White Paper

Honeywell

Honeywell Process Solutions

FTE Cabling Best Practices

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Document ID: WP-07-01-ENG
Original Issue Date: May 2007
Version: 1.0

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Introduction and Applicable Standards

Document Scope

This document is intended to provide guidance on the best practices for the design, specification, and installation of copper and fiber optic cabling to support Fault Tolerant Ethernet (FTE) systems. While this document is intended to specifically support FTE, its practices can also be used for any ethernet implementation. This document is not intended as a step by step guide to network cabling. Proper cable plant design and installation requires trained professionals such as those on staff at Honeywell. The recommendations made in this document are not intended to supersede local codes and engineering standards.

This document discusses:

- Horizontal copper cable
- Copper cable terminations
- Copper patch cables
- Grounding
- Fiber optic cable
- Fiber optic terminations
- Fiber optic patch cables

Intended Audience

This document is intended to assist:

- Honeywell system consultants, technical assistance centers, and project services personnel
- Honeywell clients

Applicable Standards and Supporting Documents

This section lists standards and supporting documents from which many of the points in this document are derived. Telecommunication Industry Association/ Electronics Industry Alliance (TIA/EIA) standards are listed in the table below. TIA/EIA standards are copyrighted by and available for purchase from IHS/Global at www.global.ihs.com.

Standard Number	Standard Title
TIA-526-7	Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant
TIA-526-14-A	Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA/EIA-568-B.1	Commercial Building Telecommunications Cabling Standard
TIA/EIA-568-B.1-1	Commercial Building Telecommunications Cabling Standard Part 1: General Requirements Addendum 1 – Minimum 4-Pair UTP and 4-Pair ScTP Patch Cable Bend Radius
TIA-568-B.1-2	Commercial Building Telecommunications Cabling Standard Part 1: General Requirements Addendum 2 – Grounding and Bonding Specifications for Screened Balanced Twisted- Pair Horizontal Cabling
TIA-568-B.1-3	Commercial Building Telecommunications Cabling Standard Part 1: General Requirements Addendum 3 – Supportable Distances and Channel Attenuation for Optical Fiber Applications by Fiber Type
TIA-568-B.1-4	Commercial Building Telecommunications Cabling Standard Part 1: General Requirements Addendum 4 – Recognition of Category 6 and 850 nm Laser-Optimized 50/125 μm Multimode Optical Fiber Cabling
TIA-568-B.1-5	Commercial Building Telecommunications Cabling Standard Part 1: General Requirements Addendum 5 – Telecommunications Cabling for Telecommunications Enclosures
TIA/EIA-568-B.2	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
TIA/EIA-568-B.2-1	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted Pair Cabling Components Addendum 1 – Transmission Performance Specifications for 4-pair 100 Ω Category 6 Cabling
TIA/EIA-568-B.2-3	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted Pair Cabling Components Addendum 3 – Additional Considerations for Insertion Loss and Return Loss Pass/Fail Determination
TIA/EIA-568-B.2-4	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted Pair Cabling Components Addendum 4 – Solderless Connection Reliability Requirements for Copper Connecting Hardware
TIA-568-B.2-5	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components Addendum 5 – Corrections to TIA/EIA-568-B.2

Standard Number	Standard Title
TIA-568-B.2-6	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted Pair Cabling Components Addendum 6 – Category 6 Related Component Test Procedures
TIA-568-B.2-11	Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components Addendum 11 – Specification of 4-Pair UTP and SCTP Cabling
TIA/EIA-568-B.3	Optical Fiber Cabling Components Standard
TIA/EIA-568-B.3-1	Optical Fiber Cabling Components Standard Addendum 1 – Additional Transmission Performance Specifications for 50/125 µm Optical Fiber Cables
TIA-569-B	Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-598-C	Optical Fiber Cable Color Coding
TIA/EIA-606-A	Administration Standard for Commercial Telecommunications Infrastructure
J-STD-607-A	Commercial Building Grounding (Earthing) and Bonding Requirements For Telecommunications
TIA-758-A	Customer-owned Outside Plant Telecommunications Infrastructure Standard

National Electrical Code

Additional guidelines can also be found in National Fire Protection Association (NFPA) 70, also known as the National Electrical Code. The NEC is available for purchase and copyrighted by IHS/Global at www.global.ihs.com.

