.

NOTE

Due to the construction of the connectors and organization of wires, the 25-pair RJ21 connector is not Category 5 compliant.

The TIA/EIA 568A cabling specification for Category 5 compliant UTP installations allows the use of two different types of cable: horizontal wire and patch wire. The specification allows horizontal wire to be used to cover distances of up to 90 m, while patch wire is restricted to a maximum length of 10 m.

NOTE
A third type of TIA/EIA 568 A cabling, **backbone wire**, does not apply to this implementation of the 100BASE-TX standard, and is not discussed in this chapter.

Horizontal wire must be constructed with solid core wires. Horizontal wire is intended to be used as the "in-the-wall" cabling of the network. Patch wire is constructed with more flexible stranded core wires, and is useful in situations where bending or movement of the wire is expected. Patch wire should only be used for connections between punchdown blocks, patch panels, or workstations.

Insertion Loss (Attenuation)

The maximum allowable insertion loss for any 100BASE-TX station on the Fast Ethernet network is 24.0 dB at a frequency of 100 MHz. This calculation must take all cabling devices in the cable path into account. A typical insertion loss test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

Impedance

Cabletron Systems 100BASE-TX equipment requires that 100BASE-TX cables in the Fast Ethernet network have an impedance within the range of 75 to 165 Ω. Typical UTP cables used in Fast Ethernet environments have an impedance between 85 and 111 Ω.

Jitter

Jitter may be caused by intersymbol interference and reflection of signal. Networking technologies that rely on particular timing or clocking schemes may be affected by jitter due to excessive signal reflection. Any 100BASE-TX cable installation should not exceed 1.4 ns of jitter. If a cable run meets the 100BASE-TX impedance requirements (detailed above), jitter should not be a concern.

Delay

The maximum propagation delay allowable on a 100BASE-TX segment is 1 microsecond (μs). If a Fast Ethernet signal is unable to traverse the entire length of an installed UTP cable run within 1 μs, Out of Window (OOW) errors will occur due to excessive delays between transmission of signals and notification of collisions. This propagation delay requirement limits UTP cabling to a total maximum length of 100 m (328 ft).

Crosstalk

Fast Ethernet UTP cables should be checked for Near-End Crosstalk, or NEXT, at installation. The acceptable amount of NEXT between pairs in a four-pair cable is not less than 27 dB for a 100 MHz link.

Noise

As “noise” is not a readily quantified and tested aspect of installed cables, there are no hard and fast rules for the amount of acceptable cable noise on a 100BASE-TX segment. If a cable that meets all other requirements for 100BASE-TX operation is experiencing an unusual number of errors, the introduction of noise may be a problem.

If you suspect that noise is causing signal degradation, examine the cable or cables in question. If they are near possible sources of outside noise, such as lighting fixtures, electric motors, or transformers, reroute the cable.

Other Considerations

Due to the small gauge of the wires in a UTP cable, it is susceptible to changes in attenuation due to heat. In an installation that exceeds the control temperature of 20° C (68° F), the attenuation of PVC jacketed UTP cabling that is within the 11 dB limitations may fall outside the acceptable range of attenuation. In installations where UTP cables are expected to be subjected to temperatures of 40° C (104° F) or greater, the use of plenum-jacketed cabling is recommended. The thicker insulating jacket of a plenum-rated cable reduces the susceptibility of that cable to heat-induced changes in attenuation characteristics.

The IEEE 802.3 100BASE-TX specification requires that all 100BASE-TX devices support UTP cables up to 100 m (328 ft) in length. This requirement does not factor in losses due to connectors, patch panels, punchdown blocks, or other cable management hardware, which introduce additional loss.

For each connector or other intrusive cable management device in the total link, subtract 12 m (39.4 ft) from the total allowable link length for purposes of estimation.

100BASE-FX (Multimode)

All Cabletron Systems 100BASE-FX products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 100BASE-FX products may be affected.

Cable Type

Networking devices built to the 100BASE-FX specification require specific types of cabling. 100BASE-FX multimode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from 62.5/125 μm multimode fiber optics.

Attenuation

Multimode fiber optic cables must be tested for attenuation with a fiber optic attenuation test set. The test set must be configured to determine attenuation of the cable at a wavelength of 850 nm. The attenuation test will confirm or deny that the cable falls within an acceptable level. The acceptable level of attenuation for a 100BASE-FX cable is 11.0 dB.

Insertion Loss

The 100BASE-FX specification allows for a total dB loss of 10.0 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

As fiber optic cabling is often used to make connections between Fast Ethernet repeaters or hubs, the 100BASE-FX specification allows a multimode fiber optic link to be configured such that the total propagation delay for the link is less than or equal to 2.56 µs one-way. Keep in mind, however, that propagation delay must be calculated for the entire network. If there are more stations than the one connected by your fiber optic link, you must also calculate the propagation delay for the longest of those station links.

If the total one-way propagation delay of any signal path exceeds 2.56 µs, the Fast Ethernet network is out of specifications, and error conditions may result. To eliminate propagation delay problems, incorporate some form of segmentation, such as bridging or routing, into the network to separate the problem signal paths from one another.

Length

The 100BASE-FX specification limits a multimode fiber optic cable segment to 412 m or less. Assuming that a fiber optic cable meets all other limitations for 100BASE-FX usage, it is possible to extend a multimode fiber optic link to an estimated maximum of 2 km. At a length of more than 2 km, the propagation delay introduced by the multimode fiber optic cable segment may exceed the 2.56 µs limit of the Fast Ethernet specification and cause excessive OOW errors. Cabletron Systems does not recommend the installation or use of any multimode fiber optic cable segment that exceeds 100BASE-FX limitations of 412 m.

Hybrid Installations

In Fast Ethernet networks, the combining of fiber optic and unshielded twisted pair media in a single, repeated network requires calculating a network radius. This is because the delay requirements for a Fast Ethernet network are so demanding that a mixed-media network must take the differences between the standard media into account.

The network radius is the calculation of the longest path in the Fast Ethernet repeater domain (from one station to a Fast Ethernet repeater and out to another station). Figure 7-1 shows an example of a mixed media Fast Ethernet repeater domain.

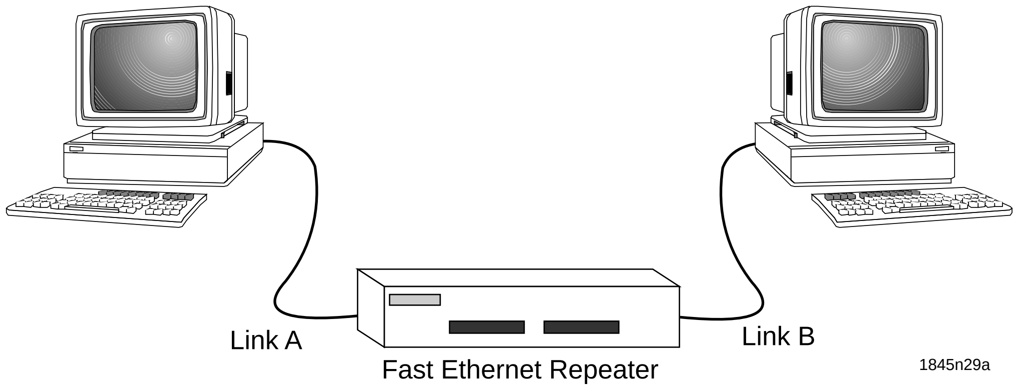


Figure 7-1. Fast Ethernet Network Radius

If the two longest links in the Fast Ethernet repeater domain are both made using UTP cable, each UTP segment may be 100 m in length, for a total network radius of 200 m. If these links were both made using multimode fiber optics, the allowable maximum network radius would be 272 m, less than that allowed by a repeater with a single 100BASE-FX link.

When media are mixed in a Fast Ethernet network, the allowable network radius changes slightly. In a mixed UTP and multimode fiber optic network, the maximum radius is 263 m. This means that the longest UTP segment in the Fast Ethernet network may be up to 100 m, and the longest 100BASE-FX link may be 160 m. The maximum network radius for each Fast Ethernet media configuration is provided in Table 7-1.

Repeater Classes

Repeaters in Fast Ethernet networking are divided into two categories, or "classes" by the 100BASE-TX standard. The difference between these Class I and Class II repeaters is the method each uses to handle received signals for transmission. The different techniques result in different rules of configuration for a Fast Ethernet network.

Class I repeaters receive the 100BASE-TX electrical signal on one interface and translate that signal from its electrical form into a digital series, much in the same way that a Fast Ethernet station receives a transmission. The Class I repeater then generates a new signal on each of its interfaces using the translated digital series. The Class I repeater does not make any decisions based of the received signal, nor does it perform any error-checking. The translation of the received signal is intended to improve the strength and validity of the repeated Fast Ethernet frame.

The Class II repeater receives and immediately repeats each received transmission without performing any translation. The repeating process is a simple electrical duplication and strengthening of the signal.

The design and operation of these different repeater types result in different operating characteristics and network limitations. Class I repeaters, by translating the received signal, produce a stronger repeated transmission. The translation process, however, takes up a number of microseconds. This additional delay reduces the total distance a signal may travel before the allowable delay for that transmission has elapsed. While Class II repeaters are faster, the signals they produce are less precise, and they cannot connect to different media types.

These differences mean that, in any Fast Ethernet network, there may be a maximum of one Class I **or** two Class II repeaters between any two end stations. These implementations also result in different maximum network radii, as shown in Table 7-1.

Buffered Uplinks

Several Fast Ethernet devices support the incorporation of buffered uplinks to help alleviate the pressures placed on network design by the small network radius of Fast Ethernet networks. The buffered uplink acts as a non-filtering bridge, providing little more than retiming and regeneration of signals. In effect, the buffered uplink provides only the distance characteristics of a bridged connection. Fast Ethernet networks that incorporate a buffered uplink effectively extend the maximum network radius. The multimode fiber optic buffered uplink can be up to 400 m in length. The overall allowable network radius for Fast Ethernet networks that incorporate buffered uplinks are also provided in Table 7-1.

Table 7-1. Fast Ethernet Maximum Network Radii

Repeater Class	UTP	UTP & Fiber Optics	Fiber Optics	UTP & Buffered Uplink	Fiber Optics and Buffered Uplink
Class I	200 m	260 m	272 m	500 m	800 m
Class II	200 m	N/A	320 m	N/A	N/A

Chapter 8

Full-Duplex Fast Ethernet Network Requirements

This chapter provides test parameters and specification requirements for Full-Duplex Fast Ethernet network cabling.

100BASE-TX

All Cabletron Systems 100BASE-TX products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 100BASE-TX products may be affected.

It is important to remember that full-duplex Fast Ethernet operation requires dedicated single links from one port of a Fast Ethernet switch to another Fast Ethernet switch or a Fast Ethernet workstation. If both endstations are not capable of full-duplex operation, a standard Fast Ethernet link will be automatically established.

Cable Type

100BASE-TX network operations are more demanding than those of standard Ethernet, and high-quality cables are required. The 100BASE-TX specification for Fast Ethernet networks requires UTP cabling meeting Category 5 specifications. Categories of UTP cabling below Category 5 may not meet the quality requirements of the networking specification, and may therefore be unable to meet the tested characteristics listed below.

The Category of cabling used in a network installation is dependent upon all the components that make up the cabling run. If an installation utilizes Category 5 cabling, and the wallplates and patch panels to which that cabling is connected are Category 3 compliant, the cable does not meet the EIA/TIA end-to-end specifications for a Category 5 installation.

Insertion Loss (Attenuation)

The maximum allowable insertion loss for any 100BASE-TX station on the Fast Ethernet network is 11.5 dB at frequencies from 5 to 10 MHz. This calculation must take all cabling devices in the cable path into account. A typical insertion loss test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

The insertion loss characteristics of a cable are one of the main determinants of link length allowed by the Fast Ethernet and 100BASE-TX specifications. As long as a UTP cable does not exceed the total link length of 11.5 dB, it may be any length up to 100 m (328 ft). The 100 meter maximum total length is based on the total allowable propagation delay in the network, and cannot be exceeded.

NOTE

As longer cables are more susceptible to other limiting factors, Cabletron Systems does not recommend the installation of 100BASE-TX cabling over 100 m in length.

Impedance

Cabletron Systems 100BASE-TX equipment requires that 100BASE-TX cables in the Fast Ethernet network have an impedance within the range of 75 to 165 Ω. Typical UTP cables used in Fast Ethernet environments have an impedance between 85 and 111 Ω.

Jitter

Jitter may be caused by intersymbol interference and reflection of signal. Networking technologies that rely on particular timing or clocking schemes may be affected by jitter due to excessive signal reflection. Any 100BASE-TX cable installation should not exceed 1.4 ns of jitter. If a cable run meets the 100BASE-TX impedance requirements (detailed above), jitter should not be a concern.

Crosstalk

Crosstalk is electrical interference between wires. Crosstalk occurs when a cable strand absorbs signals from other wires that it is adjacent to. Excessive crosstalk can be caused by a break in the insulation or shielding that separates wires from one another in a bundle.

Fast Ethernet UTP cables should be checked for Near-End Crosstalk, or NEXT, at installation. The allowable amount of NEXT for a UTP cable is dependent upon the type of cable used in the installation.

25-Pair Cable

The acceptable amount of NEXT between pairs in a 25-pair cable is at least 60 dB for a 10 MHz link.

NOTE Due to the construction of the connectors and organization of wires, the 25-pair RJ21 connector is not Category 5 compliant.

Four-Pair Cable

The acceptable amount of NEXT between pairs in a four-pair cable is not less than 60 dB for a 10 MHz link.

Noise

As “noise” is not a readily quantified and tested aspect of installed cables, there are no hard and fast rules for the amount of acceptable cable noise on a 100BASE-TX segment. If a cable that meets all other requirements for 100BASE-TX operation is experiencing an unusual number of errors, the introduction of noise may be a problem.

If you suspect that noise is causing signal degradation, examine the cable or cables in question. If they are near possible sources of outside noise, such as lighting fixtures, electric motors, or transformers, reroute the cable.

Other Considerations

Due to the small gauge of the wires in UTP cabling, it is susceptible to changes in attenuation due to heat. In an installation that exceeds the control temperature of 20° C (68° F), the attenuation of PVC jacketed UTP cabling that is within the 11.5 dB limitations may fall outside the acceptable range. In installations where UTP cables are expected to be subjected to temperatures of 40° C (104° F) or greater, the use of plenum-jacketed cabling is recommended. The thicker insulating jacket of a plenum-rated cable reduces the susceptibility of that cable to heat-induced changes in attenuation characteristics.

The IEEE 802.3 100BASE-TX specification requires that all 100BASE-TX devices support UTP cables of not less than 100 m (328 ft) in length. This requirement does not factor in losses due to connectors, patch panels, punchdown blocks, or other cable management hardware, which introduce additional loss.

For each connector or other intrusive cable management device in the total link, subtract 12 m (39.4 ft) from the total allowable link length.

Length

The 100BASE-TX standard specifies that any 100BASE-TX compliant device must be capable of transmitting a Fast Ethernet signal not less than 100 m (328 ft) over a UTP cable segment that meets the quality values listed above. As long as all specifications are met for the entire length of the cable, UTP cable segments can be run up to a maximum allowable length of 260 m (852 ft).

NOTE

As longer cables are more susceptible to noise and other limiting factors, Cabletron Systems does not recommend the installation of 100BASE-TX cabling over 100 m in length.

100BASE-FX (Multimode)

All Cabletron Systems 100BASE-FX products require that installed facility cabling and cable hardware meet the following minimum specifications. If a network cabling installation is not within the limitations presented here, the operation of the 100BASE-FX products may be affected.

Cable Type

Cabletron Systems 100BASE-FX network devices require specific types of cabling. 100BASE-FX multimode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following types of multimode fiber optics:

- 50/125 µm
- 62.5/125 µm
- 100/140 µm

Attenuation

Multimode fiber optic cables must be tested for attenuation with a fiber optic attenuation test set. The test set must be configured to determine attenuation of the cable at a wavelength of 850 nm. The attenuation test will confirm or deny that the cable falls within an acceptable level. The acceptable level of attenuation for a 100BASE-FX cable is 11.0 dB.

Insertion Loss

The 100BASE-FX specification allows for a total dB loss of 10 dB or less between any two stations or devices connected by fiber optic cabling. When calculating insertion loss, you must consider and count any loss introduced by fiber optic splices, barrel connectors, distribution boxes or other cable management devices. The typical dB loss for a splice or a connector is less than 1 dB. The loss statistics for any fiber optic cable management hardware should be available from the manufacturer.

Delay

As fiber optic cabling is often used to make connections between Fast Ethernet repeaters or hubs, the 100BASE-FX specification allows a multimode fiber optic link to be configured such that the total propagation delay for the link is less than or equal to 2.56 µs one-way. Keep in mind, however, that propagation delay must be calculated for the entire network. If there are more stations than the one connected by your fiber optic link, you must also calculate the propagation delay for the longest of those station links.

If there is any signal path whose total one-way propagation delay exceeds 2.56 μs, the Fast Ethernet network is out of specifications, and error conditions may result. To eliminate propagation delay problems, incorporate some form of segmentation, such as bridging or routing, into the network to separate the problem signal paths from one another.

Length

The 100BASE-FX specification limits a multimode fiber optic cable segment to 412 m or less. Assuming that a fiber optic cable meets all other limitations for 100BASE-FX usage, it is possible to extend a multimode fiber optic link to an estimated maximum of 2 km. At a length of more than 2 km, the propagation delay introduced by the multimode fiber optic cable segment may exceed the 2.56 μs limit of the Fast Ethernet specification and cause excessive OOW errors. Cabletron Systems does not recommend the installation or use of any multimode fiber optic cable segment that exceeds 100BASE-FX limitations of 412 m.

Chapter 9

Token Ring Media

This chapter examines the physical characteristics and requirements of both cabling and the connectors and ports used in Token Ring networks.

Cabling Types

Shielded Twisted Pair (STP)

Shielded Twisted Pair cabling is a multistranded cable most often constructed of eight 26 AWG conductive copper solid or stranded core wires. Each wire is surrounded by a non-conductive insulating material such as Polyvinyl Chloride (PVC). These wires are twisted around one another in a specific arrangement to form pairs. The pairs are made up of associated wires - transmit wires are paired with transmit wires, receive wires are paired with receive wires.

Each pair in the STP cable is then surrounded by a metallic foil shield that runs the length of the cable. Some types of STP incorporate an additional braided or foil shield that surrounds each of the shielded pairs in the cable. The overall cable is wrapped in an insulating jacket which covers the shields and holds the wires together.

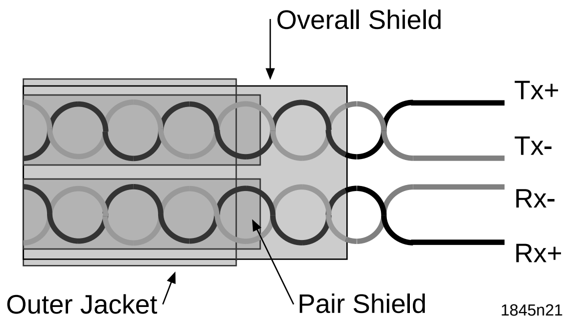


Figure 9-1. STP Cable Pair Association

Twisting the pairs together throughout the cable helps to reduce the effects of externally-induced electrical noise on the signals that pass through the cable. In each pair, one wire carries the normal network signal, while its associated wire carries a copy of the transmission that has been inverted.

The twisting of associated pairs helps to reduce the interference of the other strands of wire throughout the cable. This is due to the method of transmission used with twisted pair transmissions.

In any transceiver or Desktop Network Interface Card (DNI or NIC), the network protocol signals to be transmitted are in the form of changes of electrical state. The means by which the ones and zeroes of network communications are turned into these signals is called encoding. In a twisted pair environment, once a transceiver has been given an encoded signal to transmit, it copies the signal and inverts the voltage (see Figure 9-2). The result of this inverted signal is a mirror opposite of the original signal.

Both the original and the inverted signal are then transmitted, the original signal over the TX + transmit wire, the inverted signal over the TX - wire. As these wires are the same length, the signal travels at the same rate (propagates) through the cable. Since the pairs are twisted together, any outside electrical interference that affects one member of the pair will have the same effect on the other member of that pair.

The transmission travels through the cable, eventually reaching a destination transceiver. At this location, both signals are read in. The original signal is unchanged, but the signal that had previously been inverted is reverted to the original state. When this is done, it returns the encoded transmission to its original state, but reverses the polarity of any signal interference that the encoded transmission may have suffered.

Once the inverted transmission has been returned to the normal encoded state, the transceiver adds the two signals together. As the encoded transmissions are now identical, there is no change to the data content. Line noise spikes, however, are combined with noise spikes of their exact opposite polarity, causing them to cancel one another out.

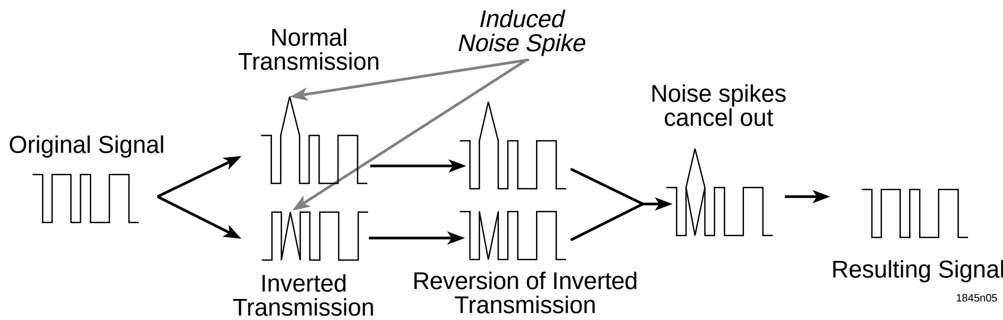


Figure 9-2. Twisted Pair Signal Equalization

STP cable is made up of four or more wires, and each wire within the cable has a specific insulator color. These colors are part of the IEEE specifications to which the cable construction process must be held. Each color identifies a particular usage for the cable. The four standard colors are black, red, green, and orange. Table 9-1, below, identifies the type of signal that each wire carries.