BICSI TDMM

Also referenced in this document is the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual (TDMM), available for purchase from and copyrighted by BICSI at www.bicsi.org.

Fault Tolerant Ethernet Product Specification

Another source of information is the Honeywell Fault Tolerant Ethernet Product Specification EP03-500-300.

Copper Cabling

Copper Cable Guidelines and Topologies

Introduction

This section details the general guidelines that apply to copper network cabling for Honeywell's FTE networks. The scope of this document only includes those copper cables specified for data communications use by TIA/EIA-568-B.2-1, ISO/IEC 11801 2nd Edition – 2000, and pending TIA/EIA-568-b.2-10.

Cable Topology

FTE cabling uses a physical star topology. This means that the workstations are each cabled back to a central switch, with the switch being the center of the star. There are two methods used to make this connection. One method is to use a structured cable plant; which means that there are permanently installed termination devices on either end of a horizontal cable.

In the equipment room, the termination device is usually a patch panel. Patch panels come in two types. One type has the jacks permanently installed in the panel and the cable is terminated on the back of the panel, usually in a 110 style clip. The other type uses the same jack as the workstation outlet and the jack is snapped into a cutout in the panel. At the workstation end, the termination device is usually a jack installed in either a faceplate or a surface mounted box. Patch cables are used to connect the jack to the workstation and the patch panel to the switch.

The other method is to use a long patch cable that has an RJ45 plug on each end, to directly connect the switch port to the NIC in the workstation.

It's advisable to use a structured cable approach when:

- There are a high number of workstations in one area
- The physical cable distance from the switch to the workstation exceeds 65.6' (20 m)
- The workstations are separated from the switch by a physical wall

Structured Cable Plant Benefits

The benefits of a structured cable plant are:

- Reliability – The horizontal cable is terminated at each end using insulation displacement connections and can be tested once the connection is made. Since the jack is either in a patch panel, face plate, or surface mount box, the cable does not move once it is installed. The connection should then remain static and not experience any future problems. In the event of a problem, it is usually not the horizontal cable that has failed; it is the patch or workstation cable. In a structured cable plant, replacing the patch cable is a simple and inexpensive matter. A jack and patch panel are shown in Figure 1 – Typical Screened Cat 6 Jack, and in Figure 2 – Typical Screened Patch Panel, which happens to be a Cat 7 patch panel.

- Manageability – At the switch end, all the terminations are contained in a patch panel, allowing the more flexible patch cords to be neatly routed from the patch panel to the switch ports. Since the outlet and the patch panels are appropriately labeled, identifying specific cable runs is easy.

Obviously, a structured cable solution has more components but overall is more organized and reliable.

Figure 1 - Typical Screened Cat 6 Jack (Image courtesy of The Siemon Company)

Figure 2 - Typical Screened Patch Panel (Image courtesy of The Siemon Company)

Long Patch Cables

Long patch cables may be used in place of a structured cabling solution when there are a small number of workstations in one area. It is important to note that FTE workstations are dual connected, which means that there are two cables connecting each workstation to the network switches. Because of this, 3 workstations mean that there are 6 cables that need to be routed from the workstations to the network switches. Typically it is recommended to keep workstation patch cables under 15’ (4.5 m) in length. The differences in construction between horizontal cables as described below and patch cables will be discussed in the patch cable section.

Figure 3 - Typical Screened Patch Cables (Image courtesy of The Siemon Company)

Copper Data Cable Construction

As specified by TIA/EIA-568-B.2, copper data cable shall consist of 22 AWG to 24 AWG thermoplastic insulated solid conductors that are formed into four individually twisted-pairs and enclosed by a thermoplastic jacket, and have a nominal impedance of 100 Ω. The standards approve both screened and unshielded copper cable for data communications use. Honeywell recommends a screened cable for our industrial networks. This type of cable has increased immunity against electromagnetic interference/radio frequency interference (EMI/RFI). Screened cables are currently available in the following types:

- Screened Twisted Pair (ScTP) in which the four pairs are covered with an overall fine wire screen
- Foil Twisted Pair (FTP) in which the four pairs are covered with an overall metal foil shield
- Pairs in Metal Foil (PiMF) in which each of the four pairs is wrapped in a metal foil shield

Double Shield Twisted Pair (SSTP) in which each of the four pairs is wrapped in a metal foil shield which are then wrapped in an overall foil metal shield. Another acronym often used to describe screened cable is Shielded Twisted Pair (STP). This acronym actually applies to older types of twisted pair cable, most notably the old serial and parallel printer cables that preceded today's USB cables and is not applicable to the twisted pair cables used for voice and data today. The most common acronyms in use for screened cable today are ScTP, FTP, and F/UTP and are usually used interchangeably to describe a screened cable that meets the specifications of TIA/EIA 568. For the purposes of this document, "screened" will mean any of the above types of shielding. Additional specifications regarding screened data cable can be found in TIA/EIA-568-B.2 Annex K. Figure 4 and Figure 5 show typical screened cables.

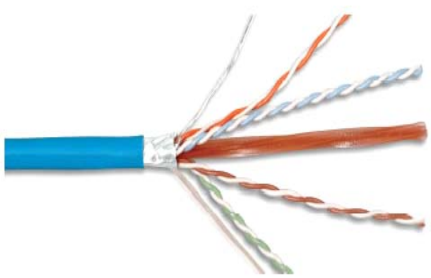

Figure 4 - Typical F/UTP Cable
(Image courtesy of The Siemon Company)

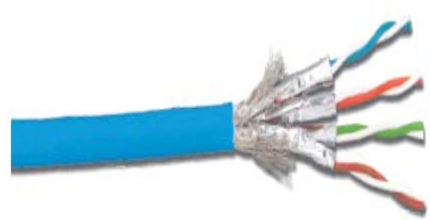

Figure 5 - Typical S/FTP Cable
(Image courtesy of The Siemon Company)

Cable Transmission Performance

In order to be standards compliant, cables must meet a set of performance requirements that are tested at certain frequencies. It is the maximum tested frequency that determines what Category (Cat), or performance level a particular cable meets. Following are some of the categories recognized by the standards.

- Cat 3 cable has been tested for the required parameters up to 16 MHz
- Cat 5 cable has been tested for the required parameters up to 100 MHz
- Cat 5e cable has been tested for the required parameters up to 100 MHz, but a number of the parameters are stricter than for Cat 5
- Cat 6 cable has been tested for the required parameters up to 250 MHz

Honeywell recommends a minimum of screened Cat 5e for FTE installations. As networks require greater performance from their cable plants, many of our customers' corporate standards require Cat 6 for all new installations. This is also supported by Honeywell as long as it is a screened Cat 6. Currently Cat 6 cable offers the highest electrical performance that is standards compliant.

Cable Jacket Types

Cable jacket construction is not specified in detail by the TIA/EIA standards other than how it affects color coding and the mechanical strength of the cable. Jacket materials are actually addressed by the NEC. For our purposes, we will only concern ourselves with low voltage cables. NEC classifies the cables by flammability and the level of hazard these cables present if burned. All Underwriters Laboratory listed cables that are approved for use by the NEC carry a classification label. The first two characters are CM, which stands for communications cable. The third character defines where the cable can be used. The classifications for communications cables included in the NEC in order of severity are:

- CMX is a communications cable suitable for residential use only
- CMG is a general purpose communications cable not suitable for use in risers or plenums
- CMR is a communications cable suitable for use in a building riser or non plenum environment
- CMP is a communications cable suitable for use in a plenum environment where a ceiling or raised floor space is used by the air conditioning system as an air return plenum