Table 9-1. STP Cable Wire Identifications

Cable Color	**Application**
Black	TX -
Red	RX +
Green	RX -
Orange	TX +

STP cabling is available in several different arrangements and construction styles, called Types. The type definitions are based on the IBM cabling system. STP cabling that may be used in Token Ring environments falls into four types, called Type 1, Type 2, Type 6, and Type 9. Any of these cable Categories can be used in a Token Ring installation, provided that the requisite IEEE 802.5 specifications regarding the cables are met.

Type 1

Type 1 STP consists of two pairs of solid 22 AWG copper strands. Each strand, approximately 0.02 inch thick, is surrounded by a layer of insulation. The characteristics of the insulation is determined by the fire resistance construction of the cable (plenum cable is thicker and made with slightly different material than normal PVC cabling).

The individual wires are twisted into pairs. The pairs that are formed by this twisting are then surrounded by a mylar foil shield. These shielded pairs are then laid alongside one another in an overall braided metal shield. The shield containing the twisted pairs is then surrounded by a tight outer covering. Type 1 STP is heavy and rather inflexible, but provides excellent resistance to interference and noise due to its construction characteristics. Type 1 STP is most commonly used as a facility cabling, while more flexible cabling is used for jumper cables and patch panel connections.

Type 2

IBM Type 2 cable is constructed in much the same fashion as Type 1 cable. The two central shielded pairs and the overall braided shield which surrounds them are constructed of the same materials, and then two additional pairs of AWG 22 insulated solid copper wires are laid outside the braided shield before the whole cable is surrounded by the tight outer covering. These outer wires may be used to carry telephone traffic, as the shields surrounding the inner, network wires is intended to eliminate the interference that might otherwise occur between the inner and outer pairs.

NOTE

Cabletron Systems does not recommend combining active voice and data wiring in the same cable. Degradation of network performance may result from any non-standard uses of cable.

The added pairs of wire in a Type 2 cable make it even less flexible than Type 1 cable. For this reason, it is typically used as facility cable. Lighter-gauge, more flexible cable types, such as Types 6 and 9, discussed below, are frequently used as patch cables between networking hardware and Type 2 cable.

Type 6

Type 6 cable uses the same dual-shielded construction that Type 1 and Type 2 cable use, but the materials used in the construction are of a narrower gauge. The wires that make up the twisted pairs in a Type 6 cable are constructed of 26 AWG stranded conductors.

The construction materials used in Type 6 cabling make it a much more flexible form of STP, but greatly reduce the cable’s ability to carry network signals over long distances. Type 6 cable is intended for use as jumper or patch panel cabling only.

Type 9

Type 9 cable is similar in construction to Type 6 cable, and is intended to be used for the same purposes. The center strands of a Type 9 cable are made of either solid or stranded 26 AWG conductors.

Unshielded Twisted Pair (UTP)

Unshielded Twisted Pair cabling (referred to here as UTP) is commonly made up of two or four pairs of 22, 24, or 26 AWG unshielded copper solid or stranded wires. These pairs of wires are twisted together throughout the length of the cable. These twisted pairs of wire within the UTP cable are broken up into transmit and receive pairs. The UTP cable used in network installations is the same type of cable used in the installation of telephone lines within buildings. UTP cabling is differentiated by the quality category of the cable itself, which is an indicator of the type and quality of wire used and the number of times the wires are twisted around each other per foot. The categories range from Category 1 to Category 5, with Category 5 cabling being of the highest quality.

The wires that make up a length of UTP cable are numbered and color coded. These color codes allow the installer of the networking cable to determine which wires are connected to the pins of the RJ45 ports or patch panels. The numbering of the wires in USOC standard cables is based on the color of the insulating jacket that surrounds the core of each wire.

Each jacket will have an overall color: brown, blue, orange, green, or white. In a 4-pair UTP cable (the typical UTP used in networking installations) there will be one wire each of brown, blue, green, and orange, and four wires whose overall color is white. The white wires will be distinguished from one another by periodically placed (usually within 1/2 inch of one another) rings of the other four colors.

Wires with a unique base color are identified by that base color: blue, brown, green, or orange. Those wires that are primarily white are identified as white/<color>, where <color> indicates the color of the rings of the other four colors in the white insulator.

The association of pairs of wire within the UTP cable jacket are decided by the specifications to which the cable is built. There are two main specifications in use around the world for the production of UTP cabling: EIA/TIA 568 and USOC. The two wiring standards are different from one another in the way that the wires are associated with one another throughout the cable.

The arrangement of the wires in the two specifications does not affect the usefulness of the resultant cables for Token Ring networking. The arrangement of the wires and pairs in the EIA/TIA and USOC specifications is discussed in the UTP Cable portion of the **Connector Types** section of this chapter.

While UTP cables are usually built to provide four pairs of wire, IEEE 802.5 standards only require the use of two pairs, referred to as Pair 1 and Pair 2 (Pair 1 and Pair 3 of the EIA/TIA 568A specification). Pair 2 of the connector is the transmit pair and Pair 1 of the connector is the receive pair. This organization of wires at the connector is referred to as a pinout. Pinouts will be discussed in greater detail in the **Connector Types** section of this chapter.

Table 9-2. IEEE 802.5 Wire Use

Wire Color	USOC Pair	Token Ring Signal Use	
		568A	568B
White/Blue (W-BL)	Pair 1 Pins 3 and 4	TX+	RX+
Blue (BL)		TX-	RX-
White/Orange (W-OR)	Pair 2 Pins 2 and 5	RX+	TX+
Orange (OR)		RX-	TX-
White/Green (W-GR)	Pair 3 Pins 1 and 6	Not Used	
Green (GR)			
White/Brown (W-BR)	Pair 4 Pins 7 and 8	Not Used	
Brown (BR)			

NOTE

Do not split pairs in a twisted pair installation. While you may consider combining your voice and data cabling into one piece of horizontal facility cabling, the crosstalk and interference produced by this practice greatly reduces the viability of the cable for either application. The use of the pairs of cabling in this fashion can also prevent the future usage of advanced networking technologies that require the use of all four pairs in a twisted pair cable.

UTP cabling is produced in a number of overall quality levels, called Categories. The requirements of networking limit UTP cabling for Token Ring to Categories 3, 4, or 5. Any of these cable Categories can be used in a Token Ring installation, provided that the requisite IEEE 802.5 specifications regarding the cables are met.

Category 3

UTP cabling that is built to the Category 3 specification consists of two or more pairs of solid 24 AWG copper strands. Each strand, approximately 0.02 inch thick, is surrounded by a layer of insulation. The characteristics of the insulation are determined by the fire resistant construction of the cable (plenum cable is thicker and made with slightly different material than normal PVC cabling).

The individual wires are twisted into pairs. The twisted pairs of cable are laid together along with a thin nylon cord. This "ripcord" is useful for stripping the outer jacket of the cable, which may be low-smoke PVC plastic or a plenum-rated insulating material. The outer jacket surrounds, but does not adhere to, the wire pairs which make up the cable.

Category 3 UTP cabling must not produce an attenuation of a 16 MHz signal greater than 40 dB/305 m (1000 ft) at the control temperature of 20° C.

Category 4

Category 4 UTP cabling is constructed in the same manner as the Category 3 cabling discussed previously. Category 4 UTP is constructed using copper center strands of 24 or 22 AWG. Each strand is insulated and twisted together with another strand to form a pair. The resulting wire pairs are then covered by a second layer of insulating jacketing.

Category 4 UTP must not produce an attenuation of a 16 MHz signal greater than 27 dB/305 m (1000 ft) at the control temperature of 20° C.

Category 5

Category 5 UTP cabling is manufactured in the same fashion as Category 3 cable, but the materials used are of higher quality and the wires that make up the pairs are more tightly wound.

Category 5 UTP consists of 2 or more pairs of 22 or 24 AWG wire. Category 5 cable is constructed and insulated such that the maximum attenuation of a 16 MHz signal in a cable run at the control temperature of 20° C is 0.655 dB/m (25 dB/1000 ft). A cable that has a higher maximum attenuation than 0.655 dB/m does not meet the Category 5 requirements.

Fiber Optics

Fiber optic cable is a high performance media constructed of glass or plastic that uses pulses of light as a transmission method. Because fiber optics do not utilize electrical charges to pass data, they are free from the possibility of interference due to proximity to electrical fields. This, combined with the extremely low rate of signal degradation and dB loss makes fiber optics able to traverse extremely long distances. The actual maximums are dependent upon the architecture being used, but distances up to 10 km (6.2 miles) are not uncommon.

Glass optical fiber is made up of a glass strand, the core, which allows for the easy transmission of light, the cladding, a glass layer around the core that helps keep the light within the core, and a plastic buffer that protects the cable.

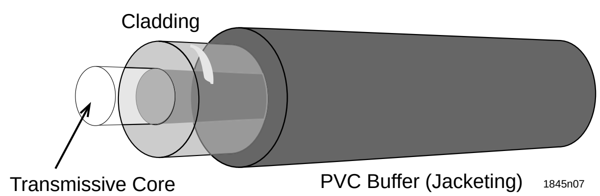


Figure 9-3. Fiber Optic Cable Construction

There are two basic types of fiber optics: multimode and single mode. The names come from the types of light used in the transmission process. Multimode fiber uses inexpensive Light Emitting Diodes (LEDs) that produce light of a single color. Due to the nature of the LED, the light produced is made up of a number of differing wavelengths of light, fired outward from the center of the LED. Not all the rays of light enter the fiber, and those that do often do so at an angle, which reduces the amount of distance the signal can effectively cover. Single mode fiber optics use lasers to achieve greater maximum distances. Since light from a laser is all of the same wavelength, and travels in a coherent ray, the resulting signal tends to be much clearer at reception than an LED signal under the same circumstances.

Fiber optics of both types are measured and identified by a variety of means. The usual means of referring to a fiber optic cable type is to identify if it is single mode or multimode, and to describe the thickness of each strand. Fiber optics are very thin, and the width of each strand is measured in microns (µm). Two measurements are important in fiber optic identification: the diameter of the core, where signals travel, and the diameter of the cladding, which surrounds the core. Thus, fiber optic measurements will usually provide two numbers separated by the "/" symbol. The first number is the diameter, in microns, of the core. The second is the diameter of the cladding. Thus, a 62.5/125 multimode cable is a type of fiber optic cabling with a 62.5 micron core and 125 micron cladding, which can be used by inexpensive LED equipment, as it allows multiple modes of light to pass through it. Incidentally, 62.5/125 µm multimode cabling is a very common type of fiber optics.

In much the same way that UTP cabling is available in two-, four-, 25-, and 50-pair cables, strands of fiber optic cabling are often bound together with other strands into multiple strand cables. These multiple strand cables are available with anywhere from two to 24 or more strands of fiber optics, all gathered together into one protective jacket.

TIP

Cabletron Systems recommends that customers planning to install fiber optic cabling not install any facility fiber optics (non-jumper cabling) containing fewer than six strands of usable optical fiber. The minimum number of strands needed to make an end-to-end fiber optic link between two network devices is **two**. In the event that a strand within the cable is damaged during installation or additional fiber pairs become desired along the cable path, the availability of extra strands of optical fiber will reduce the likelihood that a new cable must be pulled. The existing, unused pairs of optical fiber can be terminated and used immediately.

Multimode

Multimode fiber optic cabling is designed and formulated to allow the propagation of many different wavelengths, or modes, of light. Multimode fiber optics are the most commonly encountered fiber type in network installations, due to their lower cost compared to other fiber types.

Token Ring fiber optic devices that meet the IEEE 802.5j specification are terminated with ST connectors. Older network installations may utilize the IBM biconic connector or the Sub-Miniature Assembly (SMA) connector.

Single Mode

Single mode fiber optics are designed specifically to allow the transmission of a very narrow range of wavelengths within the core of the fiber. As the precise wavelength control required to accomplish this is performed using lasers, which direct a single, narrow ray of light, the transmissive core of single mode fiber optics is typically very small (8 to 12 µm). Single mode fiber is more expensive to produce than multimode fiber, and is typically used in long-haul applications.

Due to the very demanding tolerances involved in connecting two transmissive media with diameters approximately one-quarter as thick as a sheet of paper, single mode fiber optics require very precise connectors that will not move or shift over time. For this reason, single mode fiber optics should only be terminated with locking, preferably keyed, connectors. Token Ring fiber optic installations must use the ST connector to be compliant with the IEEE 802.5j specification.

Connector Types

STP

Medium Interface Connector (MIC)

The Medium Interface Connector is a genderless connector that is designed to be used with IBM Type 6 and Type 9 STP cabling. The MIC connector may also be used on Type 1 or Type 3 STP cabling.

The design of the MIC connector allows it to be properly and securely connected to any other Token Ring MIC connector. It is made up of a plastic outer shell and four gold-plated contacts arranged in two rows of two each, as shown in Figure 9-4.

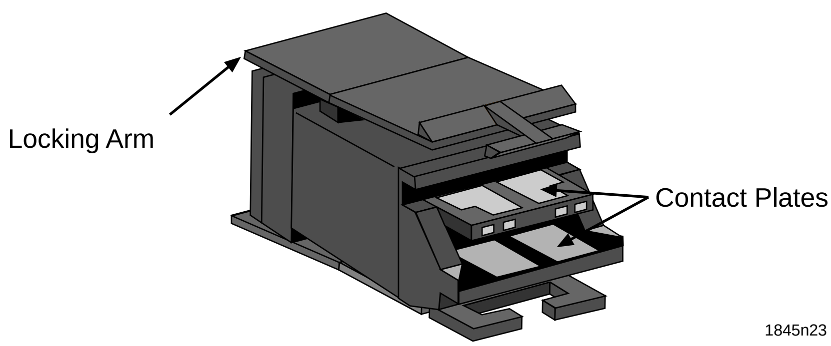


Figure 9-4. The Medium Interface Connector

The design of the MIC connector allows it to internally self-short. Spring-release mechanisms within the connector open the transmit and receive paths in the MIC connector when it is properly attached to another MIC connector. Once unplugged, the paths are looped back onto one another, allowing Token Ring signals to travel back through the cable and remain in the Token Ring network, keeping the ring whole. This helps prevent error conditions from occurring every time a station or cable is unplugged.

Attaching a MIC connector to the end of an STP cable run is relatively simple to understand, as the pins of the MIC connector are color coded in the same manner as the wires of the STP cable. To attach the connector, the individual wires of the STP cable are attached to the four pins in the arrangement shown by the color coded posts that hold the wires once the connector is assembled.

DB9

The DB9 connector is a smaller standard connector for IEEE 802.5 networking applications, typically used for desktop and networking hardware connections. It is used in locations where a sturdy connection to STP cabling is required, but the use of MIC connectors is either impossible or undesirable. The DB9 cabling is usable on all types of STP cabling, but is most commonly found on jumper cabling such as IBM Types 6 and 9.

The DB9 connector is a metal or composite shell with nine pins or channels at the end of the connector, arranged in two staggered rows. The pins are numbered from one to nine, beginning with the upper row of five pins or channels, that are numbered one to five, starting from the far right pin. The lower four pins are numbered from six to nine, beginning also at the far right. The arrangement of pins in the DB9 connector is shown in Figure 9-5, below.

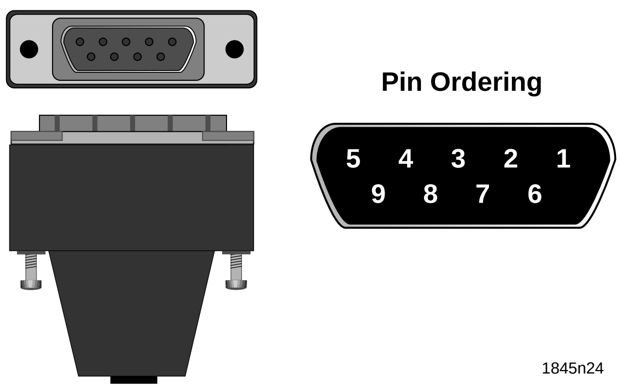


Figure 9-5. DB9 Pin Arrangement

The male DB9 connector housing, or shell, also incorporates two securing screws. These screws are used to secure the DB9 connector to a female DB9 connector and hold it in place. The screws of a DB9 connector should always be used to ensure a solid connection between two connectors, otherwise, disconnection of the cable or damage to the connectors may result.

NOTE

The DB9 connector looks identical to the PC EGA monitor connector. If a Token Ring lobe connection is attached to the monitor port, the Token Ring network will enter an error state. This is due to the resemblance that EGA monitor current has to the phantom current required to open a Token Ring lobe connection.

The DB9 connector does not perform a wrap on disconnect as does the larger MIC connector. There is no internal mechanism for performing these operations. Stations connected to networking hardware with DB9 connectors rely on the networking hub to perform any wrapping in the event of a disconnection or cable error.

STP wires that are connected to a DB9 cable must be set up in the fashion detailed below:

Table 9-3. IEEE 802.5 DB9 Pinouts

STP Wire Color	IEEE 802.5 Signal	DB9 Pinout
Black	TX -	1
Green	RX -	5
Orange	TX +	6
Red	RX +	9

RJ45

The shielded RJ45 connector used with STP cable is identical in shape to the standard RJ45 connector used in other network applications such as Ethernet and FDDI TP-PMD. The difference between the shielded RJ45 and the standard RJ45 is the addition of a metal shielding ground to the plastic housing of the RJ45 connector. This shield is connected to the braided outermost shield of the STP cable.

The connector itself is a rectangular keyed connector with a locking clip. The RJ45 connector can only be inserted into an RJ45 port in its proper alignment, and, when inserted, will lock into place. Due to the lighter construction characteristics of the RJ45 connector in comparison with the other STP cable connectors, care should be taken to ensure that the strain placed on an RJ45 connection is minimized through proper use of cable management hardware.

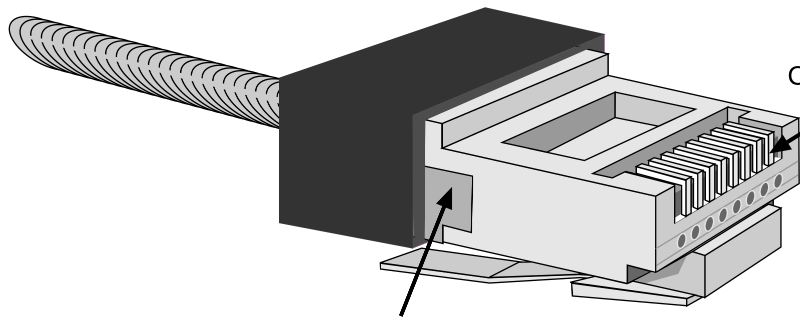


Figure 9-6. The Shielded RJ45 Connector

The shielded RJ45 cable is made up of the plastic and metal outer housing and locking clip. Within the housing, a series of contact blades are lined up next to one another to provide contact points for the pins of the RJ45 port. The contact blades themselves are square-shaped, flat on three sides and with a set of two or three triangular teeth on one side. The teeth of the connector are at the bottom of the blades to pierce the individual wires of the STP cable when the connector is crimped shut.

Shielded RJ45 connectors are available in configurations designed to attach to either solid core or stranded core STP wires. Be sure when selecting cabling and connectors that the RJ45 connector chosen is correct for the type of cabling to be used. The blades of the RJ45 connector (shown in Figure 9-8) end in a series of points that pierce the jacket of the wires and make the connection to the core. Different types of connections are required for each type of core composition. These connectors are differentiated by the arrangement of the teeth of the contact blades.

An STP cable that uses solid core wires requires the use of contact blades with three teeth. This is due to the inability of the teeth to effectively penetrate the solid core of the STP wire without damaging the cable. The three teeth are placed in a staggered left-right-left orientation that pierces the insulator of the STP wire and wedges the core between the teeth, making an electrical contact at three points.

A cable that uses stranded core wires will allow the contact points to nest among the individual strands. The contact blades in a stranded RJ45 connector, therefore, are laid out with their contact points in a straight line. The contact points cut through the insulating material of the jacket and make contact with several strands of the core.

The wires of the STP cable must be organized in the RJ45 connector properly, based upon the USOC specification and the IEEE 802.5 specification. This organization of the wires at the connector is known as a pinout. The proper pinout for the Token Ring shielded RJ45 connector is given in Table 9-4, below. In addition to arranging the cables properly, the braided shield of the STP cable must be connected to the metal shield of the RJ45 connector.

The USOC specification orders the pairs in a four-pair cable into the pinout shown in Figure 9-7, below. The RJ45 connector in the figure is being viewed from the contact blade end, with the locking clip up. The contact blades of the RJ45 connector are numbered one through eight from left to right for purposes of identification.

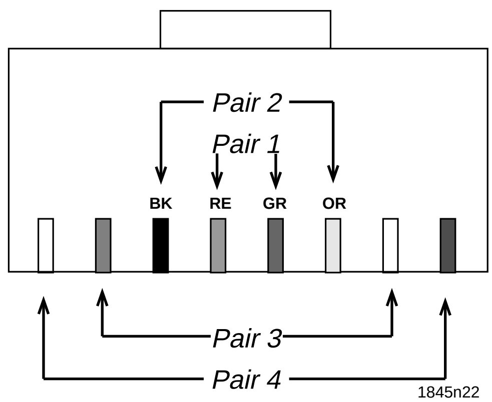


Figure 9-7. USOC Pair Organization - STP

Table 9-4. IEEE 802.5 RJ45 Pinouts for STP

Wire Color	IEEE 802.5 Signal	RJ45 Pinout
Black	TX -	3
Red	RX +	4
Green	RX -	5
Orange	TX +	6

Unshielded Twisted Pair Cable

RJ45

The RJ45 connector is a modular, plastic connector that is often used in UTP cable installations. The RJ45 is a keyed connector, designed to be plugged into an RJ45 port only in the correct alignment. The connector is a plastic housing that is crimped onto a length of UTP cable using a custom RJ45 die tool. The connector housing is often transparent, and consists of a main body, the pins, the raised key, and a locking clip.

The locking clip, part of the raised key assembly, secures the connector in place after a connection is made. When the RJ45 connector is inserted into a port, the locking clip is pressed down and snaps up into place. A thin arm, attached to the locking clip, allows the clip to be lowered to release the connector from the port. For a complete discussion of connecting and disconnecting RJ45 connectors, refer to Chapter 14, **Connecting and Terminating**.