CMP can be substituted for any of the cables above it in the list and CMR can be substituted for any of the cables above it. See Article 800.179 of the NEC for additional information on these cable types. For FTE use, Honeywell recommends CMR rated cable, unless the local environment requires a plenum rated cable. Typically our clients' environments are non plenum or the cable is in conduit. A riser rated cable will cost less than a plenum rated cable and the jacket is more flexible and, in some cases, more durable. There are even some cables designed exclusively for the industrial environment that have chemical resistant jackets. None of these cables carries a CMP rating. A cable plant design professional can assist in determining if a plenum rated cable is required.

Regardless of the cable jacket type, there are a number of colors available. It is recommended that different colored cables be used for the A and B cables in the system, preferably yellow and green.

Honeywell's Recommended FTE Horizontal Copper Cable

Based on the previous sections, Honeywell recommends a minimum of a screened Cat 5e cable for FTE installations. Most likely this will be either of a ScTP or FTP construction. More often than not, a non plenum cable will meet local requirements and will be less expensive than a plenum version of the same cable. Based on the expected increased performance requirements of future networks, if there is a substantial amount of cabling required for the project, screened Cat 6 is generally considered to be the most appropriate cable plant investment. Copper cable is generally only acceptable for intra building connectivity. FO cabling is the recommended media for inter building connectivity.

Termination Practices

TIA/EIA 568 has defined the UTP connecter for data use to be an eight pin RJ 45 modular connection. This can be either a plug or a jack. In the event that a long patch cable has been used, an RJ45 plug will be installed on the ends of the cable. It is not recommended that this method be used for field termination as the completed assembly cannot be properly certified by field instruments. Should this method be used, a certified patch cable should be ordered from the manufacturer. When selecting a manufacturer, it is important to select one that tests all patch cords before they leave the factory, and either offers the patch cables in yellow or green jackets or with color coded boots that go over the plugs.

The other method used in a structured cabling environment involves a jack terminated on either end of the horizontal cable. In the rack room or wiring closet where the network switches are located, a patch panel or surface mounted box is installed to house the jacks. At the work station end, the jack will be installed in a surface mounted box or possibly a flush mounted wall plate. Patch cables are then used to connect the jacks to the network switches and the work stations. In all but the smallest of installations, Honeywell recommends a structured cable plant. The recommended pinout for terminating jacks is the 568B pinout as shown in Figure 6.

If space permits, it is recommended that one patch panel be used for all the green cables and another for all the yellow cables. It is also helpful to order jacks that are colored yellow and green to aid in connecting the system together and trouble shooting. Figure 7 shows a screened RJ45 plug with a boot installed.

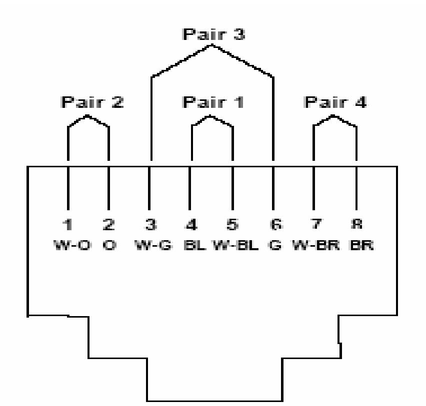

Figure 6 - 568B Pinout

Figure 7 - Typical RJ45 Plug (Image courtesy of The Siemon Company)

Industrial Connectors

An enhanced version of the standard RJ45 plug and jack has recently been introduced to market by a number of the major cable systems manufacturers. This type of plug and jack incorporates either a threaded or bayonet style collar so that the assembly is water and dust proof. Special patch cables are also manufactured for this application. Depending on the manufacturer, these connectors are offered in Cat 5e, Cat 6, and FO versions with seals conforming to IP66/67. Because the patch cables are designed for industrial environments the connectors are very robust and the cable jacket can be rather stiff. Because of these construction traits these cables are not suited well to most control room environments. They are very useful for connections in PLC or other control cabinets that may be sometimes left open to the elements. Figure 8, Figure 9, and Figure 10 show various industrial connectivity products. In areas that are not so severe as to warrant a sealed connection, but still require some protection, there are various types of covered outlets available. Figure 11 shows a water resistant face plate with space for 4 jacks.

Figure 8 - Stainless Steel Faceplate with Industrial Jack and Plug
(Image courtesy of Panduit Corp)

Figure 9 - Industrial Jack and Plug
(Image courtesy of The Siemon Company)

Figure 10 - Industrial Surface Mount Box with Copper and FO Jacks
(Image courtesy of The Siemon Company)

Figure 11 - Water Resistant Faceplate (Image courtesy of Panduit Corp)

Cable Plant Performance Standard

It is important to note that the overall performance of the cable plant will be that of the lowest performing component. A Cat 6 cable that has been terminated using Cat 5 jacks will only pass Cat 5 tests. A complete Cat 6 system that uses Cat 5 patch cables will actually be only a Cat 5 system.

Patch Cables

Patch cables, as defined by TIA/EIA-568, are intended to be relatively short cables used to connect equipment to the horizontal cable plant. In recent years, that definition has been expanded to take in account “zone cabling”. This is a design that uses clustered jacks that are wired back to the telecommunications closet using horizontal cable. The jacks are then connected to the workstations using relatively long patch cables. This system was originally intended to support cubicle areas that may be frequently reconfigured. The horizontal cable was not disturbed, as it is often terminated in an enclosure in the ceiling, and the patch cables are simply replaced once the cubes are reconfigured. Because of this changing of the standards, Honeywell does support using long patch cables for some installations, providing they meet the requirements mentioned in the Long Patch Cables section on page 3.

Regardless of whether they are long or short, patch cables should:

- Have a non plenum jacket for greater flexibility
- Match the desired performance category and shielding type of the entire cable plant
- Have been assembled and tested at the factory. Field assembly is strongly advised against, as stated in TIA/EIA-568-B.1.10.2.4
- Have IDC RJ 45 plugs on each end
- Utilize stranded conductors for increased durability and flexibility
- Be of screened construction
- Match the definition of a patch cable and meet minimum requirements as stated in TIA/EIA-568
- Either have yellow or green colored jackets or connector boots
- A jacket or boot color other than yellow or green may be used for a non FTE device such as a printer
- If a long patch cable is used in lieu of structured cabling, it should be 33’ or less in length. If a longer cable is required, structured cabling should be installed.

TIA/EIA-568-B.2 contains the requirements for patch cables up to Cat 5e and TIA/EIA-568-B.2-1 contains the requirements for Cat 6 patch cables. Additional requirements are listed in TIA/EIA-568-B.2-K.7.

Cable Management

When installing data cabling it is important to properly manage:

- Cable identification
- Cable bend radius
- Cable pulling tension

Cable Identification

Cable identification refers specifically to cable labeling. This includes the actual cable, the patch panel, and the outlet. This should always be done with a label printer designed for printing permanent labels using the appropriate labeling tape. Outdoor cable may require either a UV stabilized plastic label or a stainless steel label depending on the environment. TIA/EIA 606 – A contains detailed recommendations for labeling cable plants but is written more to manage systems containing hundreds of outlets. Some of the more important points for the relatively low outlet density industrial environments are:

- It is recommended that a labeling scheme be created and standardized on. It should include the same number of characters so that, should a software based cable management solution be implemented, it will be easier to create and populate the data fields.
- Cable labels are the same at both ends of the cable. Altering the label to indicate which end of the cable is closer only means that there will be twice as many cable numbers to manage.
- The label should include an indicator of where both ends of the cable terminate and a unique cable identification number.

20-CCB-XXX-Y is an example of a standard cable label. In this case, 20 is the cable number. It is in the Central Control Building. The next 3 characters are space fillers. If this had been an inter-building cable this is where the identifier for the building at the other end of the cable would be. A Y has been added to designate that this cable is specifically to be used for the FTE yellow cable. Typically in a control room it is acceptable to simply number the cables sequentially and add either a “Y” or “G” for yellow and green.