RJ45 connectors for UTP cabling are available in two basic configurations; stranded and solid. These names refer to the type of UTP cabling that they are designed to connect to. The blades of the RJ45 connector end in a series of points that pierce the jacket of the wires and make the connection to the core. Different types of connections are required for each type of core composition.

A UTP cable that uses stranded core wires will allow the contact points to nest among the individual strands. The contact blades in a stranded RJ45 connector, therefore, are laid out with their contact points in a straight line. The contact points cut through the insulating material of the jacket and make contact with several strands of the core.

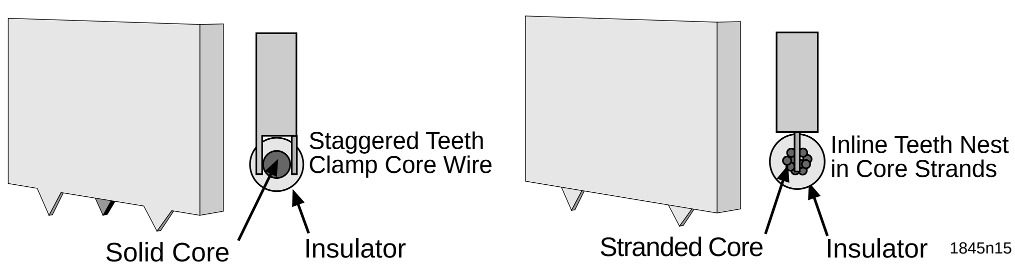


Figure 9-8. Solid and Stranded Contact Blades

The solid UTP connector arranges the contact points of the blades in a staggered fashion. The purpose of this arrangement is to pierce the insulator on either side of the core wire and make contacts on either side. As the contact points cannot burrow into the solid core, they clamp the wire in the middle of the blade, providing three opportunities for a viable connection.

The wires of the UTP cable must be organized in the RJ45 connector properly, based upon the USOC specification and the IEEE 802.5 specification. This organization of the wires at the connector is known as a pinout. The proper pinout for the Token Ring RJ45 connector is given in Table 9-5.

The USOC specification orders the pairs in a four-pair cable into the pinout shown in Figure 9-9, below. The RJ45 connector in the figure is being viewed from the contact blade end, with the locking clip up. The contact blades of the RJ45 connector are numbered from left to right for purposes of identification.

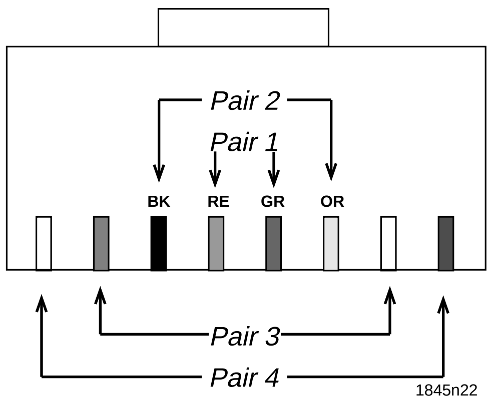


Figure 9-9. USOC Pair Association

The EIA/TIA specifications, which are used in Ethernet environments, do not match those of the USOC specification. The difference in the two specifications is the arrangement of Pair 3 and Pair 4. While EIA/TIA cables may be used in an IEEE 802.5 installation, they are not preferred. Although EIA/TIA cables will function in a Token Ring environment, USOC cables will not function in an Ethernet or FDDI TP-PMD environment. This is due to the usage of different wire pairs by the different networking technologies.

The connection of individual wires of a UTP cable to the pins of an IEEE 802.5 compliant RJ45 connector are given in Table 9-5.

Table 9-5. IEEE 802.5 RJ45 Pinout for UTP

Wire Color	IEEE 802.5 Signal	RJ45 Pinout
White/Orange	TX -	3
Blue	RX +	4
White/Blue	RX -	5
Orange	TX +	6

Fiber Optics

Straight-Tip

Fiber optic connectors in Token Ring environments must meet the IEEE 802.5j specifications, which requires the use of Straight-Tip (ST) connectors for any fiber optic cabling strand. The ST connector is a locking, keyed connector. The ST connector may either be male or female. Male ST connectors are typically attached to cable strand ends, while the female ST connectors are usually found on networking and cable management hardware.

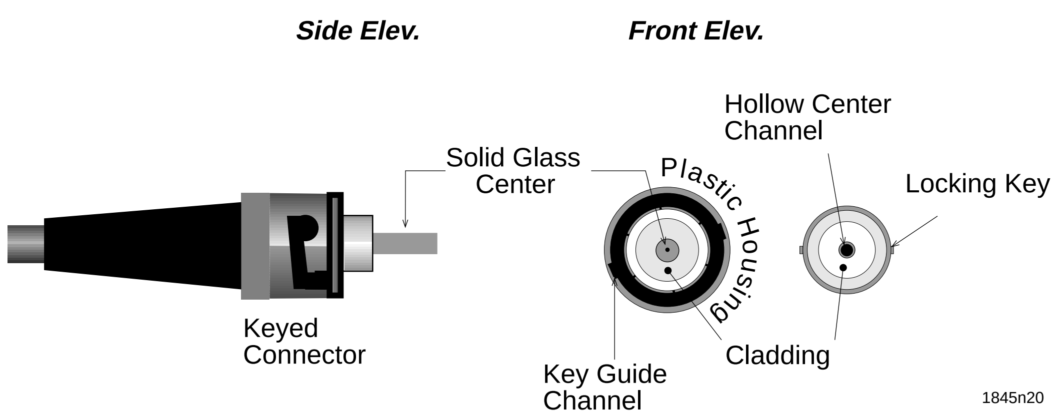


Figure 9-10. ST Connectors

The male ST connector is inserted into the channel of the female connector, its guide channels aligned with the locking pins of the female connector. Once the ST connector has been properly aligned, it is pressed in and rotated clockwise, the locking pins and guide channels pulling the ST connectors together. Once the locking pins have reached the ends of the guide channels, the ST connector locks into position.

The locking mechanism of the ST connector assures proper alignment of the fiber optic strands within the cable and the fiber optic receptors or transmitters in the networking hardware. The locking mechanism also helps to eliminate excess pressure or stress on the connection that may be caused by over-torquing a threaded connector.

Chapter 10

Token Ring Network Requirements

This chapter provides test parameters and specification requirements for Token Ring network cabling.

IEEE 802.5 Shielded Twisted Pair

All Cabletron Systems Token Ring products for STP Token Ring connectivity require that installed facility cabling and cable management hardware meet the following minimum specifications. If the network cabling in question is not within the limitations and ranges presented in this chapter, the operation of the Token Ring network may be adversely affected.

Cable Type

The IEEE 802.5 specifications for Token Ring require the use of STP cables that meet certain design and construction requirements. Cabling that is not specifically designed for use in IEEE 802.5 network installations should not be used. Within the class of compatible STP cabling, only certain types of STP are allowed for use with IEEE 802.5 networking devices. These are IBM Cable Types 1, 2, 6, and 9. The use of any other type of STP cabling may result in a loss of performance or poor network operation.

Due to the differences between cable types, the network requirements of STP cabling given below will be broken up by cable type. The requirements are also separated by the type of Token Ring network devices being used: active or passive circuitry.

Attenuation

The attenuation limit for any Token Ring STP cable link is dependent upon the operating speed of the Token Ring network. Token Ring networks that operate at a 16 Mbps speed (16 MHz) have slightly different cabling requirements than those Token Ring networks operating at 4 Mbps (4 MHz).

Attenuation, when calculated, must take all cabling devices in the cable path into account. A typical attenuation test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

STP Type 1,2

Acceptable levels of attenuation for STP cables of Types 1 and 2 are not dependent upon the circuitry type being used by the Token Ring networking hardware. The attenuation limit for Type 1 or Type 2 STP at 4 MHz is 22 dB/km or less. If the speed of the Token Ring network is 16 Mbps, the attenuation limit is 45 dB/km or less.

STP Type 6,9

The attenuation limits for Type 6 and Type 9 STP cabling are slightly higher for each speed class. Networks operating at 4 MHz may use cabling with an attenuation of less than 33 dB/km, while 16 MHz networks may use cabling with attenuation levels below 66 dB/km.

Impedance

All STP cable used in a Token Ring installation must have an impedance rating between 127.5 Ω and 172.5 Ω. STP cables of any type that are not within this impedance window may not function properly with the Token Ring hardware, causing poor network performance or error conditions.

Link Length

The operation of the Token Ring network places limitations on the amount of time a signal may travel through the Token Ring. This limitation, in conjunction with the amounts of loss that signals are susceptible to over different types of cabling, results in specified maximum link lengths for all cabling in any Token Ring network. The maximum link lengths given below assume that the cabling being used to make the link is all of a homogenous type (all Type 1, all Type 6, etc.) and that all cabling meets the other specified limits for Token Ring cabling.

The link length maximums are dependent upon the operating speed of the Token Ring network and the circuitry type being used. Active circuitry connections (those that provide regeneration and reclocking of the Token Ring signal at each port) can support longer links than passive Token Ring networks.

STP Type 1,2

An active Token Ring network operating at 4 Mbps may incorporate Type 1 or Type 2 STP links with lengths not exceeding 300 m (984 ft). If the Token Ring network operates at 16 Mbps, this length is reduced to 150 m (492 ft).

If the Token Ring network does not incorporate active technology, the maximum link length for a 4 Mbps Type 1 or 2 STP connection is 200 m (656 ft). When the network speed is 16 Mbps, the maximum length is reduced to 100 m (328 ft).

STP Type 6

No matter what circuitry or speed is used in a Token Ring network, the length of any Type 6 cable in that network may not exceed 30 m (98 ft). Type 6 cabling that exceeds this 30 m length limit may not function properly in a Token Ring network.

NOTE

STP cables of Type 6 should only be used as jumper or patch cables.

STP Type 9

An active Token Ring network operating at 4 Mbps may incorporate Type 9 STP links with lengths not exceeding 200 m (656 ft). If the Token Ring network operates at 16 Mbps, this length is reduced to 100 m (328 ft).

If the Token Ring network does not incorporate active technology, the maximum link length for a 4 Mbps Type 9 STP connection is 133 m (436 ft). When the network speed is 16 Mbps, the maximum length is reduced to 66 m (216 ft).

Special Cases of Link Length

If cable types are mixed in an installation, the different cable attenuations and qualities must be compensated for. In any installation, Type 6 and Type 9 cable may only be run for 2/3 the distance of Type 1 or Type 2 cable. This means that in order to be equivalent to a 10 meter length of Type 1 cable, Type 6 cable must be 2/3 of 10 meters, or 6.6 meters.

When calculating the longest link length in the installation, this compensation can be used to determine the absolute maximum Type 6 jumper cable length that may be used. For example: If a 16 Mbps Token Ring using passive circuitry had a Type 1 STP link measuring 60 meters, the maximum length of Type 6 cable that could be connected to it would be 26.4 m.

```
   100 m (Maximum Type 1 Cable Length)
-   60 m (Length of Existing Type 1 Cable)
    40 m (Remaining Type 1 Length Budget)

    40m
×    0.66
    26.4 m Maximum Type 6 Cable Length
```

Figure 10-1. Type 6 Cable Calculations

Trunk Cable Length

Just as there are maximum lengths for lobe cabling, Ring-In/Ring-Out, or trunk cables, must be within specified limits. The length limitations given here assume that the trunk cabling under examination meets all other specifications of the IEEE 802.5 standard for STP cabling.

IBM Type 1

The maximum link length of a Type 1 STP trunk cable at 4 Mbps is 770 m (2,525 ft). A 16 Mbps Token Ring network would allow a maximum Type 1 STP trunk link length of 346 m (1,134 ft). Other types of STP cable are not recommended for use as trunk cables by the IEEE 802.5 specification.

IEEE 802.5 Unshielded Twisted Pair

Cable Type

The IEEE 802.5 specification for Token Ring networks requires UTP cabling of Category 3, 4, or 5. Categories of UTP cabling below Category 3 may not meet the quality requirements of the networking specification, and may therefore be unable to meet the tested characteristics listed below. As the requirements for Category 3 installations are different from those required of a Category 5 installation, the three different cabling types and their respective test specifications are discussed separately in each section that follows. Each discussion of a cabling Category differentiates between any specifications for passive and active Token Ring networking devices.

The Category of cabling used in a network installation is dependent upon all the components that make up the cabling run. If an installation utilizes Category 5 cabling, and the wallplates and patch panels to which that cabling is connected are Category 3 compliant, the cable does not meet the EIA/TIA end-to-end specifications for a Category 5 installation.

Attenuation

The maximum allowable attenuation for any Token Ring UTP cable link is dependent upon the operating speed of the Token Ring network. Token Ring networks that operate at a 16 Mbps speed (16 MHz) have more stringent cabling requirements than those Token Ring networks operating at 4 Mbps (4 MHz).

Token Ring lobe cabling of Category 3 quality that is to be used in a 4 Mbps Token Ring network is allowed a maximum total attenuation of 56 dB/km at 4 MHz. Category 3 cabling to be used in a 16 Mbps Token Ring network may not exceed a total end to end attenuation of 131 dB/km at 16 MHz.

Category 4 lobe cabling intended for use in a 4 Mbps Token Ring network may not exceed 42 dB/km. If the same Category 4 UTP cabling is to be used in a 16 Mbps Token Ring network, the maximum attenuation allowable is 88 dB/km.

Lobe cabling of Category 5 quality may not be allowed to exceed 42 dB/km for a 4 Mbps network, or 82 dB/km for a 16 Mbps Token Ring.

Attenuation, when calculated, must take all cabling devices in the cable path into account. A typical attenuation test must include the jumper cabling used at the station and at the wiring closet, and any patch panels, punchdown blocks, and wallplates in the installation.

Impedance

All UTP cabling used in a Token Ring installation must test to an impedance of 85 to 115 Ohms. Cabling with higher or lower impedance ratings may not operate properly in the Token Ring network environment.

Crosstalk

Crosstalk is electrical interference between wires. Crosstalk occurs when a cable strand absorbs signals from other wires that it is adjacent to. Excessive crosstalk can be caused by a break in the insulation or shielding that separates wires from one another in a bundle.

Token Ring UTP cables should be checked for Near-End Crosstalk, or NEXT, at installation.

Category 3

The maximum acceptable amount of near-end crosstalk for a Category 3 UTP link is 23 dB/1000 ft.

Category 4

The maximum acceptable amount of near-end crosstalk for a Category 4 UTP link is 36 dB/1000 ft.

Category 5

The maximum acceptable amount of near-end crosstalk for a Category 5 UTP link is 44 dB/1000 ft.

Link Length

Category 3, 4

UTP cabling of Categories 3 and 4 are similar enough in quality to receive similar treatments and specifications under the IEEE 802.5 standard. Cabling of Category 3 or 4 is allowed different maximum link lengths based on the speed of the network and the use of active or passive Token Ring circuitry.

In an active network, a UTP link using Category 3 or 4 UTP may be 200 m (656 ft) or less at 4 Mbps. A 16 Mbps active Token Ring network may support a Category 3 or 4 link of up to 100 m (328 ft).

When passive Token Ring technology is used, the link length for each network operating speed is reduced. A passive 4 Mbps Token Ring network may support Category 3 or 4 UTP cabling lengths of 100 m (328 ft) or less, while a 16 Mbps network can support a maximum length of 60 m (196 ft).

Category 5

Category 5 UTP cabling, being of higher construction quality, is capable of supporting longer link lengths than UTP cabling of Categories 3 or 4. As with other types of UTP cabling, the type of circuitry used and the speed of the network affect the maximum link length allowable.

A Token Ring network using active technology and operating at 4 Mbps may support a Category 5 UTP cable link of 250 m (820 ft), while the same network, if set to operate at the higher 16 Mbps speed, can support a maximum Category 5 link length of 120 m (393 ft).

The use of passive Token Ring technology reduces the maximum link length to 130 m (426 ft) at 4 Mbps, or 85 m (278 ft) at 16 Mbps.

The maximum link lengths specified for UTP cabling of any Category assume that all other specifications and limitations for IEEE 802.5-compliant UTP cabling have been met.

Trunk Cable Length

The length limitations given here assume that the trunk cabling under examination meets all other specifications of the IEEE 802.5 standard for UTP cabling.

NOTE

UTP is not recommended for Ring-In/Ring-Out connections.

Category 3/4

The tested requirements for Category 3 or 4 UTP trunk cables are the same as those required for UTP lobe cables using Category 3 or Category 4 cabling. The maximum link length of a Category 3 or 4 trunk cable at 4 Mbps is 200 m (656 ft). A 16 Mbps Token Ring network would allow a maximum Category 3 or 4 UTP trunk link length of 100 m (328 ft).

Category 5

The tested requirements for Category 5 UTP trunk cables are the same as those required for UTP lobe cables using Category 5 cabling. The maximum link length of a Category 5 trunk cable at 4 Mbps is 250 m (820 ft). A 16 Mbps Token Ring network would allow a maximum Category 5 UTP trunk link length of 120 m (393 ft).

IEEE 802.5j (Multimode Fiber Optics)

Cable Type

IEEE 802.5j multimode fiber optic products for Token Ring networks require specific types of cabling. Token Ring multimode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following construction sizes of multimode fiber optics:

- 50/125 µm
- 62.5/125 µm
- 100/140 µm

The use of other types of multimode fiber optic cabling may result in poor network performance or inability to establish links.

Attenuation

Multimode fiber optic cables must be tested for attenuation with a fiber optic attenuation test set. The test set must be configured to determine attenuation of the cable at a wavelength of 850 nm. The attenuation test will confirm or deny that the cable falls within an acceptable level. The acceptable level of attenuation for a cable is dependent upon the type of multimode fiber optic cable being tested. The acceptable levels of attenuation for the types of multimode fiber optic cabling supported by Cabletron Systems products are listed in Table 10-1:

Table 10-1. Multimode Fiber Optic Attenuation Limits

Cable Type	Maximum Attenuation
50/125 µm	13.0 dB
62.5/125 µm	16.0 dB
100/140 µm	19.0 dB

Link Length

The IEEE 802.5j specification sets the maximum length of a multimode fiber optic link in a Token Ring installation at 2 km (6,560 ft). This maximum length assumes that all other requirements for a Token Ring fiber optic link as detailed above are met.

Trunk Cable Length

The maximum length of a multimode fiber optic trunk cable is identical to the maximum allotment for station connections using the same media.

IEEE 802.5j Single Mode Fiber Optics

Cable Type

IEEE 802.5j single mode fiber optic products for Token Ring networks require specific types of cabling. Token Ring single mode fiber optic devices manufactured by Cabletron Systems are able to support connections to and from the following construction sizes of single mode fiber optics:

- 8.3/125 µm
- 12/140 µm

The use of other types of single mode fiber optic cabling, or any type of multimode fiber optic cabling, may result in poor network performance or inability to establish links.

Attenuation

Single mode fiber optic cables must be tested with an attenuation test set configured for a 1,300 nm wavelength. The attenuation test will confirm or deny that the cable falls within an acceptable level. All single mode fiber optic cables that are allowable by the IEEE 802.5j specification must not exceed 15.1 dB of total attenuation.

Link Length

The IEEE 802.5j specification sets the maximum length of a single mode fiber optic station cable to 10 km (32,800 ft). The single mode fiber optic cable must meet all other requirements of single mode fiber optic cables as detailed above.

Trunk Cable Length

The maximum length of a single mode fiber optic trunk cable is identical to the maximum allotment for station connections using the same media.

Chapter 11

FDDI Media

This chapter details the standard media and connector types that may be used in Fiber Distributed Data Interface (FDDI) networks.

Cabling Types

Unshielded Twisted Pair (UTP)

Unshielded Twisted Pair cabling (referred to here as UTP, but also may be termed copper wire, 10BASE-T wire, Category 5 wire, telephone cable, or twisted pair without shielded or unshielded qualifier) is commonly made up of four pairs of 22, 24, or 26 AWG unshielded copper solid or stranded wires. These pairs of wires are twisted together throughout the length of the cable. These twisted pairs of wire within the UTP cable are broken up into transmit and receive pairs. In each pair, one wire carries the normal FDDI transmission, while its associated wire carries a copy of the transmission that has been inverted.

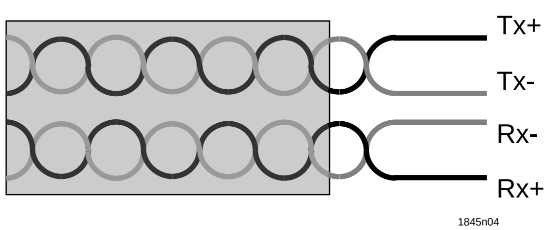


Figure 11-1. UTP Cable Pair Association (2 Pairs Shown)

The twisting of associated pairs helps to reduce the interference of the other strands of wire throughout the cable. This is due to the method of transmission used with twisted pair transmissions.

In any transceiver or Network Interface Card (NIC), the network protocol signals to be transmitted are in the form of changes of electrical state. The means by which the ones and zeroes of network communications are turned into these signals is called encoding. In a twisted pair environment, once a transceiver has been given an encoded signal to transmit, it will copy the signal and invert the polarity of that signal (see Figure 11-2, below). The result of this inverted signal is a mirror opposite of the original signal.

Both the original and the inverted signal are then transmitted, the original signal over the one transmit wire, the inverted signal over the other. As these wires are the same length, the signal travels at the same rate (propagates) through the cable. Since the pairs are twisted together, any outside electrical interference that affects one member of the pair with have the same effect on the other member of that pair.

The transmission travels through the cable, eventually reaching a destination transceiver. At this location, both signals are read in. The original signal is unchanged, but the signal that had previously been inverted is reverted to the original state. When this is done, it returns the encoded transmission to its original state, but reverses the polarity of any signal interference that the encoded transmission may have suffered.

Once the inverted transmission has been returned to the normal encoded state, the transceiver adds the two signals together. As the encoded transmissions are now identical, there is no change to the data content. Line noise spikes, however, are combined with noise spikes of their exact opposite polarity, causing them to cancel one another out.

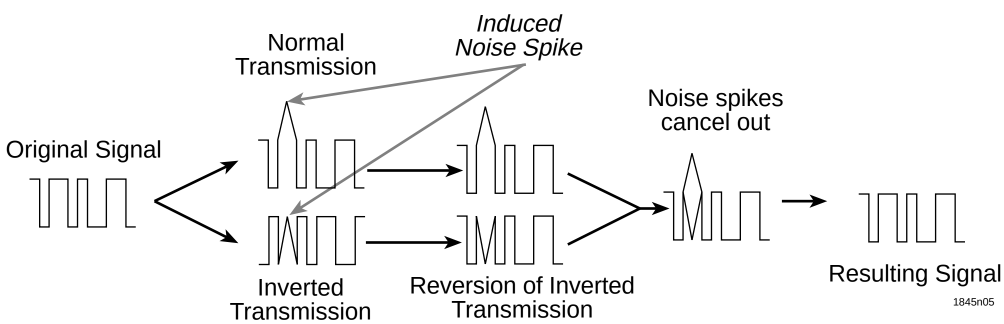


Figure 11-2. UTP Signal Equalization

The UTP cable used in network installations is the same type of cable used in the installation of telephone lines within buildings. UTP cabling is differentiated by the quality category of the cable itself, which is an indicator of the type and quality of wire used and the number of times the wires are twisted around each other per foot. The categories range from Category 1 to Category 5, with Category 5 cabling being of the highest quality.

The wires that make up a length of UTP cable are numbered and color coded. These color codes allow the installer of the networking cable to determine which wires are connected to the pins of the RJ45 ports or patch panels. The numbering of the wires in EIA/TIA standard cables is based on the color of the insulating jacket that surrounds the core of each wire.

The association of pairs of wire within the UTP cable jacket are decided by the specifications to which the cable is built. There are two main EIA/TIA specifications in use around the world for the production of UTP cabling; EIA/TIA 568A and the EIA/TIA 568B. The two wiring standards are different from one another in the way that the wires are associated with one another at the connectors.

Since the FDDI Twisted Pair - Physical Medium Dependent (TP-PMD) specification requires the use of all eight wires in a four-pair cable, the EIA/TIA specification to which the cable is constructed is of prime importance. The arrangement of the wires and pairs in the EIA/TIA 568 specifications is discussed in the **UTP** portion of the **Connector Types** section of this chapter.

Keep in mind that the selection of an EIA/TIA wiring scheme will determine the characteristics of Wallplates, Patch Panels, and other UTP interconnect hardware you add to the network. Most manufacturers supply hardware built to both of these specifications.

NOTE

TP-PMD Specifications limit the use of UTP cabling to Single Attached Station connections from FDDI concentrators to stations (M ports to S ports).

Crossovers

As all connectors in the FDDI TP-PMD specification are organized in the same fashion with regard to pinouts, the FDDI TP-PMD specification requires UTP connections between TP-PMD devices be crossed over. Crossing over is the reversal of the transmit and receive pairs at opposite ends of a single cable. Each cable that swaps the location of the transmit and receive pairs at only one end is called a crossover cable. Those cables that maintain the same location for transmit and receive pairs at both ends are called straight-through cables.

If two TP-PMD devices are connected using a straight-through cable, the transmit pins of one device will be connected to the transmit pins of the other device. In effect, the two devices will both attempt to transmit on the same pair of the cable between them. This will cause the FDDI ring to wrap.

To overcome this, a crossover must be placed between the FDDI TP-PMD ports, forcing the transmit pins of one device to connect to the receive pins of the other device. When two devices are being connected to one another using UTP cabling, an odd number of crossover cables, preferably one, must be part of the cabling between them. For ease of cable management, it is preferable to use straight-through cabling for horizontal cable runs, and place any necessary crossover cables in the wiring closet or data center.

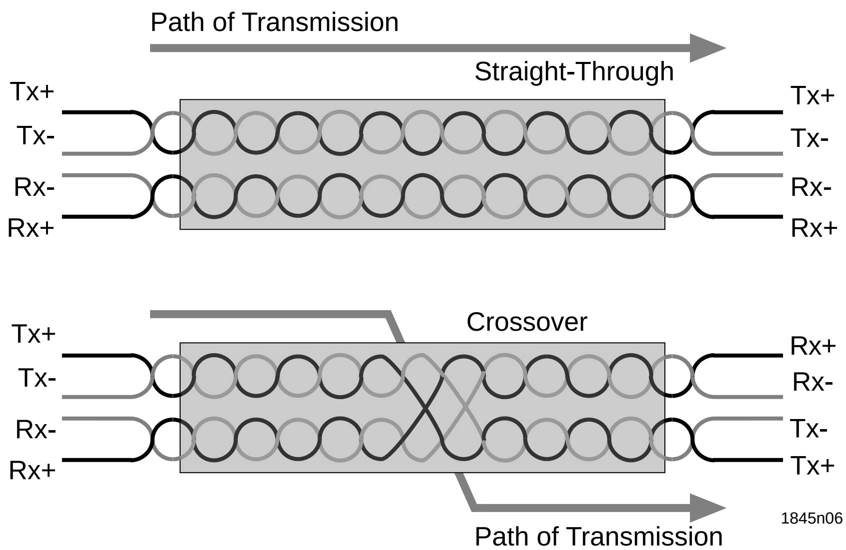


Figure 11-3. Straight-Through vs. Crossover Cables

UTP Cable Quality

UTP cabling is produced in a number of overall quality levels, called Categories. The UTP cabling used in FDDI installations must adhere to the minimum quality characteristics detailed in the ANSI X3T9.5 TP-PMD specification. UTP cabling that is Category 4 or lower is not capable of meeting the stringent quality requirements of the TP-PMD specification, and should never be used in an FDDI environment. Only cabling of Category 5 may be used for FDDI TP-PMD installations. Descriptions of lower-quality cables may be found in the Ethernet and Token Ring sections of this document.

Category 5

Category 5 UTP cabling is manufactured in the same fashion as standard telephone installation cable, but the materials used are of higher quality and the wires that make up the pairs are more tightly wound. This closer association helps to reduce the likelihood that any one member of a pair may be affected by external noise sources without the other member of the pair experiencing the same event.

Category 5 UTP consists of 2 or more pairs of 22 or 24 AWG wire. Category 5 cable is constructed and insulated such that the maximum attenuation of a 10 MHz signal in a cable run at the control temperature of 20° C is 65 dB/km. A cable that has a higher maximum attenuation than 65 dB/km does not meet the Category 5 requirements.

Shielded Twisted Pair (STP)

The TP-PMD specification is also able to utilize high-quality Shielded Twisted Pair, or STP cable. Shielded Twisted Pair cabling is a multistranded cable most often constructed of four 26 AWG conductive copper solid or stranded core wires. Each wire is surrounded by a non-conductive insulating material such a Polyvinyl Chloride (PVC). These wires are twisted around one another in a specific arrangement to form pairs. The pairs are made up of associated wires - transmit wires are paired with transmit wires, receive wires are paired with receive wires.

Each pair in the STP cable is then surrounded by a metallic foil shield that runs the length of the cable. Some types of STP incorporate an additional braided or foil shield that surrounds each of the shielded pairs in the cable. The overall cable is wrapped in an insulating jacket that covers the shields and holds the wires together.

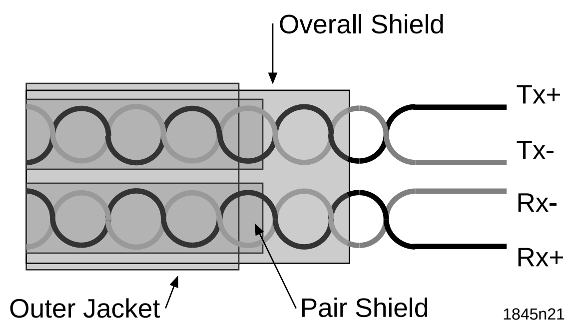


Figure 11-4. STP Cable Pair Association

Twisting the pairs together throughout the cable helps to reduce the effects of externally-induced electrical noise on the signals that pass through the cable. In each pair, one wire carries the normal network signal, while its associated wire carries a copy of the transmission that has been inverted.

The twisting of associated pairs helps to reduce the interference of the other strands of wire throughout the cable. This is due to the method of transmission used with twisted pair transmissions.

In any transceiver or Network Interface Card (NIC), the network protocol signals to be transmitted are in the form of changes of electrical state. The means by which the ones and zeroes of network communications are turned into these signals is called encoding. In a twisted pair environment, once a transceiver has been given an encoded signal to transmit, it copies the signal and inverts the voltage (see Figure 11-5, below). The result of this inverted signal is a mirror opposite of the original signal.

Both the original and the inverted signal are then transmitted, the original signal over the one transmit wire, the inverted signal over the other. As these wires are the same length, the signal travels at the same rate (propagates) through the cable. Since the pairs are twisted together, any outside electrical interference that affects one member of the pair will have the same effect on the other member of that pair.

The transmission travels through the cable, eventually reaching a destination transceiver. At this location, both signals are read in. The original signal is unchanged, but the signal that had previously been inverted is reverted to the original state. When this is done, it returns the encoded transmission to its original state, but reverses the polarity of any signal interference that the encoded transmission may have suffered.

Once the inverted transmission has been returned to the normal encoded state, the transceiver adds the two signals together. As the encoded transmissions are now identical, there is no change to the data content. Line noise spikes, however, are combined with noise spikes of their exact opposite polarity, causing them to cancel one another out.

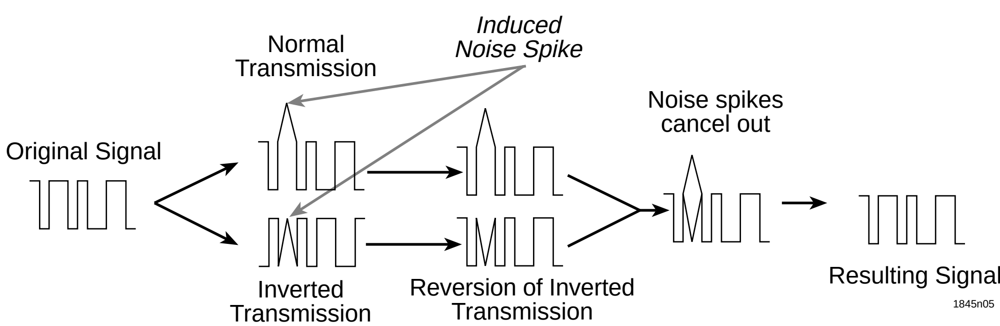


Figure 11-5. Twisted Pair Signal Equalization

STP cable is made up of four or more wires, and each wire within the cable has a specific insulator color. These colors are part of the industry specifications to which the cable construction process must be held. Each color identifies a particular usage for the cable. The four colors are black, red, green, and orange. Table 11-1, below, identifies the type of signal that each wire carries.

Table 11-1. STP Cable Wire Identifications

Cable Color	Application
Black	TX -
Red	RX +
Green	RX -
Orange	TX +

NOTE

As STP cabling provides only two pairs of wire, it may only be used for Single Attached Station connections from FDDI concentrators to stations (M ports to S ports).

STP Cable Quality

STP cable is available in a series of construction and quality styles, known as Types. FDDI TP-PMD applications require STP cables that meet the quality and construction specifications of Type 1 or Type 2 STP cable, as detailed in the sections that follow.

Type 1

Type 1 STP consists of two pairs of solid 22 AWG copper strands. Each strand, approximately 0.02 inch thick, is surrounded by a layer of insulation. The characteristics of the insulation is determined by the fire resistance construction of the cable (plenum cable is thicker and made with slightly different material than normal PVC cabling).

The individual wires are twisted into pairs. The pairs that are formed by this twisting are then surrounded by a mylar foil shield. These shielded pairs are then laid alongside one another in an overall braided metal shield. The shield containing the twisted pairs is then surrounded by a tight outer covering. Type 1 STP is heavy and rather inflexible, but provides excellent resistance to interference and noise due to its construction characteristics. Type 1 STP is most commonly used as a facility cabling, while more flexible cabling is used for jumper cables and patch panel connections.

Type 2

IBM Type 2 cable is constructed in much the same fashion as Type 1 cable. The two central shielded pairs and the overall braided shield that surround them are constructed of the same materials, and then two additional pairs of AWG 22 insulated solid copper wires are laid outside the braided shield before the whole cable is surrounded by the tight outer covering. These outer wires may be used to carry telephone traffic, as the shields surrounding the inner, network wires is intended to eliminate the interference that might otherwise occur between the inner and outer pairs.

NOTE

Cabletron Systems does not recommend combining active voice and data wiring in the same cable. Degradation of network performance may result from any non-standard uses of cable.

The added pairs of wire in a Type 2 cable make it even less flexible than Type 1 cable. For this reason, it is typically used as facility cable.

Fiber Optics

Fiber optic cable is a high performance media constructed of glass or plastic which uses pulses of light as a transmission method. Because fiber optics do not utilize electrical charges to pass data, they are free from the possibility of interference due to proximity to electrical fields. This, combined with the extremely low rate of signal degradation and dB loss makes fiber optics able to traverse extremely long distances. The actual maximums are dependent upon the architecture being used, but distances of up to 50 km (164,000 ft) are not unknown when using the FDDI technology.

Glass optical fiber is made up of a glass strand, the core, which allows for the easy transmission of light, the cladding, a less transmissive glass layer around the core which helps keep the light within the core, and a plastic buffer which protects the cable.

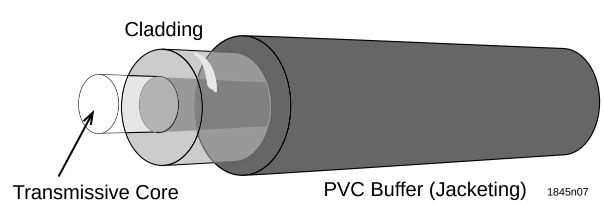


Figure 11-6. Fiber Optic Cable Construction

There are two basic types of fiber optics: multimode and single mode. The names come from the types of light used in the transmission process. Multimode fiber uses inexpensive Light Emitting Diodes (LEDs) that produce light of a single color. Due to the nature of the LED, the light produced is made up of a number of differing wavelengths of light, fired outward from the center of the LED. Not all the rays of light enter the fiber, and those that do often do so at an angle, which reduces the amount of distance the signal can effectively cover. Single mode fiber optics use lasers to achieve greater maximum distances. Since light from a laser is all of the same wavelength, and travels in a coherent ray, the resulting signal tends to be much clearer at reception than an LED signal under the same circumstances.

Fiber optics of both types are measured and identified by a variety of means. The usual means of referring to a fiber optic cable type is to identify if it is single mode or multimode, and to describe the thickness of each strand. Fiber optics are very thin, and the width of each strand is measured in microns (μm). Two measurements are important in fiber optic identification: the diameter of the core, where signals travel, and the diameter of the cladding, which surrounds the core. Thus, fiber optic measurements will usually provide two numbers separated by the "/" symbol. The first number is the diameter, in microns, of the core. The second is the diameter of the cladding. Thus, a 62.5/125 multimode cable is a type of fiber optic cabling with a 62.5 μm core and 125 μm cladding, which can be used by inexpensive LED equipment, as it allows multiple modes of light to pass through it. Incidentally, 62.5/125 μm multimode cabling is a very common type of FDDI fiber optics.

In much the same way that UTP cabling is available in two-, four-, 25-, and 50-pair cables, strands of fiber optic cabling are often bound together with other strands into multiple strand cables. These multiple strand cables are available with anywhere from two to 24 or more strands of fiber optics, all gathered together into one protective jacket.

TIP

Cabletron Systems recommends that customers planning to install fiber optic cabling not install any facility fiber optics (non-jumper cabling) containing fewer than six strands of usable optical fiber. The minimum number of strands needed to make an end-to-end fiber optic link between two FDDI network devices is **two**. In the event that a strand within the cable is damaged during installation or additional fiber pairs become desired along the cable path, the availability of extra strands of optical fiber will reduce the likelihood that a new cable must be pulled. The existing, unused pairs of optical fiber can be terminated and used immediately.

Multimode

Multimode fiber optic cabling is designed and formulated to allow the propagation of many different wavelengths, or modes, of light. Multimode fiber optics are the most commonly encountered fiber type in FDDI installations, due to their lower cost compared to other fiber types.

The FDDI MMF-PMD specification specifies the Media Interface Connector, or MIC, as the standard connector for MMF-PMD networks. The LCF-PMD specification recommends the use of the SC-Type connector for all station connections. Other connector types are nonstandard and their use may result in poor network performance. The MIC and SC connectors are described in greater detail in the **Connector Types** section of this chapter.

Single Mode

Single mode fiber optics are designed specifically to allow the transmission of a very narrow range of wavelengths within the core of the fiber. As the precise wavelength control required to accomplish this is performed using lasers, which direct a single, narrow ray of light, the transmissive core of single mode fiber optics is typically very small (8 to 10 µm). Single mode fiber is more expensive to produce than multimode fiber, and is typically used in long-haul applications. The FDDI networking technology allows for the creation of single mode fiber optic cabling runs of up to 58 km.

Due to the very demanding tolerances involved in connecting two transmissive media with diameters approximately one-quarter as thick as a sheet of paper, single mode fiber optics require very precise connectors that will not move or shift over time. For this reason, single mode fiber optics should only be terminated with locking, preferably keyed, connectors. The FDDI Single Mode Fiber Physical Medium Dependent (SMF-PMD) specification requires that all fiber optic cabling used in the FDDI network, regardless of type, should be connected only with MIC connectors, which are discussed in detail later in this chapter. Some FDDI devices for single mode fiber optics use the SC connector used by the LCF-PMD specification.

Low-Cost

In response to the expensive media and bulky connectors of the MMF-PMD and SMF-PMD standards, the Low Cost Fiber - Physical Medium Dependent, or LCF-PMD has been proposed. The LCF-PMD specification uses multimode fiber optics, and is terminated with smaller, less expensive connectors.The LCF-PMD specification allows for connections that are not longer than 500 m (1,640 ft). LCF-PMD links are designed for connections between concentrators and end stations.

The LCF-PMD specification uses the SC Connector, a modular, keyed connector designed much like the FDDI MIC connector (discussed in the **Connector Types** section of this document).

Connector Types

UTP

RJ45

The RJ45 connector is a modular, plastic connector that is often used in UTP cable installations. The RJ45 is a keyed connector, designed to be plugged into an RJ45 port only in the correct alignment. The connector is a plastic housing that is crimped onto a length of UTP cable using a custom RJ45 die tool. The connector housing is often transparent, and consists of a main body, the pins, the raised key, and a locking clip.

The locking clip, part of the raised key assembly, secures the connector in place after a connection is made. When the RJ45 connector is inserted into a port, the locking clip is pressed down and snaps up into place. A thin arm, attached to the locking clip, allows the clip to be lowered to release the connector from the port. For a complete discussion of connecting and disconnecting RJ45 connectors, refer to Chapter 14, **Connecting and Terminating**.

RJ45 connectors for UTP cabling are available in two basic configurations: stranded and solid. The names refer to the type of UTP cabling that they are designed to connect to. The blades of the RJ45 connector end in a series of points that pierce the jacket of the wires and make the connection to the core.

NOTE: The Category 5 UTP cable required by FDDI TP-PMD networking equipment is constructed with solid core wires only. Do not use RJ45 connectors with contact blades designed for stranded cable.

A UTP cable that uses solid core wires requires the use of contact blades with three teeth. This is due to the inability of the teeth to effectively penetrate the solid core of the UTP wire without damaging the cable. The three teeth are placed in a staggered left-right-left orientation that pierces the insulator of the UTP wire and wedges the core between the teeth, making an electrical contact at three points.

The order in which the connector and wiring standard place the wires of the cable are called the pinout of the cable. The pinout order of an EIA/TIA 568A compliant RJ45 connector is shown in Figure 11-7.

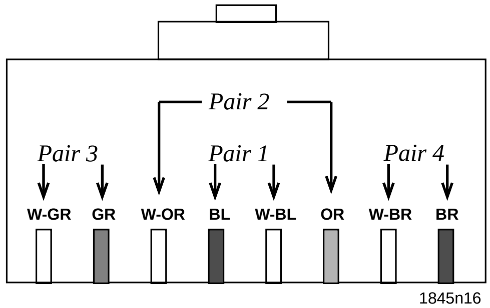


Figure 11-7. EIA/TIA 568A Pinout and Pair Association

The EIA/TIA 568 B specification reverses the arrangement of Pair 1 and Pair 2, but does not change the association of pairs within the cable. The Universal Service Order Code, or USOC, a standard often used for older building telephone wiring, uses a different pair association than EIA/TIA 568A. The use of either of these alternate cable construction standards will lead to error conditions in FDDI TP-PMD networks.

STP

Shielded RJ45

The shielded RJ45 cable used with STP cable is identical in shape to the standard RJ45 cable used in other network applications such as Ethernet and Token Ring. The difference between the shielded RJ45 and the standard RJ45 is the addition of a metal shielding ground to the plastic housing of the RJ45 connector. This shield is connected to the braided outermost shield of the STP cable.

The connector itself is a rectangular keyed connector with a locking clip. The RJ45 connector may only be inserted into an RJ45 port in its proper alignment, and, when inserted, will lock into place. Due to the lighter construction characteristics of the RJ45 connector in comparison with the other STP cable connectors, care should be taken to ensure that the strain placed on an RJ45 connection is minimized through proper use of cable management hardware.

The shielded RJ45 cable is made up of the plastic and metal outer housing and locking clip. Within the housing, a series of contact blades are lined up next to one another to provide contact points for the pins of the RJ45 port. The contact blades themselves are square-shaped, flat on three sides and with a set of two or three triangular teeth on one side. The teeth of the connector are at the bottom of the blades to pierce the individual wires of the STP cable when the connector is crimped shut.

NOTE

The type of STP cable required by FDDI TP-PMD networking equipment is constructed with solid core wires only. Do not use RJ45 connectors with contact blades designed for stranded cable.

An STP cable that uses solid core wires requires the use of contact blades with three teeth. This is due to the inability of the teeth to effectively penetrate the solid core of the STP wire without damaging the cable. The three teeth are placed in a staggered left-right-left orientation that pierces the insulator of the STP wire and wedges the core between the teeth, making an electrical contact at three points.

The wires of the STP cable must be organized in the RJ45 connector properly, based upon the USOC specification and the ANSI X3T9.5 specification. The proper arrangement of the wires in the RJ45 connector are given in Table 11-2, below. In addition to arranging the cables properly, the braided shield of the STP cable must be connected to the metal shield of the RJ45 connector.