Cable Bend Radius and Pulling Tension

All cable has minimum bend radius and pulling tension guidelines published by the cable manufacturer. As far a copper cable is concerned, there are guidelines for both the patch cables and the horizontal cable. A ScTP patch cable has a minimum no load bend radius of 2” (50mm) and a ScTP horizontal cable has a minimum bend radius of 8 times the cable diameter. Pulling tensions are published by the cable manufacturers and should be adhered to during installation.

It is important to adhere to minimum bend radius requirements when dressing in patch cables in a cabinet, since over bending a cable can distort the pairs and impede performance. Also, when tie wrapping cables it is important not to distort the cable. Tie wraps should be snug, but not so tight that they indent the cable jacket. The newer Velcro tie wraps are much more effective at managing patch cables than a plastic tie wrap.

Grounding

This section summarizes recommended grounding procedures for the copper cable plant including the network switches. Additional information can be found in TIA/EIA-568-B.1-2 and NEC Article 250.

Equipment Grounding

This section discusses grounding procedures for the network switch cabinets and the equipment mounted in the cabinets.

Equipment Room Grounding

Within each rack or telecommunications room, there should be a central grounding point, often called a telecommunications grounding bus bar or TGB. Equipment cabinets should be bonded to this bus bar using solid copper cable. The equipment in the cabinet are usually grounded via the ground prong on the power plug.

Remote Network Equipment Cabinets

A remote network equipment cabinet is any cabinet that is separate from the main equipment cabinet and contains network equipment connected to the FTE network. Two examples of this type of cabinet are a cabinet containing Level 2 FTE switches or a cabinet containing Honeywell's CF9. While it is within the standards to connect these cabinets using copper, unless it is certain that the remote cabinet will be on the same ground bus as the main cabinet, FO would be the better choice. In general, linking these cabinets using copper can safely be done if:

- The cabinets are in adjacent rooms
- The cabinets are within 60' (18.2 m) of each other
- There are drawings or other first hand knowledge that the two locations are on the same ground bus
- The jack in the remote cabinet is housed in a non metallic surface mount box

If there is any doubt that the two locations are not on the same ground bus, a ground wire should be installed along with the copper data cable to extend the TGB out to the remote location. Usually it costs less to link the two locations using FO and gain EMI/RFI immunity than to have to extend the TGB.

Cable Grounding

This section summarizes grounding practices for screened cable plants.

Equipment Room Grounding

In the equipment room, the equipment cabinet should be bonded to the equipment room ground, also known as the telecommunications grounding bar (TGB). In order to realize the benefit of a screened cable system, it is important to use screened components throughout the installation. This includes cable, jacks, patch panels, and patch cables. Assuming the cabinet is properly grounded, the patch panel can be grounded either by attaching a 6 AWG ground wire to the grounding lug on the patch panel and attaching the other end of the ground wire to the cabinet, or by simply making sure that there is a bare metal connection between the mounting rails in the cabinet and the patch panel via the mounting screws.

It is also important to bond the shield of the cable either to the shield of the jack or to a common grounding point on the patch panel. When the jack is terminated at the outlet end, the shield will be bonded to the shield of that jack. This ensures a complete ground path from the work station outlet jack all the way back to the equipment room ground. Only the end in the equipment room should be bonded to the TGB, as grounding both ends of the channel may result in ground loops or a difference of potential from one end o the cable to the other. Any additional ground paths such as this, either deliberate or accidental, may degrade the performance of the cable.

Short, intra-cabinet connections are assumed to be grounded to the equipment via the cable shield and the equipment chassis ground. It is not expected that equipment within the same cabinet or cabinet row would be on different ground potentials.