Table 11-2. FDDI TP-PMD Pinouts for STP

Wire Color	IEEE 802.5 Signal	RJ45 Pinout
Black	TX -	3
Red	RX +	4
Green	RX -	5
Orange	TX +	6

Fiber Optics

FDDI MIC

The FDDI Media Interface Connector, not to be confused with the Token Ring Medium Interface Connector, is a gendered connector that is used with all fiber optic cabling for FDDI networks meeting the MMF-PMD and SMF-PMD standards. It consists of a plastic housing that separates the strands of a two-strand fiber optic cable and a set of ferrules that provide the physical point of connection for the fibers.

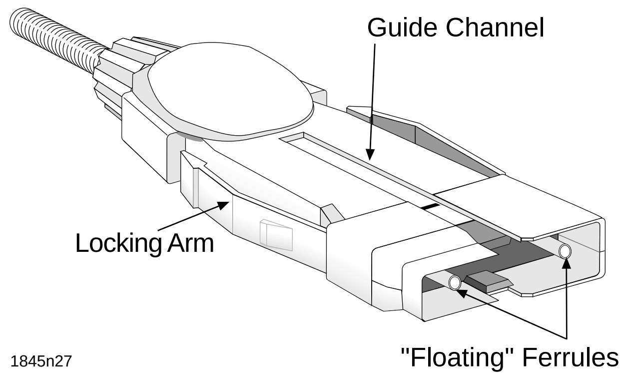


Figure 11-8. FDDI Media Interface Connector

The MIC connector is designed to prevent the mis-connection of segments and devices. It is specifically constructed in an asymmetrical fashion that prevents the connection of transmit strands in the connector to the transmit devices of an FDDI device.

The sides of the FDDI MIC connector have built-in locking arms that snap the connector into place once it has been fully inserted and keep it from being pulled out.

The FDDI standard requires very precise alignment of the fiber optic strands in order to make an acceptable connection. In order to accomplish this, FDDI connectors and ports each incorporate “floating” ferrules that make the final connection between fibers. These floating ferrules are held in place relatively loosely. This arrangement allows the ferrules to move slightly when making a connection. This small amount of movement manages to accommodate the subtle differences in construction found from connector to connector and from port to port.

The FDDI MIC connector also has a built-in guide channel along one surface. This guide channel allows small plastic keys to be snapped into place and restrict the connection of the FDDI MIC connector to certain types of FDDI ports. Keys are available for FDDI ports of types A, B, or M. Once a MIC connector has been configured with a B key, it will only fit properly in a B port on an FDDI device.

SC Connector

The SC connector is a gendered connector that is recommended for use in FDDI networks that incorporate multimode fiber optics adhering to the LCF-PMD specification. It consists of two plastic housings, the outer and inner. The inner housing fits loosely into the outer, and slides back and forth with a travel of approximately 2 mm (0.08 in). The inner housing ends in two floating ferrules, which are very similar to the floating ferrules used in the FDDI MIC connector.

The sides of the outer housing are open, allowing the inner housing to act as a latching mechanism when the connector is inserted properly in an SC port.

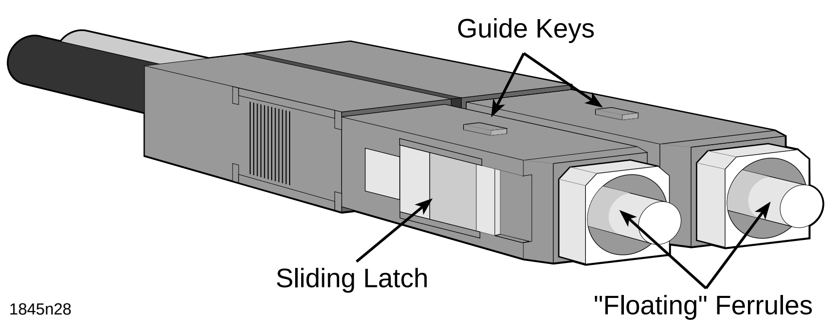


Figure 11-9. FDDI SC Connector

FDDI Network Requirements

This chapter details the test specifications and limitations for media used in FDDI networks.

MMF-PMD

Cable Type

The FDDI PMD specification that deals with multimode fiber optic cabling in FDDI environments specifies the use of 62.5/125 µm fiber optic cabling which is designed for use with 1300 nm wavelengths. Other sizes of fiber optic cabling may be used with MMF-PMD compliant products, but the performance of links made with these nonstandard cables will be reduced.

Attenuation

The FDDI specification allows any FDDI link made over multimode fiber optic cabling a total end to end attenuation of 11 dB at a wavelength of 1300 nm. Note that connectors, splices and passive FDDI devices introduce additional loss into cables. When estimating total loss, assume a loss of 0.5 dB for any splice or connector other than those at the end stations. If an optical bypass switch is included in the cable segment, the switch introduces additional loss, usually 2.5 dB.

Length

As long as all other cable quality specifications are met, the FDDI PMD allows a multimode fiber optic link to be no longer than 2 km from station to station. This 2 km length must include all connector and patch panels between the two stations. Keep in mind when determining the maximum length of an FDDI fiber optic link that the FDDI network may not exceed a maximum total length of 100 km. If the sum of all cable lengths within the network exceeds this 100 km limit, the FDDI network will experience errors in token rotation timing and other operations, and be unable to effectively recover from certain cable faults.

Emitted Power

The FDDI specification requires that links meet transmission power requirements. If these power requirements are not met, the strength of the FDDI signal will be insufficient for proper recognition and reception. If an FDDI transmitter does not produce signals with an emitted power of -20 dBm or better, the signal will have difficulty propagating through the cable effectively and may not be received properly at the termination of the link.

SMF-PMD

Cable Type

The FDDI SMF-PMD specification requires the use of 8.3/125 µm single mode fiber optic cabling which is designed for use with 1300 nm wavelengths. Other sizes of single mode fiber optic cabling may be used with SMF-PMD compliant products, but the performance of links made with these nonstandard cables will be reduced.

Attenuation

The SMF-PMD specification allows any FDDI link made over single mode fiber optic cabling a total end to end loss of 10 dB at a wavelength of 1300 nm. The same penalties apply to the cable segment for splices and optical bypass switches that apply to MMF-PMD links as discussed earlier.

Length

If all other cable quality specifications are met, the FDDI SMF-PMD allows a single mode fiber optic link to be no longer than 58 km from station to station. This total length must include all connector and patch panels between the two stations. Keep in mind when determining the maximum length of an FDDI fiber optic link that the FDDI network may not exceed a total length of 100 km. If the sum of all cable lengths within the network exceeds this 100 km limit, the FDDI network will experience errors in token rotation timing and other operations, and be unable to effectively recover from certain cable faults.

Emitted Power

The SMF-PMD specification requires that links meet transmission power requirements. If these power requirements are not met, the strength of the FDDI signal will be insufficient for proper recognition and reception. If an FDDI transmitter does not produce signals with an emitted power of -20 dBm or better, the signal will have difficulty propagating through the cable effectively and may not be received properly at the termination of the link.

LCF-PMD

Cable Type

The LCF-PMD specification requires the use of 62.5/125 µm multimode fiber optic cabling. While some other sizes of fiber optic cabling are permitted and may partially interoperate with LCF-PMD devices, their use is nonstandard and not recommended.

Attenuation

The LCF-PMD specification allows any FDDI link made over low-cost fiber optic cabling a total end to end loss of 7 dB at a wavelength of 1300 nm. The same penalties apply to the cable segment for splices and optical bypass switches that apply to MMF-PMD links as discussed earlier.

Length

Assuming that all other cable quality specifications are met, the FDDI LCF-PMD allows a low-cost fiber optic link to be no longer than 500 m from station to station. This total length must include all connectors and patch panels between the two stations. Keep in mind when determining the maximum length of an FDDI fiber optic link that the FDDI network may not exceed a total length of 100 km. If the sum of all cable lengths within the network exceeds this 100 km limit, the FDDI network will experience errors in token rotation timing and other operations, and be unable to effectively recover from certain cable faults.

Emitted Power

The LCF-PMD specification requires that links meet transmission power requirements. If these power requirements are not met, the strength of the FDDI signal will be insufficient for proper recognition and reception. If an FDDI transmitter does not produce signals with an emitted power of -22 dBm or better, the signal will have difficulty propagating through the cable effectively and may not be received properly at the termination of the link.

TP -PMD (UTP)

Cable Type

The demands of the TP-PMD specification are such that only Category 5 UTP cabling may be used for TP-PMD links. All connectors, patch panels, and other cable management hardware incorporated in the cable installation must also be Category 5 compliant in order for the cabling to be viable in a TP-PMD environment.

Attenuation

The TP-PMD specification allows any FDDI link made over Category 5 UTP cabling a total end to end loss of 11 dB at a frequency of 100 MHz. Note that connectors, splices, and passive FDDI devices introduce additional loss into cables.

Length

TP-PMD cabling which is within all other requirements of the specification may be no longer than 100 m from station to station. This total length must include all connectors and patch panels between the two stations. As with fiber optic connections, it is important to remember the 100 km total ring length of FDDI networks when planning installations.

TP-PMD (STP)

Cable Type

The TP-PMD specification demands cables of very high quality. The STP cable type which has construction characteristics that are of sufficient quality for the TP-PMD specification is IBM Type 1 STP cabling.

As IBM Type 1 cabling is made up of only two pairs of wire, the TP-PMD specification details the use of STP cabling for Single Attached Station connections only. The use of STP cabling to configure a dual counterrotating ring is not in compliance with the TP-PMD specification, and such a connection will not provide a failover path for transmission and reception of network signals.

Attenuation

The TP-PMD specification allows any FDDI link made over Type 1 STP cabling a total end to end loss of 11 dB at a frequency of 100 MHz. Note that connectors, splices and passive FDDI devices introduce additional loss into cables.

Length

TP-PMD cabling that is within all other requirements of the specification may be no longer than 100 m from station to station. This total length must include all connectors and patch panels between the two stations. As with fiber optic connections, it is important to remember the 100 km total ring length of FDDI networks when planning installations.

Chapter 13

Cabling Devices

This chapter identifies a number of commonly-used cabling installation and management devices which may be used to facilitate easy network troubleshooting, installation, and expansion.

Cable management devices are those pieces of equipment which allow the organization of cables and networking hardware into well-defined and easily modified groups. Good use of the cable management devices described in this chapter can greatly aid future changes to the cabling plant or troubleshooting operations, and can help speed the process of locating and repairing cable problems.

The three types of cable management devices treated in this section are those used for hardware mounting, cable termination, and facility cable management. Hardware mounting equipment provides centralized locations where networking devices such as hubs and routers or other cable management devices may be placed. Cable termination equipment provides easy to use endpoints for facility cabling and access to the cabling by users and end stations. Facility cable management devices are those used to divide cabling into specific groups or separate cables and groups from one another.

Hardware Mounting

Relay Rack

The relay rack, or electrical equipment rack, is a metal frame that is commonly used to secure and support networking, electrical, or telephony equipment in network centers or wiring closets. Most large cable management devices and networking products such as modular chassis are designed to be either mounted directly in the relay rack or placed on shelves set up in the rack.

Relay racks are available in a range of heights from as small as one meter (3.28 ft) to as tall as two meters (6.56 ft) or more. Equipment is fastened to the rack with screws or bolts. The bolts are passed through some form of frame on the device to be mounted in the rack and through the upright, perforated metal supports of the relay rack. Once tightened, the bolts hold the equipment safely.

When loading a relay rack, attempt to keep the majority of the weight of the components at or near the bottom of the rack. Locating heavy devices at the top of the rack can lead to top-heaviness, which can cause the rack to tip over and cause damage to equipment or potential injury.

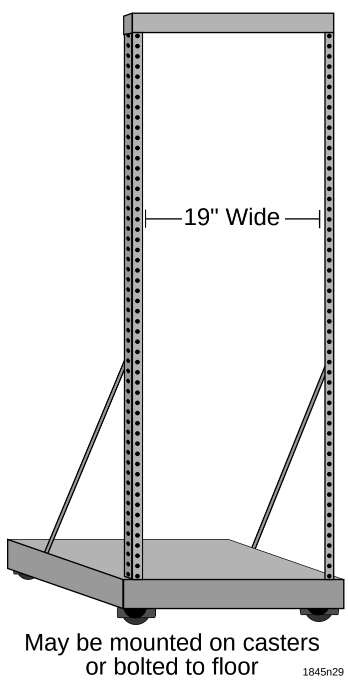


Figure 13-1. Relay Rack

Enclosed Equipment Cabinet

The enclosed equipment cabinet, sometime referred to as a “glass front rack,” is basically a relay rack inside a protective metal frame. The enclosed equipment cabinet allows networking devices to be secured as though in a relay rack, and also prevents unauthorized access to the equipment. Keeping the cabinet door closed and locked helps to ensure that unauthorized personnel will not be able to modify the current organization of cables and devices.

The enclosed equipment cabinet also presents a more finished appearance, and is often used in locations where there is no wiring closet to hide cable management devices in. In these cases, a smoked glass front door allows LEDs and lit indicators to be examined without having to reveal the array of cabling inside.

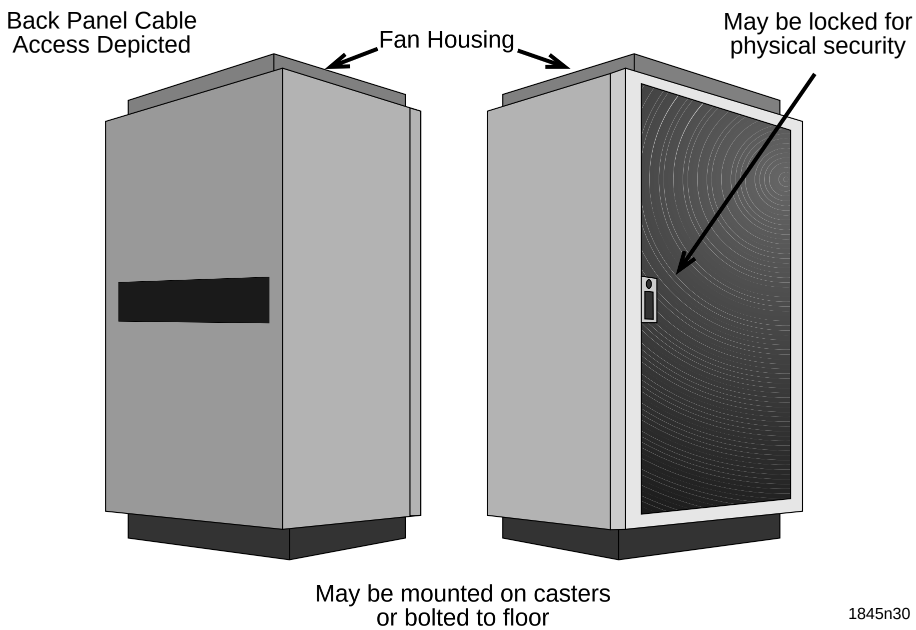


Figure 13-2. Enclosed Equipment Cabinet

Cable Termination

Cable termination equipment provides points where facility cabling may be easily connected to jumper cabling. Cable termination equipment basically provides endpoints for the raw facility cabling.

Patch Panel

A patch panel is a piece of cable termination equipment which connects raw facility cabling to standard ports or connectors. These ports or connectors may then be used for simplified connections to jumper cabling, allowing a single, manageable point of access for several cables.

Patch panels are typically built to be mounted in a relay rack or enclosed equipment cabinet. The front surface, or faceplate, of the patch panel provides a series of modular ports or connectors, depending upon the media being connected. The back of the patch panel is made up of a number of connection points for facility cable.

The most common types of patch panels are those for twisted pair cabling (UTP or STP) and for fiber optic cabling.

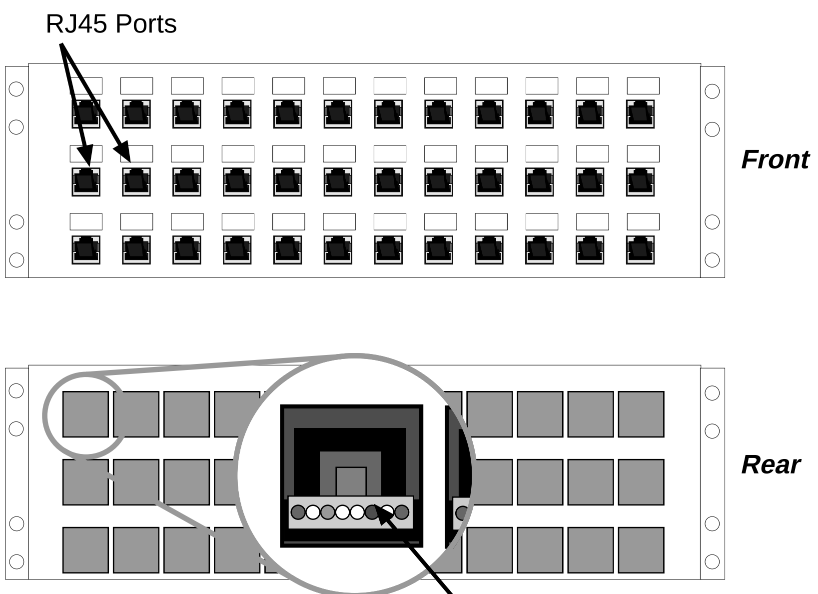


Figure 13-3. Twisted Pair Patch Panel

Harmonica

The Harmonica is a specialized type of patch panel. It is used only in twisted pair networking situations. The harmonica provides front surface modular connections like a patch panel. The back surface provides one or more RJ21 connectors. Through the use of a harmonica, one or more 24-pair UTP cables with 50-pin connectors can be broken out into 12 separate RJ45 ports.

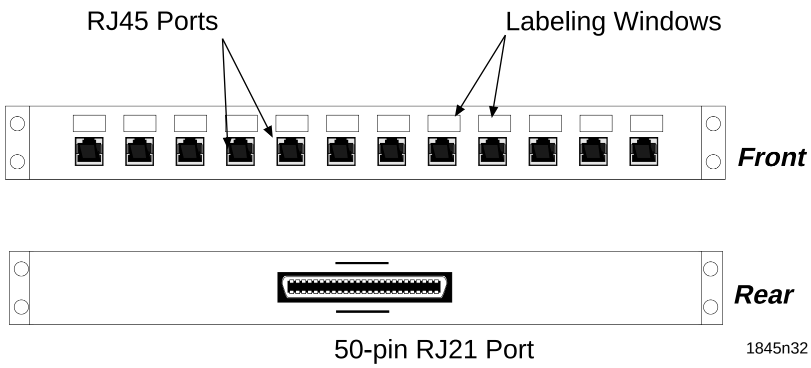


Figure 13-4. Harmonica

Punchdown Block

A punchdown block is another means of attaching raw strands of facility cable to a single jumper cable. The punchdown block allows the actual metal strands of facility UTP cable to be punched down, using a special tool, onto bayonet pins. These bayonet pins are connected to one another through the punchdown block's internal wiring. Most punchdown blocks wire the leftmost column of pins to the left inside column, and the rightmost column of pins to the inside right column. Punchdown blocks are also available which provide a prewired 50-pin RJ21 connector for connection to 25-pair facility UTP.

Punchdown blocks are commonly used in the same way patch panels are. They provide an access point for connecting and repairing cables. The exposed, conductive bayonet pins provide an easily accessible testing point for checking the operation of a cable after installation.

Punchdown blocks are often identified by a model number. A very common type of punchdown block is the AT&T 66 block.

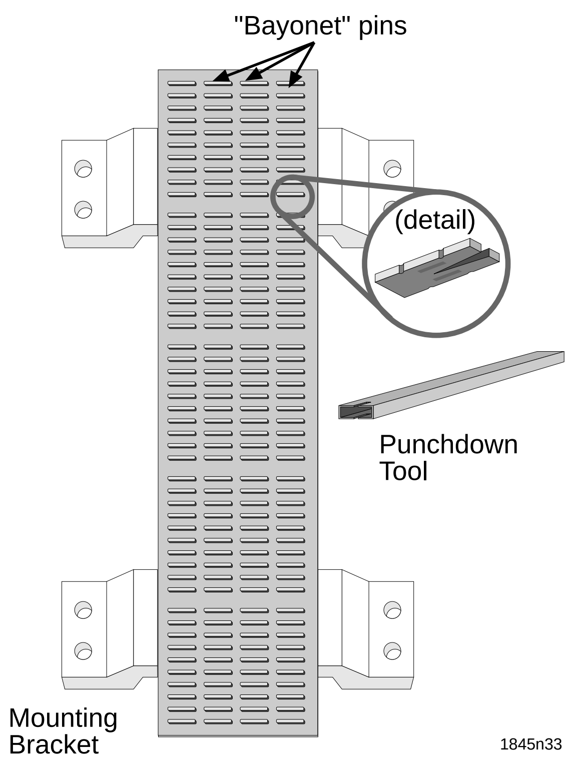


Figure 13-5. AT&T 66 Punchdown Block

Distribution Box

A distribution box is a form of patch panel that is used with fiber optic cabling. The distribution box provides an access point for multiple strand facility fiber optic cable. As distribution boxes are commonly used as intermediary cabling devices, they are designed to be mounted to walls or ceilings.

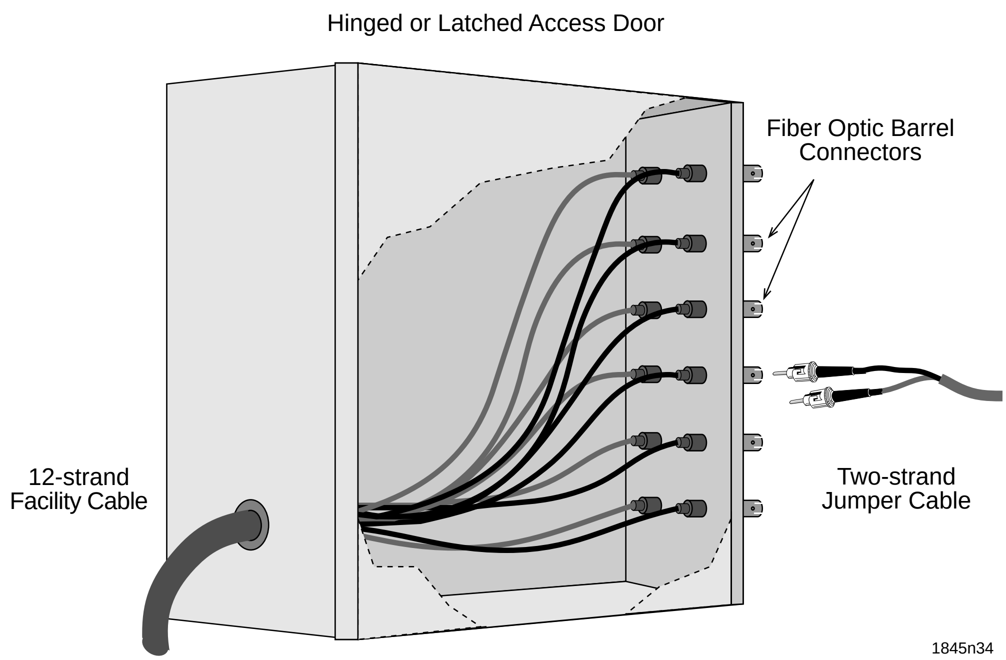


Figure 13-6. Fiber Optic Distribution Box

Wallplate

A wallplate is a form of small patch panel typically used at end user locations. The wallplate provides a connection and termination point for the facility cabling to which a user station may be connected with a length of jumper cabling.

Wallplates are available in several styles, and for all types of standard connectors. Wallplates may provide only one connector, or may be capable of supporting eight or more separate connectors. Those wallplates which can support multiple connectors are called modular wallplates. The construction of a modular wallplate allows a number of individually selected connector types to be placed in each individual wallplate. Using the modular wallplate construction options, you may have wallplates with a mix of RJ45, BNC, or fiber optic ST connectors, all based upon the needs of the location in question.

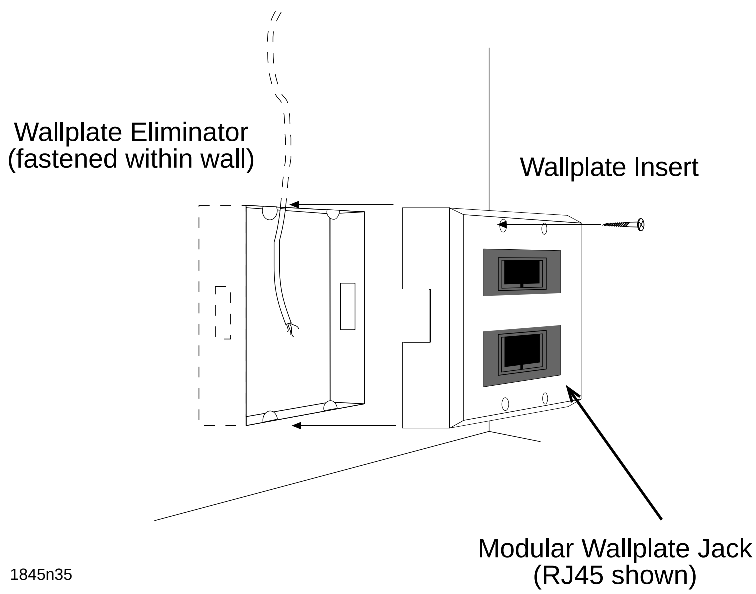


Figure 13-7. Modular Wallplate

Wallplates are installed by cutting a hole in the wall where the wallplate is to be located. Into this hole you place a wallplate eliminator, a recessed box which performs the actual securing for the wallplate assembly. The wallplate itself, once the cable connections are made, is locked or fastened into the wallplate eliminator.

Surface Mount Box

A surface mount box is a type of wallplate which, instead of being mounted in a hole in the wall is attached to the wall with an adhesive. The surface mount box is typically used in locations where connections to end user stations are to be made from a wall which is constructed of a material that is not easily cut through. Firewalls, cinderblock, and packed-earth are some of the wall types that should not be punctured to run cabling.

Facility Cable Management

The devices described in the following sections are used to organize and control the placement of cable in a facility. Cable management is an often-overlooked, but exceptionally important, part of installation planning and maintenance. The devices described below can prove very useful for facilitating easier installation, troubleshooting, and expansion of the network.

Conduit

Conduit is pre-installed PVC or metal pipe which is run through a building to ease the installation of cable. Most conduit is 1.25 cm (0.5 inch) in diameter or larger. Conduit is commonly used to provide readily-accessible paths for cable between floors in a facility or to simplify the installation of cable through firewalls and around obstacles such as elevator shafts and structural supports. Conduit in plenum environments should be steel piping. All conduit should contain pullstrings for cable installation.

D-Rings

D-rings are metal rings that are mounted to a wall or beam. The D-rings are shaped like the letter “D”. Once the rings are in place and secured (using screws, rivets, or adhesive) cabling is passed through the rings. The D-rings support the weight of the cables run through them and keep the cables in one location. D-rings may also be useful for holding cables away from sources of electrical interference or physical damage, such as lighting, automation, or HVAC equipment.

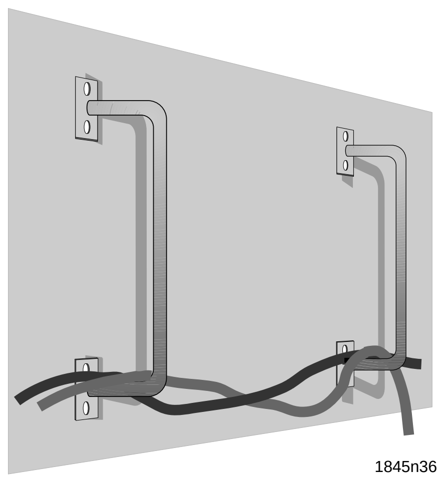


Figure 13-8. D-rings

J-Hooks

J-hooks are cable management devices similar in form and function to D-rings. Whereas a D-ring, once mounted on a wall, support, or other solid surface, is a closed hoop through which cable is threaded, J-hooks are open, and simply act as a support for the cable. J-hooks are often used to provide strain relief at strategic points in a run of cable or bundle of cables, or may be used in locations where cables must be added or removed from easily-accessible areas often. An example of this latter type of installation might be a testing laboratory which provides lines of J-hooks along the walls for the routing of temporary cables.

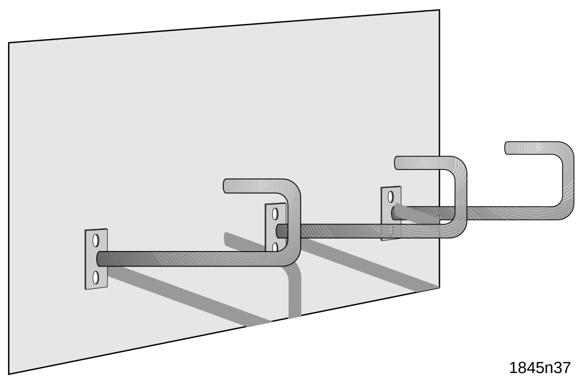


Figure 13-9. J-Hooks

Strain-Relief Bracket

The strain-relief bracket is a cable management device that is often used when networking hardware is mounted in an equipment cabinet or electrical equipment rack. The strain-relief bracket is a wide, U-shaped metal bar tthat extends forward from a device which cables plug into.

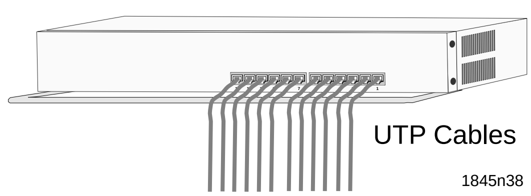


Figure 13-10. Strain Relief Bracket

The strain-relief bracket provides a location where cables may be tied off. This alleviates the strain of the weight of the cable, removing it from the port or connector and transferring it to the strain-relief bracket. Cables may be fastened to strain-relief brackets with wire twist ties, string, or Ty-Wraps.

Innerduct

Innerduct is a corrugated plastic tubing that is used to protect cabling. Most often, innerduct is used with fiber optic cabling, due to that media's susceptibility to damage during or following installation. Typically bright orange in color, innerduct may be pulled through a conduit or raceway before fiber optic cable installation, or used in areas where the cable would otherwise be exposed.

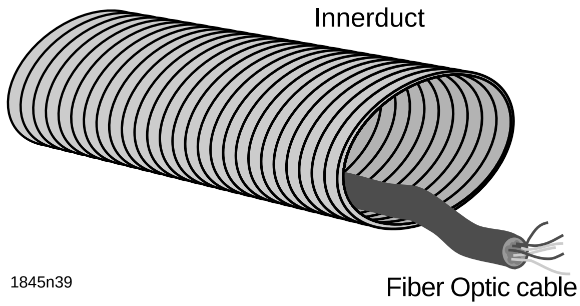


Figure 13-11. Innerduct

Latching Duct

Firewalls, filled cinderblock walls, and packed-earth walls should not be cored through for the installation of wallplates. By the same token, unless cable conduits specifically for network or telephony cabling are already installed in walls of these types, cabling should not be fished down within them. In these situations, the use of a surface mount box takes care of the need for a wallplate. Cabling to the surface mount box is run up from the floor or down from the ceiling (depending upon the location of the horizontal facility cabling) along the walls. Latching duct provides a plastic channel that can be affixed to the wall and protect the cable. Latching duct is made of two sections, front and rear. The rear section is backed with adhesive, allowing it to be easily affixed to walls. Once the rear section is in place, the cable is laid in the duct and the front section is snapped into place.

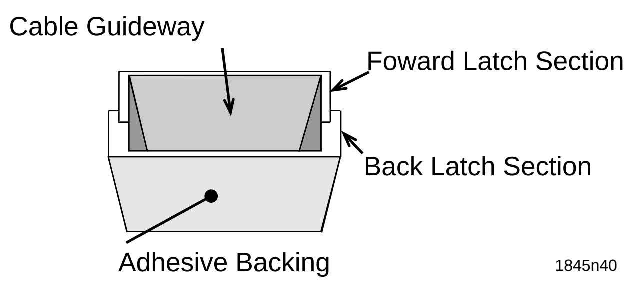


Figure 13-12. Latching Duct

Raceway

The term “Raceway” is used to refer to several items in cable installation. A raceway of any type is a channel, tray, or platform along which cable is laid. Most raceways are differentiated from conduits in the construction of each; where a conduit is a cylinder that is closed on all sides and open at both ends, raceway is typically open on one side along its entire length.

Floor raceway is a channel or trench set into the floor of a facility that cable may be placed in. Floor raceway usually is a characteristic of a facility’s construction that cannot be added after the facility has been completed.

Another common type of raceway is the tray-type raceway. Open on the top, the tray-type raceway is often run along walls like a series of D-rings or used in open areas, such as the space above suspended ceilings, to force cabling to follow a specific path, routing it around sources of potential physical damage or electrical noise.

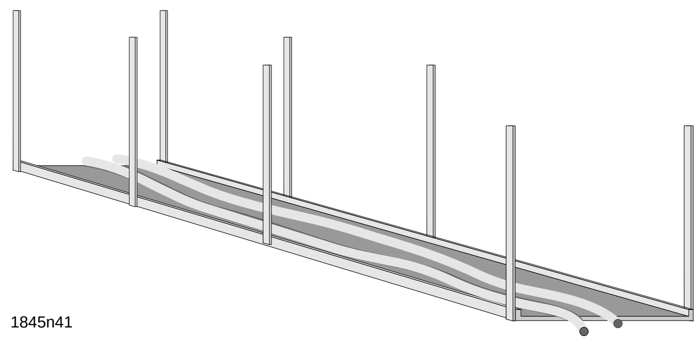


Figure 13-13. Tray-Type Raceway

Labeling Tape

All cables in an installation should be labeled. The addition of detailed labels to cabling in an installation makes the process of installing, troubleshooting, repairing, replacing, or expanding the facility cabling much easier. Cable labeling tape is a markable tape (it may be written upon) with strong adhesive. When labeling cables, keep the installation requirements of the cable run in mind. If a cable which you are labeling needs to be pulled through a conduit or innerduct, large, loose labels may bind or be pulled off during installation.

Ty-Wraps and Adhesive Anchors

Ty-Wraps, also called Ty-Fasts, plastic securing straps, and zip straps, are ribbons of tough plastic, usually white in color. The center portion of the plastic strip is ribbed or knurled, and one end of the strap is a slot with a racheting or friction-based means of holding the center portion of the plastic ribbon tightly.

Ty-wraps are typically wrapped around a cable or bundle of cables. The flat end of the plastic strip is inserted into the securing slot at the other end. The ribbon is then pulled through the slot until all slack in the Ty-Wrap has been taken up. The racheting or friction mechanism of the end slot will only allow the ribbon to pass in one direction, thus the Ty-wrap can be tightened but never loosened.

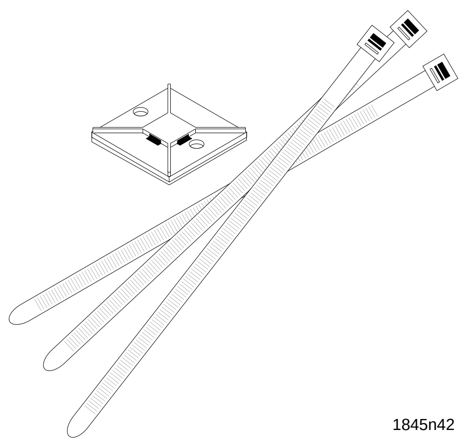


Figure 13-14. Ty-Wraps and Adhesive Anchor

CAUTION

Some cable types, notably fiber optic cables, may be damaged by excessive pressure applied to them. Do not tighten Ty-wraps or other securing materials to the point of “denting” the outer jacket of the cable.

Ty-wraps are inexpensive and easy to use, even with one hand. They are tough and flexible, resistant to water and moisture, and last for years. Besides being used to bundle cable together, Ty-wraps can be used in conjunction with adhesive anchors to provide securing points for cables. These securing points can help to alleviate the strain of a cable’s weight resting on a suspended ceiling or another structure. Adhesive anchors provide a raised, slotted platform through which the Ty-wrap is threaded, and an adhesive backing for fastening to a smooth surface. Ty-Wraps and anchors are ideal for securing temporary cables to desks and smooth cubicle walls.

When the Ty-wrap needs to be removed, it must be cut. This is easily accomplished with a normal cable stripping and cutting tool or a pair of heavy shears.

Chapter 14

Connecting and Terminating

This chapter deals with the methods used to attach connectors to facility or jumper cables and the termination requirements of the cable and connector types.

Ethernet

DB15

DB15 connectors and ports are used to make connections between Ethernet transceivers and Ethernet stations. The DB15 connector is the most commonly encountered Ethernet AUI cable connector, and is often used to connect a workstation or Ethernet device to a coaxial cable backbone. The instructions which follow detail the process used to connect a DB15 connector to a station port.

1. Align the DB15 connector of the AUI cable with the AUI port of the network device as shown in Figure 14-1. The port will only connect if it is properly aligned.

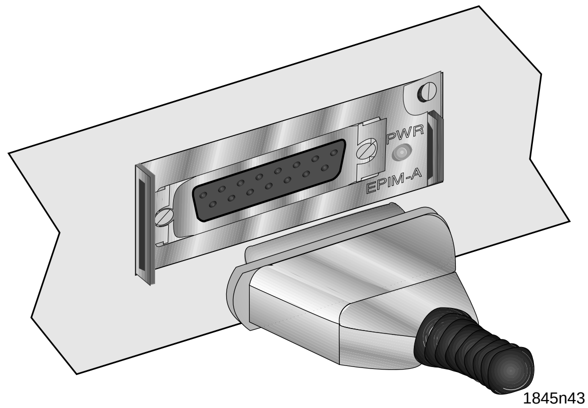


Figure 14-1. DB15 Connector Insertion

2. Firmly press the AUI connector over the AUI port. The locking clips on the sides of the AUI connector should snap into place when the connection is made.
3. If a sliding latch is present on the connector or port, slide it into place to secure the connector to the port.

If a link indicator is present for the port, check to see if it is on. If it is not on, perform the following actions until you achieve a valid link.

- Check that the Ethernet transceiver device at the other end of the AUI segment is operating.
- Check the DB15 connector for bent or missing pins. Keep in mind that several DB15 connectors do not provide pins for the inactive wires in the AUI cable.
- Verify that the DB15 connectors on the AUI segment have the proper pinouts.
- Attempt the connection with a known good patch cable.
- Check that the AUI connection meets all cable specifications outlined in Ethernet Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the DB15 connector from the port once it is locked in, examine the connector for a sliding latch or other locking method. If one is present, slide it to the unlocked position. Grasp the connector firmly between your thumb and forefinger. Pull the connector straight out of the port. The spring clips at the side of the connector should disengage under light strain and allow the connector to pull free. Do not rock the connector or attempt to jerk it out of the port by the cable.

RJ45

The RJ45 connector is used to make connections to UTP and some STP cabling. The instructions which follow detail the process used to connect an RJ45 connector to a station port.

1. Align the RJ45 connector with the socket of the RJ45 port. The connector will only insert and lock if the raised locking clip of the RJ45 connector is inserted into the correct location.

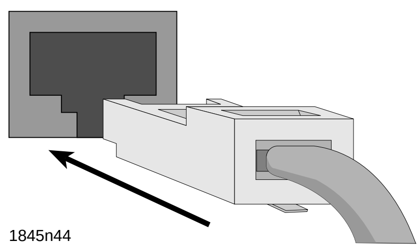


Figure 14-2. RJ45 Connector Insertion

2. Press the RJ45 connector into the port until the click of the locking clip is felt. The pressure required to perform this should be minimal. If you encounter resistance or excessive friction, remove the connector and check the port for obstruction. Also, verify that the connector and the port are of the same type.

Once the locking clip snaps into place, the RJ45 connector will remain in the port.

If a link indicator is present for the port, check that it is on. If the indicator is not on, the port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the 10BASE-T device at the other end of the twisted pair segment is on.
- Verify that the RJ45 connectors on the twisted pair segment have the proper pinouts.
- Verify the proper crossover of the cable link between the two devices.
- Check the cable for continuity.

- Check that the twisted pair connection meets dB loss and cable specifications outlined in 10BASE-T Twisted Pair Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the RJ45 connector from the port once it is locked in, grasp the cable where it enters the network device. Using your finger or a non-conductive probe, pinch the exposed arm of the locking clip towards the main body of the housing. When the arm contacts the housing, the locking clip has been disengaged. Without releasing the arm, gently pull the RJ45 connector directly out of the port.

If the connector will not come out, there may be damage to the locking clip. Examine the arm of the locking clip. While pressing the arm back toward the shell of the connector, verify that the clip, located within the port, is being moved. If the clip is broken, you may need to use a non-conductive probe to disengage the locking clip.

Do not place foreign objects into device ports while they are connected to a power source.

RJ21

The RJ21 connector is commonly used to make connections to 25-pair UTP cabling. To connect the RJ21 connector to a port on a module or other device, follow the procedure below.

1. Align the RJ21 connector with the RJ21 port on the device. The D shape of the connector should align with the D shape of the port. Firmly press the connector into the port.

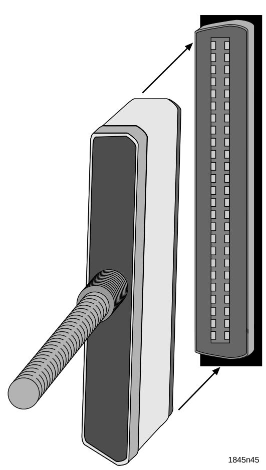


Figure 14-3. RJ21 Connector Insertion

2. When the RJ21 connector has been correctly inserted, it should remain in place naturally. If there are Velcro fastening straps provided, use them to secure the connector to the port.

If link indicators are present for the ports serviced by the RJ21 connector, check that they are on. If an indicator is not on, that port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the 10BASE-T device at the other end of the twisted pair segment is on.
- Verify that the RJ21 connector has the proper pinouts.
- Verify the proper crossover of the cable link between the two devices.
- Examine the punchdown block or patch panel that the UTP cable is connected to for proper wiring or punchdowns.
- Check the cable for continuity.
- Check that the twisted pair connection meets dB loss and cable specifications outlined in 10BASE-T Twisted Pair Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the RJ21 connector from the jack, unfasten any locking straps or clips that are present and pull the connector straight out of the port. Do not rock the connector from side to side, as damage to the contacts may result.

BNC

The BNC connector is used for connections to 10BASE2 coaxial cable. The instructions which follow detail the process used to connect a male BNC connector to a female BNC barrel connector.

Before attaching a male BNC connector to a female BNC barrel connector or terminator, look into the end of the male connector to verify that the gold contact pin is present and centered. Any bent or broken pins may not connect properly and should be replaced.

1. Align the guide channels of the BNC (male) metal housing with the locking keys of the BNC barrel (female) connector. Slide the metal housing of the male connector straight over the metal housing of the female connector.

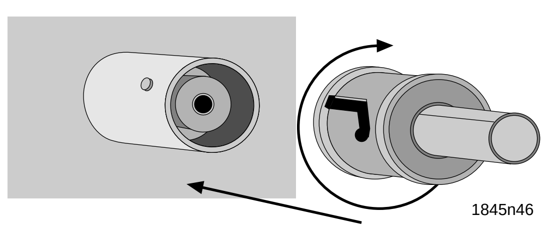


Figure 14-4. BNC Connector Insertion

2. Once the housing stops moving in, turn the metal housing clockwise while continuing to apply light forward pressure. It is likely that the female connector will have to be secured in order to stop it from rotating as you turn the male connector.
3. The locking keys of the female connector will pull the connector in until they reach the circular locking holes at the end of the guide channels. The keys will click the connector into place and hold it there.

If a link indicator is present for the connector, check that it is on. If the link indicator does not show a valid connection, perform the following actions until you achieve a link.

- Examine the BNC connector for a bent or damaged center pin. A badly-corroded pin may not connect properly.
- Verify that the cable is 50 Ohm RG-58 A/U type thin coaxial cable.
- Examine the cable for breakage or kinks that may indicate fracturing of the cable due to overbending or poor maintenance.
- Check the cable for continuity.
- Check that the thin coaxial cable segment meets the cable specifications outlined in Ethernet Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the BNC connector, perform the numbered procedures above in reverse order, turning the metal housing counter-clockwise and pulling the connector straight off of the female BNC connector.

N-Type

The N-Type connector is used for intrusive taps in thick coaxial cabling. The instructions which follow detail the process used to connect a male N-Type connector to a female N-Type barrel connector.

Before attaching a male N-Type connector to a female N-Type barrel connector or terminator, look into the end of the male connector to verify that the gold contact pins are present and centered. Any bent or broken pins may not connect properly and should be replaced.

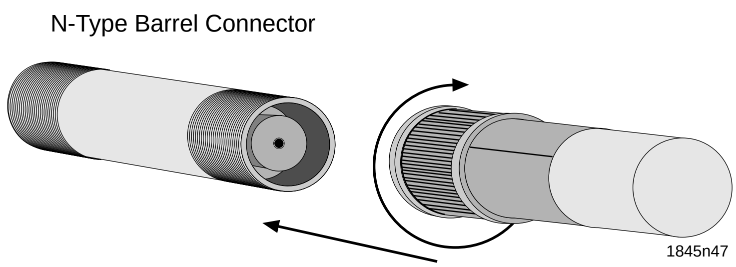


Figure 14-5. N-Type Connector Insertion

1. Slide the threaded metal housing of the male connector straight over the metal housing of the female connector.
2. Once the housing stops moving in, turn the metal housing clockwise while continuing to apply light forward pressure. As the threads of the male and female housings match up, the contacts will be pulled together.
3. Once the male N-type connector housing can no longer be turned by hand, do not tighten any further.

ST Connector

Each fiber optic link consists of two strands of fiber optic cabling: the transmit (TX) and the receive (RX). The transmit strand from a module port connects to the receive port of a fiber optic Ethernet device at the other end of the segment. The receive strand of the applicable port on the module connects to the transmit port of the fiber optic Ethernet device.

Cabletron Systems recommends labeling fiber optic cables to indicate receive and transmit ends. Many cables are prelabeled, providing matching labels or tapes at both ends of each strand of cable.

The instructions which follow detail the process used to connect an ST connector to a station port.

1. Remove the protective plastic covers from the fiber optic ports on the applicable port on the module, and from the ends of the connectors on each fiber strand.

CAUTION: Do not touch the ends of the fiber optic strands, and do not let the ends come in contact with dust, dirt, or other contaminants. Contamination of cable ends causes problems in data transmissions. If necessary, clean contaminated cable ends using alcohol and a soft, clean, lint-free cloth.

2. Attach one fiber to the applicable receive port on the module. Insert the ST connector into the port with the alignment slot on the connector inserted over the locking key on the port. Turn the connector clockwise to lock it down

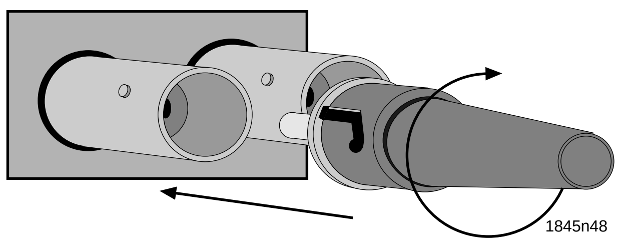


Figure 14-6. ST Connector Insertion

3. Attach the other fiber of the pair to the applicable transmit port on the module. Use the same procedure for insertion of the ST connector.
4. At the other end of the fiber optic cable, attach the fiber pair to the transmit and receive ports of the device.

If link indicators are present for the fiber optic connection, check that they are on. If an indicator is present but not on, that port does not have a valid link. Perform each of the following steps until you reach a resolution of the problem and achieve a link.

- Check that the device at the other end of the link is operating.
- Verify proper crossover of the fiber strands. Try swapping the transmit and receive connections at only one end of the link.
- Verify that the fiber connection meets the dB loss specifications outlined in Fiber Optic Network Requirements.

If you are still unable to establish a link, attempt to make the connection between the devices with another fiber optic cable. If this is unsuccessful, contact Cabletron Systems Technical Support.

Token Ring

DB9

The DB9 connector is often used to connect Token Ring stations to STP jumper cables. The instructions which follow detail the process used to connect a DB9 connector to a station port.

NOTE

The DB9 connector looks identical to the PC EGA monitor connector. If a Token Ring lobe connection is attached to the monitor port, the Token Ring network will enter an error state. This is due to the resemblance that EGA monitor current has to the phantom current required to open a Token Ring lobe connection.

1. Align the DB9 connector of the STP cable with the DB9 port of the network device as shown in Figure 14-7. The D-shape of the connector should be aligned with the D-shape of the port. The connector will only connect if it is properly aligned.

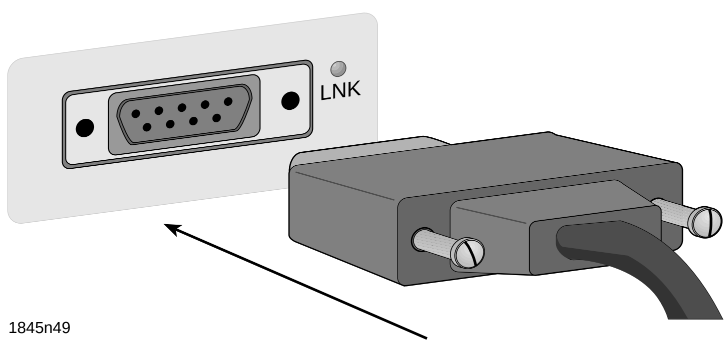


Figure 14-7. DB9 Connector Insertion

2. Firmly press the DB9 connector over the DB9 port. Once the connector has been fully inserted, secure the connector to the port by screwing in the small machine screws on either side of the DB9 connector.

If a link indicator is present for the port, check to see if it is on. If it is not on, perform the following actions until you reach a resolution of the problem and achieve a link.

- Check that the Token Ring device at the other end of the AUI segment is operating.
- Verify proper crossover of the STP segment.
- Check the DB9 connector for bent or missing pins. Keep in mind that several DB9 connectors provide only four pins at the connector.
- Verify that the DB9 connectors on the STP segment have the proper pinouts.
- Attempt the connection with a known good patch cable.
- Check that the twisted pair connection meets all cable specifications outlined in Token Ring Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the DB9 connector from the port once it is locked in, unscrew both of the machine screws at either side of the connector which fasten it to the port. Grasp the connector firmly between your thumb and forefinger. Pull the connector straight out of the port. Do not rock the connector or attempt to jerk it out of the port by the cable.

RJ45

The RJ45 connector is used to make connections to UTP and STP cabling. The instructions which follow detail the process used to connect an RJ45 connector to a station port.

1. Align the RJ45 connector with the socket of the RJ45 port. The connector will only insert and lock if the raised locking clip of the RJ45 connector is inserted into the correct location.

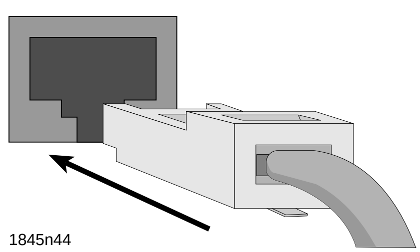


Figure 14-8. RJ45 Connector Insertion

2. Press the RJ45 connector into the port until the click of the locking clip is felt. The pressure required to perform this should be minimal. If you encounter resistance or excessive friction, remove the connector and check the port for obstruction. Also, verify that the connector and the port are of the same type.

Once the locking clip snaps into place, the RJ45 connector will remain in the port.

If a link indicator is present for the port, check that it is on. If the indicator is not on, the port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the Token Ring device at the other end of the twisted pair segment is on.
- Verify that the RJ45 connectors on the twisted pair segment have the proper pinouts.
- Check the cable for continuity.
- Check that the twisted pair connection meets dB loss and cable specifications outlined in IEEE 802.5 Twisted Pair Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the RJ45 connector from the port once it is locked in, grasp the cable where it enters the network device. Using your finger or a non-conductive probe, pinch the exposed arm of the locking clip towards the main body of the housing. When the arm contacts the housing, the locking clip has been disengaged. Without releasing the arm, gently pull the RJ45 connector directly out of the port.

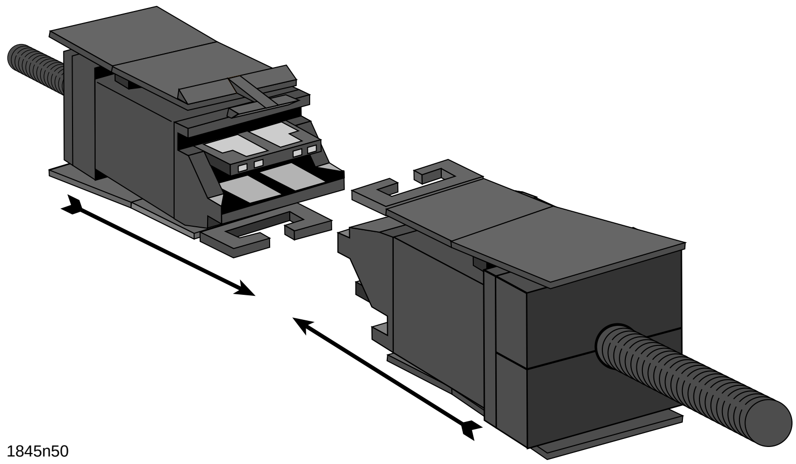
If the connector will not come out, there may be damage to the locking clip. Examine the arm of the locking clip. While pressing it back toward the shell of the connector, verify that the clip, located within the port, is being moved. If the clip is broken, you may need to use a non-conductive probe to disengage the locking clip.

Do not place foreign objects into device ports while they are connected to a power source.

Token Ring MIC

Token Ring MIC connectors only attach to other Token Ring MIC connectors or ports. In order to connect two Token Ring MICs, perform the following procedures:

1. Align the connectors such that the moving arms at the outside edges of both connectors are aligned. Looking at the connectors from the side, it should be obvious if the connectors will nest properly in their current arrangement.



1845n50

Figure 14-9. Token Ring MIC Connector Insertion

2. Press the two connectors straight into one another. The connectors should meet and the locking arms on the top and bottom of one connector should snap into place with an audible click. If the connectors do not slide together, rotate one of the two connectors 180° and re-attempt the connection.

To disconnect a pair of MIC connectors, grasp each connector firmly. Place the thumb and forefinger of one hand over the latching arms at the rear of one connector and press them in toward the housing. This should release the locking clips at the front of the connector. The MIC connectors may then be pulled apart. If the latching arms do not move, there may be a physical lock inserted behind them to keep them from releasing inadvertently. Either remove any physical locks under the latching arms or attempt to move the latching arms of the other MIC connector.

ST Connector

The instructions which follow detail the process used to connect a set of ST connectors to a station port.

ST connectors for fiber optic cables are connected to ST ports on devices through a "twist and lock" procedure.

Each fiber optic link consists of two strands of fiber optic cabling: the transmit (TX) and the receive (RX). The transmit strand from a module port connects to the receive port of a fiber optic Ethernet device at the other end of the segment. The receive strand of the applicable port on the module connects to the transmit port of the fiber optic Ethernet device.

Cabletron Systems recommends labeling fiber optic cables to indicate receive and transmit ends. Many cables are prelabeled, providing matching labels or tapes at both ends of each strand of cable.

1. Remove the protective plastic covers from the fiber optic ports on the applicable port on the module, and from the ends of the connectors on each fiber strand.

Do not touch the ends of the fiber optic strands, and do not let the ends come in contact with dust, dirt, or other contaminants. Contamination of cable ends causes problems in data transmissions. If necessary, clean contaminated cable ends using isopropyl alcohol and a soft, clean, lint-free cloth.

2. Attach one fiber to the applicable receive port on the module. Insert the ST connector into the port with the alignment slot on the connector inserted over the locking key on the port. Turn the connector clockwise to lock it down.

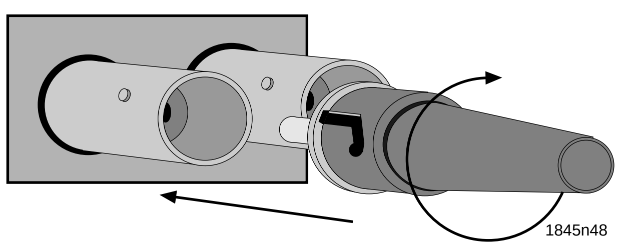


Figure 14-10. ST Connector Insertion

3. Attach the other fiber of the pair to the applicable transmit port on the module. Use the same procedure for insertion of the ST connector.
4. At the other end of the fiber optic cable, attach the fiber pair to the transmit and receive ports of the device.

If link indicators are present for the fiber optic connection, check that they are on. If an indicator is present but not on, that port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the device at the other end of the link is on.
- Verify proper cross-over of the fiber strands. Try swapping the transmit and receive connections at only one end of the link.
- Verify that the fiber connection meets the dB loss specifications outlined in Fiber Optic Network Requirements.

If you are still unable to establish a link, attempt to make the connection between the devices with another fiber optic cable. If this is unsuccessful, contact Cabletron Systems Technical Support.

FDDI

RJ45

The RJ45 connector is used to make TP-PMD connections using either UTP or STP cabling. The instructions which follow detail the process used to connect an RJ45 connector to a station port.

1. Align the RJ45 connector with the socket of the RJ45 port. The connector will only insert and lock if the raised locking clip of the RJ45 connector is inserted into the correct location.

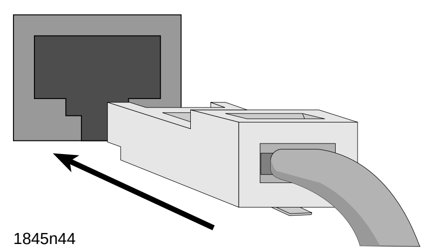


Figure 14-11. RJ45 Connector Insertion

2. Press the RJ45 connector into the port until the click of the locking clip is felt. The pressure required to perform this should be minimal. If you encounter resistance or excessive friction, remove the connector and check the port for obstruction. Also, verify that the connector and the port are of the same type.

Once the locking clip snaps into place, the RJ45 connector will remain in the port.

If a link indicator is present for the port, check that it is on. If the indicator is not on, the port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the FDDI device at the other end of the twisted pair segment is on.
- Verify that the RJ45 connectors on the twisted pair segment have the proper pinouts.
- Check the cable for continuity.
- Check that the twisted pair connection meets dB loss and cable specifications outlined in TP-PMD Network Requirements.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the RJ45 connector from the port once it is locked in, grasp the cable where it enters the network device. Using your finger or a non-conductive probe (the cap of a ballpoint pen is a useful tool for recessed ports) pinch the exposed arm of the locking clip towards the main body of the housing. When the arm contacts the housing, the locking clip has been disengaged. Without releasing the arm, gently pull the RJ45 connector directly out of the port.

If the connector will not come out, there may be damage to the locking clip. Examine the arm of the locking clip. While pressing it back toward the shell of the connector, verify that the clip, located within the port, is being moved. If the clip is broken, you may need to use a non-conductive probe to disengage the locking clip.

Do not place foreign objects into device ports while they are connected to a power source.

FDDI MIC

Before attaching connectors to an FDDI MIC port, remove the protective rubber plug from the FDDI port. Also remove the plastic hood from the MIC connector to be used. Usually, there will be three plastic inserts, colored red, blue, and green, in holders on the connector hood. These plastic inserts are used to key the MIC connector for use only in certain types of FDDI ports.

Using a paper clip or probe, push the insert you require out of its holder. The insert colors and the FDDI port type they key the MIC connector for are listed in Table 14-1, below. Snap the insert into place in the recessed channel of the FDDI MIC connector. The MIC connector is now ready to be connected to the type of port indicated by the key.

Table 14-1. FDDI MIC Key Coloration

Color	Port Type*
Red	A
Blue	B
Green	M

*. FDDI S ports are not keyed, and can accept any connection.

1. Align the MIC connector with the FDDI MIC port, such that the side of the connector containing the key is lined up with the side of the port which contains the internal raised guide, or “rib.”
2. Press the MIC connector into the port. As the connector reaches the back side of the port, the clips on either side of the MIC connector will pull in toward the connector housing. When the clips spring back to their rest positions, the connector is locked in place.

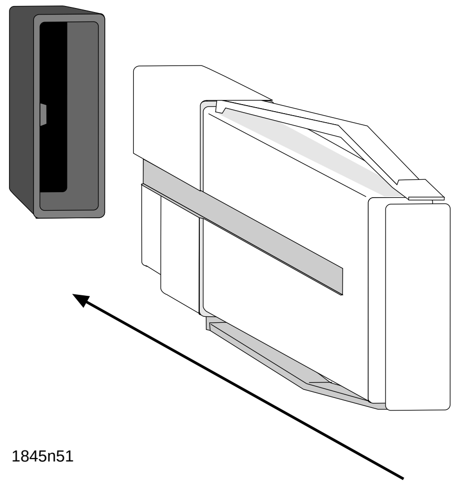


Figure 14-12. FDDI Media Interface Connector Insertion

The link LED associated with the port should come on, indicating a valid link. If the link LED for the port does not light up, there is a condition present which will not allow the FDDI device to recognize a link. Perform the following examinations and actions until you achieve a link.

- Check that the FDDI device at the other end of the cable is on.
- Check the connection type that you have made against the FDDI connection table below. Any connection other than M to M or S to S should function properly.
- Test the FDDI cable for continuity.
- Check that the fiber optic connection meets all cable specifications outlined in ANSI X3T9.5 MMF-PMD or SMF-PMD Network Requirements, whichever applies.
- If all else fails, contact Cabletron Systems Technical Support.

To remove the MIC connector, grasp the protruding portion of the connector, holding the two locking clips with your thumb and forefinger. Pinch both clips back toward the main housing until they contact the sides of the connector. With the clips still held against the connector housing, firmly pull the MIC connector straight out of the port. Do not rock the connector back and forth, as damage to the port or connector may result.

Once the connector has been removed, cover the exposed end of the connector with the plastic hood and insert the rubber plug into the exposed FDDI port to protect the fiber optic ends.

SC Connector

Each fiber optic link consists of two strands of fiber optic cabling: the transmit (TX) and the receive (RX). The transmit strand from a module port connects to the receive port of a fiber optic Ethernet device at the other end of the segment. The receive strand of the applicable port on the module connects to the transmit port of the fiber optic Ethernet device. As duplex SC Connectors are designed to only be inserted into SC ports in one fashion, there is little chance of a mis-connection due to improper crossover occurring.

Cabletron Systems recommends labeling fiber optic cables to indicate receive and transmit ends. Many cables are prelabeled, providing matching labels or tapes at both ends of each strand of cable.

1. Remove the protective plastic covers from the fiber optic port on the applicable module, and from the ends of the ferrules of the SC Connector.

Do not touch the ends of the fiber optic strands, and do not let the ends come in contact with dust, dirt, or other contaminants. Contamination of cable ends causes problems in data transmissions. If necessary, clean contaminated cable ends using isopropyl alcohol and a soft, clean, lint-free cloth.

2. Align the SC connector with the SC port to which it is to be connected. Hold the SC Connector as shown in the figure below, with the raised guide keys at the top.

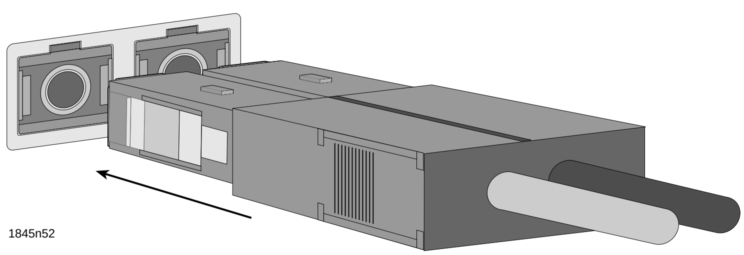


Figure 14-13. SC Connector Insertion

3. Press the connector straight into the port. When the port is fully inserted, the inner housing will latch and lock the connector into place.

If link indicators are present for the fiber optic connection, check that they are on. If an indicator is present but not on, that port does not have a valid link. Perform each of the following actions until you reach a resolution of the problem and achieve a link.

- Check that the device at the other end of the link is on.
- Verify proper crossover of the fiber strands. Try swapping the transmit and receive connections at only one end of the link.
- Verify that the fiber connection meets the dB loss specifications outlined in FDDI Network Requirements.

If you are still unable to establish a link, attempt to make the connection between the devices with another fiber optic cable. If this is unsuccessful, contact Cabletron Systems Technical Support.

To remove the SC connector from the port, grasp it firmly with thumb and forefinger and pull it straight out of the port. There will be some initial resistance before the inner latching mechanism allows the connector to slip. Do not pull quickly or rock the connector back and forth, as damage to the connector or port may result.

Once the connector is removed, place the protective plastic covers over the fiber optic port on the module, and over the ends of the ferrules of the SC Connector.

Appendix A

Charts and Tables

This chapter presents essential information dealing with the minimum, maximum, and recommended characteristics for standards-compliant cabling for Ethernet, Token Ring, and FDDI networks.

Ethernet

10BASE5 Cable Characteristics

Aspect	Limit
Tap Spacing	≥ 2.5 m
Max Length	500 m
Max Stations	100

10BASE2 Cable Characteristics

Aspect	Limit
Tap Spacing	≥ 0.5 m
Max Length	185 m
Max Stations	30

10BASE-T Cable Characteristics

Aspect	Limit
Impedance	75 - 165 Ω
Insertion Loss @ 10 MHz	11.5 dB
Jitter	≤ 5.0 ns
One-way Propagation Delay	1000 ns
Max Length	200 m

10BASE-F Cable Characteristics (multimode)

Aspect	50/125 μm	62.5/125 μm	100/140 μm
Attenuation @ 850 nm	≤ 13.0 dB	≤ 16.0 dB	≤ 19.0 dB
Insertion Loss @ 10 MHz	≤ 10 dB	≤ 10 dB	≤ 10 dB
One-way Propagation Delay	25.6 μs		
Max Length	2 km		

10BASE-F Cable Characteristics (single mode)

Aspect	8/125 μm	12/125 μm
Attenuation @ 1300 nm	10.0 dB	10.0 dB
Insertion Loss @ 10 MHz	≤ 10 dB	≤ 10 dB
One-way Propagation Delay	25.6 μs	
Max Length	5 km	

These are not correct yet:

100BASE-TX Cable Characteristics

Aspect	Limit
Impedance	75 - 165 Ω
Insertion Loss @ 10 MHz	11.5 dB
Jitter	≤ 5.0 ns
One-way Propagation Delay	1000 ns
Max Length (simplex)	200 m
Max Length (duplex)	200 m

100BASE-FX Cable Characteristics (multimode)

Aspect	50/125 μm	62.5/125 μm	100/140 μm
Attenuation @ 850 nm	≤ 13.0 dB	≤ 16.0 dB	≤ 19.0 dB
Insertion Loss @ 10 MHz	≤ 10 dB	≤ 10 dB	≤ 10 dB
One-way Propagation Delay	25.6 μs		
Max Length (simplex)	2 km		
Max Length (duplex)	412 m		

100BASE-FX Cable Characteristics (single mode)

Aspect	8/125 μm	12/125 μm
Attenuation @ 1300 nm	10.0 dB	10.0 dB
Insertion Loss @ 10 MHz	≤ 10 dB	≤ 10 dB
One-way Propagation Delay	25.6 μs	
Max Length	5 km	

Token Ring

Lobe Cable Distances

Media	Circuitry	Cable Type	Max Lobe Length	
			4 Mbps	16 Mbps
STP	active	IBM Types 1, 2	300 m	150 m
		IBM Types 6, 9*	200 m	100 m
	passive	IBM Types 1, 2	200 m	100 m
		IBM Type 9	133 m	66 m
UTP	active	Category 5	250 m	120 m
		Categories 3, 4	200 m	100 m
	passive	Category 5	130 m	85 m
		Categories 3, 4	100 m	60 m
Fiber Optics	active	Multimode	2000 m	2000 m
		Single Mode	2000 m	2000 m

*. IBM Type 6 cable is recommended for use as jumper cabling only, and should not be used for facility cabling installations.

Trunk Cable Distances

Media	Max Distance (4 Mbps)	Max Distance (16 Mbps)
Shielded Twisted Pair	770 m	346 m
Unshielded Twisted Pair		
Category 3/4	200 m	100 m
Category 5	250 m	120 m
Fiber Optics (Multimode)	2000 m	2000 m
Fiber Optics (Single Mode)	2000 m	2000 m

STP Test Requirements

Aspect	Type 1/2		Type 6/9	
	4 Mbps	16 Mbps	4 Mbps	16 Mbps
Impedance	127.5 - 172.5 Ω			
Attenuation (dB/km)	≤ 22	≤ 45	≤ 33	≤ 66

UTP Test Requirements

Aspect	Category 3		Category 4		Category 5	
	4 Mbps	16 Mbps	4 Mbps	16 Mbps	4 Mbps	16 Mbps
Impedance	85 - 115 Ω					
Attenuation (dB/km)	≤ 56	≤ 131	≤ 42	≤ 88	≤ 42	≤ 82
Near-End Crosstalk	23 dB/1000 ft		36 dB/1000 ft		44 dB/1000 ft	

Multimode Fiber Optic Test Requirements

Aspect	50/125 μm Multimode	62.5/125 μm Multimode	100/140 μm Multimode
Total Attenuation	13.0 dB @ 850 nm	16.0 dB @ 850 nm	19.0 dB @ 850 nm

Single Mode Fiber Optic Test Requirements

Aspect	8.3/125 μm Single mode	12/140 μm Single mode
Total Attenuation	15.1 dB @ 1300 nm	

FDDI

Maximum Cable Distances

Table 14-2. FDDI Distance Limitations

Media	PMD Standard	Max Link Distance
Fiber Optics (Multimode)	MMF-PMD	2 km
Fiber Optics (Single Mode)	SMF-PMD	60 km
Unshielded Twisted Pair*	TP-PMD	100 m
Shielded Twisted Pair†		100 m

*. Category 5 UTP cabling only

†. IBM Type 1 STP cabling only

This glossary provides brief descriptions of some of the recurrent terms in the main text, as well as related terms used in discussions of the relevant networking discussions. These descriptions are not intended to be comprehensive discussions of the subject matter. For further clarification of these terms, you may wish to refer to the treatments of these terms in the main text.

Words in the glossary description text listed in boldface type indicate other entries in the glossary which may be referred to for further clarification.

10BASE2
IEEE standard which governs the operation of devices connecting to Ethernet thin **coaxial** cable.

10BASE5
IEEE standard which governs the operation of devices connecting to Ethernet thick **coaxial** cable.

10BASE-FL
IEEE standard which governs the operation of devices connecting to Ethernet **fiber optic** cable. Supersedes previous **FOIRL** standard.

10BASE-T
IEEE standard which governs the operation of devices connecting to Ethernet Unshielded Twisted Pair (**UTP**) cable.

A/B Ports
FDDI ports which provide connection, in pairs, to the dual counter-rotating ring.

Alarm
A notification, generated by the operation of **SNMP**, which is sent to a management station to indicate a problem with the network or warn of an error condition.

Application
1: A software operation performed by a workstation or other network **node**. 2: A layer of the **OSI** Model.

Architecture
A collective rule set for the operation of a network. Architectures describe the means by which network devices relate to one another. Architecture types include Mainframe-Terminals, Peer-to-Peer, and Client-Server.

ATM
Asynchronous Transfer Mode. A networking technology that is based on the use of connections between communicating devices that are set up, used, and then eliminated.

Attenuation Loss of signal power (measured in decibels) due to transmission through a cable. Attenuation is dependent on the type, manufacture and installation quality of cabling, and is expressed in units of loss per length, most often dB/m.

AUI Attachment Unit Interface. A cabling type used in Ethernet networks, designed to connect network stations and devices to **transceivers**.

Backbone A portion of a network which provides the interconnection of a number of separate, smaller networks.

Backplane The portion of a **modular chassis** to which all **modules** are connected. Typically the backplane provides power and management functions to each module, and is used to provide networking connections, via **buses**, to all modules in the modular chassis.

Bit Binary Digit. A bit is the smallest unit of information, consisting of a single binary number. A bit is represented by a numerical value of 1 or 0.

BOOTP Bootstrap Protocol. Checks **MIB** variables of an **SNMP** manageable device to determine whether it should start up using its existing **firmware** or boot up from a network **server** specifically configured for the purpose.

Branch Group A collection of **MIB**s related by common function. These MIBs are collected into families called branches. See also **Leaf Object**, **MIB Tree**.

Bridge Bridges are network devices which connect two or more separate network segments while allowing traffic to be passed between the separate networks when necessary. Bridges read in packets and decide to either retransmit them or block them based on the destination to which the packets are addressed.

BRIM Bridge/Router Interface Module. BRIMs are added to BRIM-capable Cabletron Systems equipment to provide connections to external networks through an integrated **bridge** or **router**.

Broadcast A type of network transmission; a broadcast transmission is one which is sent to every station on the network, regardless of location, identification, or address.

Buses Physical portions of the **backplane** of a modular chassis which pass information between **modules**.

Card See **Module**.

Channel
A portion of a backplane **bus** which is specifically partitioned off for the transmission of one type of network data.

Chassis
See **Modular Chassis**.

Client
A workstation or node which obtains services from a **server** device located on the network.

Client-Server
A computing model which is based on the use of dedicated devices (**servers**) for the performance of specific computational or networking tasks. These servers are accessed by several **clients**, workstations which cannot perform those functions to the same extent or with the same efficiency as the servers.

Coaxial
An Ethernet **media** type which consists of a core of electrically conductive material surrounded by several layers of insulation and shielding.

Community Name
An identification which allows a specific level of access to the network device. Similar to a password, a Community Name acts to restrict access to control capabilities and network statistics.

Concentrator
A network device which allows multiple network ports in one location to share one physical interface to the network.

Congestion
An estimation or measure of the utilization of a network, typically expressed as a percentage of theoretical maximum utilization of the network.

Connectivity
The physical connection of cabling or other **media** to network devices. The coupling of media to the network.

Console
See **Terminal**.

Crossover
A length of multi-stranded cable in which the transmit wire(s) of one end is/are crossed over within the cable to connect to the receive wire(s) of the other end. Crossovers are used to connect devices to like devices, ensuring that transmit and receive connections are properly made.

Crosstalk
A corruption of the electrical signal transmitted through a Shielded or Unshielded Twisted Pair cable. Crosstalk refers to signals on one strand or set of strands affecting signals on another strand or set of strands.

CSMA/CD

Carrier Sense Multiple Access with Collision Detection. CSMA/CD is the basis for the operation of **Ethernet** networks. CSMA/CD is the method by which stations monitor the network, determine when to transmit data, and what to do if they sense a collision or other error during that transmission.

Data

Information, typically in the form of a series of **bits**, which is intended to be stored, altered, displayed, transmitted, or processed.

Data Loop

A condition caused by the creation of duplicate paths which network transmissions could follow. Data loops are created by the use of redundant connections between network segments or devices. Ethernet networks cannot effectively function with data loops present. To allow the creation of fault-tolerant networks, data loops are automatically detected and eliminated by the **Spanning Tree** algorithm.

DB15

A 15-pin connector used to terminate **transceiver** cables in accordance with the **AUI** specification.

DB9

A 9-pin connector, typically used in Token Ring networks and for serial communications between computers.

Decryption

The translation of data from an encrypted (see **encryption**) form into a form both recognizable and utilizable by a workstation, **node**, or network **device**.

Dedicated

Assigned to one purpose or function.

Default Gateway

The IP address of the network or host to which all packets addressed to unknown network or host are sent.

Device (network)

Any discrete electronic item connected to a network which either transmits and receives information through it, facilitates that transmission and reception, or monitors the operation of the network directly.

DLM

Distributed LAN Monitor. DLM is a feature of some SNMP management devices which allows that device to locally monitor other devices under its control and report to a central network management station any noted errors. This frees the network management station from directly monitoring every SNMP device.

DNI

Desktop Network Interface. DNI cards are devices which are added to workstations to provide them with a connection to a network (NIC).

Dual Attached

Connected to an **FDDI** dual counter-rotating ring through the use of **A/B ports**.

Dual Homing — A station connection method for **FDDI** which connects a device's **A/B ports** to the **M ports** of two separate **dual-attached concentrator** devices, providing fault-tolerance.

EEPROM — Electronic Erasable Programmable Read-Only Memory.

Encryption — A security process which encodes raw data into a form that cannot be utilized or read without **decryption**.

EPIM — **Ethernet Port** Interface Module. EPIMs are added to specifically-designed slots in Cabletron Systems Ethernet products to provide connections to external **media**. EPIMs allow a great flexibility in the media used to connect to networks.

Ethernet — A networking technology which allows any station on the network to transmit at any time, provided it has checked the network for existing traffic, waited for the network to be free, and checked to ensure the transmission did not suffer a collision with another transmission. See also **CSMA/CD**.

Fault-Tolerance — The ability of a design (device or network) to operate at full or reduced capacity after suffering a failure of some essential component or connection. See also **redundant**.

FDDI — Fiber Distributed Data Interface. A high-speed networking technology. FDDI requires that stations only transmit data when they have been given permission by the operation of the network, and dictates that stations will receive information at pre-determined intervals. See also **Token**.

Fiber Optics — Network **media** made of thin filaments of glass surrounded by a plastic cladding. Fiber optics transmit and receive information in the form of pulses of light. See **multimode** and **single mode**.

File — A collection of related **data**.

Fileserver — A network **server** device which stores and maintains data files for access and modification by **users**.

Firmware — The software instructions which allow a network device to function.

Flash EEPROM — See **EEPROM**.

FNB — Flexible Network Bus. A Cabletron Systems **backplane** design which enables an FNB-configured chassis to support multiple network technologies simultaneously.

Frame

A group of **bits** that form a discrete block of information. Frames contain network control information or data. The size and composition of a frame is determined by the network **protocol** being used. Frames are typically generated by operations at the Data Link Layer (Layer 2) of the **OSI Model**.

Gateway

A device which connects networks with dissimilar network architectures and which operates at the Application Layer of the **OSI Model**. May also be used to refer to a **router**.

Heartbeat

See **SQE**.

Hexadecimal

A base 16 numerical system. Digits in hexadecimal run from 0 to 9 and continue from A to F, where F is equivalent to the decimal number 16.

Host

A device which acts as the source or destination of data on the network.

Hot Swap

Hot Swap capability indicates that a product is capable of being removed from an operating **modular chassis** and reinserted or replaced without requiring that the chassis and all associated modules be powered down.

Hub

See **Modular Chassis**.

IANA

Internet Assigned Numbers Authority. An agency which assigns and distributes **IP addresses**.

IEEE

Institute of Electrical and Electronic Engineers. A standards-making body.

IETF

Internet Engineering Task Force. A standards-making body.

Image File

Software instruction code which is downloaded to an intelligent network device. See also **Firmware**.

Impedance

A measure of the opposition of electrical current or signal flow in a length of cable.

In-Band

Performed through the operating network architecture. Refers most commonly to management functions. See also **Out-of-Band**.

Interface

A connection to a network. Unlike a **port**, an interface is not necessarily an available physical connector accessible through the front panel of a device. Interfaces may be used as backplane connections, or may be found only in the internal operation of a module (All ports are interfaces, but not all interfaces are ports).

Internet — A world-wide network which provides access through a vast chain of private and public **LAN**s.

Interoperability — The capacity to function in conjunction with other devices. Used primarily to indicate the ability of different vendors' networking products to work together cohesively.

IP — Internet Protocol.

IP Address — Internet Protocol address. The IP address is associated, by the network manager or network designer, to a specific **interface**. The availability of IP addresses is controlled by the **IANA**.

ISO — International Organization for Standardization. The ISO has developed a standard model on which network operation is based, called the **OSI** Model.

Jitter — Degradation of network signals due to a loss of synchronization of the electrical signals. Jitter is often a result of passing a signal through too many **repeaters**.

LAN — Local Area Network.

LANVIEW — A system which relates diagnostic, troubleshooting, and operational information pertaining to network **devices** through the use of prominently displayed **LED**s.

LDRAM — Local Dynamic Random Access Memory.

Leaf Object — An end unit in a **MIB tree**. Leaf objects are accessed through a series of **branch groups**. Leaf objects are always individual **MIB**s.

LED — Light Emitting Diode. A simple electronic light, used in networking equipment to provide diagnostic indicators. Also used as a light source for some **fiber optic** communications equipment.

Load — An indication of network utilization.

M Ports — **FDDI** connectivity ports located on **concentrator** devices, to which end **nodes** connect through their **S ports**.

MAC Address — Media Access Control address. The MAC address is associated, usually at manufacture, with a specific **interface**.

MAU — Multistation Access Unit.

Mbps Megabits Per Second. Mbps indicates the number of groups of 1000 **bits** of data that are being transmitted through an operating network. Mbps can be roughly assessed as a measure of the operational "speed" of the network.

Media Physical cabling or other method of interconnection through which network signals are transmitted and received.

MIC Connector 1: Token Ring genderless connector. 2: FDDI fiber optic connector which may be keyed to act as an **M** or **S** connector or **A/B** connector.

Micron (μ) A micrometer, one millionth of a meter.

MIM Media Interface Module. See also **Module**.

Mission-Critical Vital to the operation of a network, company, or agency.

Modular Chassis A device which provides power, cooling, interconnection, and monitoring functions to a series of flexible and centralized **modules** for the purposes of creating a network or networks.

Module A discrete device which is placed in a **modular chassis** to provide functionality which may include, but is not limited to, bridging, routing, connectivity, and repeating. Modules are easily installed and removed. Also, any device designed to be placed in another device in order to operate.

Multichannel A Cabletron Systems Ethernet design which provides three separate network channels (of Ethernet or Token Ring technology) through the backplane of a chassis, allowing for the creation of multiple networks in a single chassis.

Multimode A type of **fiber optics** in which light travels in multiple modes, or wavelengths. Signals in Multimode fiber optics are typically driven by **LED**s.

Nanometer One billionth of a meter.

NAUN Nearest Active Upstream Neighbor.

Node Any single end station on a network capable of receiving, processing, and transmitting packets.

NVRAM Non-Volatile Random Access Memory. Memory which is protected from elimination during shutdown and between periods of activity, frequently through the use of batteries.

Octet — A numerical value made up of eight binary places (**bits**). Octets can represent decimal numbers from zero (0000 0000) to 255 (1111 1111).

OID — Object Identifier.

OSI Model — Open Standards Interconnect. A model of the way in which network communications should proceed from the user process to the physical media and back.

Out-Of-Band — Performed without requiring the operation of the network technology. Most commonly used in reference to local management operations.

Packet — A discrete collection of **bits** that form a block of information. Packets are similar to **frames**. Packets are typically generated at the Network Layer (Layer 3) of the **OSI Model**, and are encapsulated in frames before being transmitted onto a network media.

Passive — Not utilizing per-port reclocking and regeneration of the signal which is propagated throughout the device. Commonly applied to **Token Ring** equipment to distinguish it from **active** devices.

Phantom Current — A weak voltage passed by **Token Ring** end nodes to the **MAU** to open the **relay** for that port.

Plenum — A cabling term which indicates a cable with insulating material that is considered safe to use in return-air plenum spaces (in contrast to **PVC** insulation) due to its low relative toxicity if ignited.

Port — A physical connector which is used as an interface to cabling with modular or pinned connectors. Ports are associated with **Interfaces**.

Port Assignment — The association, through software management, of specific **ports** on a network device to specific **channels** of a **backplane**. This assignment is done on an individual port basis.

Protocol — A set of rules governing the flow of information within a communications infrastructure. Protocols control operations such as **frame** format, timing, and error correction. See also **Architecture**.

PVC — Polyvinyl Chloride. A material commonly used in the fabrication of cable insulation. This term is used to describe a non-plenum rated insulating material. See also **Plenum**. PVC releases toxic smoke when burned.

Redundant — Extra or contingent. A redundant system is one that is held in reserve until an occurrence such as a failure of the primary system causes it to be required.

Relay
An electrical switch which opens and closes in response to the application of voltage or current.

Repeater
A network device consisting of a receiver and transmitter which is used to regenerate a network signal to increase the distance it may traverse.

Ring-In/Ring-Out
Token Ring connections which are made between **MAU**s utilizing two separate physical cables and incorporating an auto-wrap recovery feature.

RJ45
A modular connector style used with twisted pair cabling. The RJ45 connector resembles the modern home telephone connector (RJ11).

RMIM
Repeating Media Interface Module. A term used to indicate a family of Cabletron Systems Ethernet Media Interface Modules (See **MIM**) which are capable of performing their own repeater functions.

RMON
Remote MONitoring. RMON is a network management standard which provides more detailed network information and status reporting than **SNMP**.

Router
A router is a device which connects two or more different network segments, but allows information to flow between them when necessary. The router, unlike a **bridge**, examines the data contained in every **packet** it receives for more detailed information. Based on this information, the router decides whether to block the packet from the rest of the network or transmit it, and will attempt to send the packet by the most efficient path through the network.

S Ports
FDDI ports which are used by FDDI stations and end nodes to make **single attached** connections to FDDI **concentrators**.

SDRAM
Shared Dynamic Random Access Memory.

Segment
A portion of a network which is separated from other networks. A segment may be one portion of a bridged, switched, or routed network. Segments must be capable of operating as their own networks, without requiring the services of other portions of the network.

Server
A workstation or host device that performs services for other devices (**clients**) on the network.

SIMM
Single In-line Memory Module. A collection of Random Access Memory (RAM) microprocessors which are placed on a single, replaceable printed circuit board. These SIMMs may be added to some devices to expand the capacity of certain types of memory.

Single Attached

Connected to an **FDDI** network through a single cable which does not provide for auto-wrap functions.

Single Mode

A type of **fiber optics** in which light travels in one predefined mode, or wavelength. Signals in single mode fiber optics are typically driven by lasers. The use of lasers and the transmission characteristics of single mode fiber optics allow the media to cover greater distances than **multimode** fiber optics.

SMA

Sub-Miniature Assembly. A modular connector and port system used in **multimode** fiber optic cabling. The SMA connector is threaded, and is screwed into an SMA port.

SNMP

Simple Network Management Protocol. SNMP is a standardized set of network monitoring tools. See also **RMON**.

Spanning Tree

A mathematical comparison and decision algorithm performed by Ethernet bridges at power-up. Spanning tree detects the presence of data loops and allows the bridges to selectively activate some ports while others remain in a standby condition, avoiding the data loops and providing redundant paths in the event of bridge failures.

SQE

Signal Quality Error. A self-monitoring test performed by some Ethernet equipment which examines the status of the device at arbitrary and predefined intervals.

ST

Straight-Tip. A modular connector and port system used with both **multimode** and **single mode** fiber optic cabling. The ST connector utilizes an insert and twist-lock mechanism.

Station

See **node**.

STP

Shielded Twisted Pair. Refers to a type of cabling, most commonly used in Token Ring networks, which consists of several strands of cables surrounded by foil shielding, which are twisted together. See also **UTP**.

Straight-Through

A length of multi-stranded cable in which the transmit wire(s) of one end is/are passed directly through the cable to the same location on the other end. Straight-through cables are used for most facility cabling. See also **crossover**.

Subnet

A physical network within an **IP** network.

Subnet Mask

A 32-**bit** quantity which may be set up in **SNMP** management devices to indicate which bits in an **IP address** identify the physical network.

Switch
A network device which connects two or more separate network segments and allows traffic to be passed between them when necessary. A switch determines if a **packet** should be blocked or transmitted based on the destination address contained in that packet.

TCP
Transmission Control Protocol.

Terminal
A device for displaying information and relaying communications. Terminals do not perform any processing of data, but instead access processing-capable systems and allow users to control that system.

Throughput
The rate at which discrete quantities of information (typically measured in **Mbps**) are received by or transmitted through a specific device.

Token
A particular type of frame which informs a station in the **Token Ring** and **FDDI** network technologies that it may transmit data for a specified length of time. Once that time has expired, the station must stop transmitting and pass the token along to the next station in the network.

Token Ring
A network technology which requires that stations only transmit data when they have been given permission by the reception of a **Token**, and dictates that stations will receive information at pre-determined intervals and in a definite series.

Topology
The physical organization of stations and devices into a network.

TP-PMD
Twisted Pair - Physical Medium Dependent.

Transceiver
A device which transmits and receives. A transceiver provides the electrical or optical interface to the network media, and may convert signals from one media for use by another.

Trap
See **Alarm**.

User
Any person who utilizes a workstation or node on the network.

UTP
Unshielded Twisted Pair. A type of network media which consists of a number of individual insulated cable strands which are twisted together in pairs.

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