It is also important to ensure that the equipment room and the workstation location are on the same grounding system and that there is not a difference of potential between the two which could result in equipment damage or personal injury. TIA/EIA-568-B.1-2-5.1-4.6 stresses that “At the work area end of the horizontal cabling, the voltage measured between the screen and the ground wire of the electrical outlet used to provide power to the equipment shall not exceed 1.0 V rms and shall not exceed 1.0 V dc. The cause of any higher voltage should be removed before using the cable.”

Figure 12 – Typical F/UTP Cable System Grounding shows a typical F/UTP cable plant grounding scenario. Items 1 and 2 are a screened jack and patch panel. Item 3 is the cable bonding the patch panel to the rack. Item 4 is the rack bonded to the TGB. Note that the workstation end is not grounded.

The various cable component manufacturers, such as the Siemon Company and Panduit Corporation, also publish installation guidelines for their screened cable products.

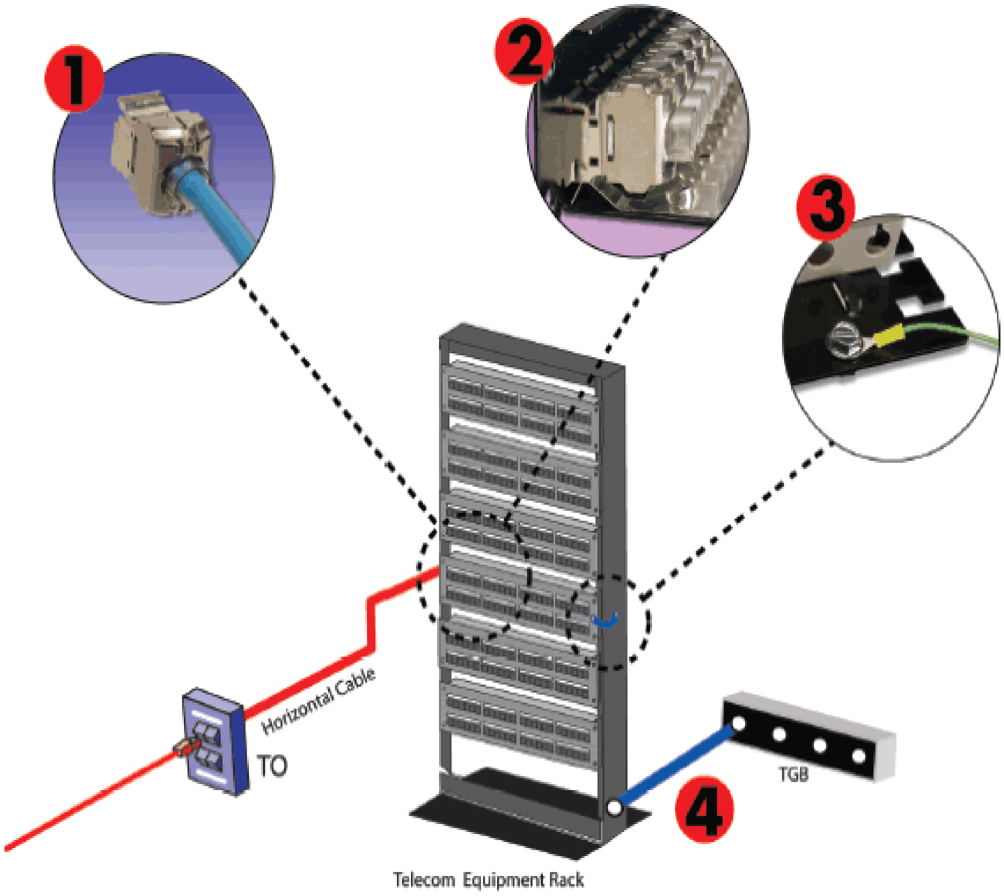

Figure 12 - Typical F/UTP Cable System Grounding (Image courtesy of The Siemon Company)

Fiber Optic Cabling

Fiber Optic Cable Types and Modes

Introduction

This section describes the sizes of approved fiber optic cables and their modal qualities.

Optical Fiber Types

There are two types of fiber optic (FO) cable used in data communications. These are multi mode (MM) and single mode (SM). These terms refer to how the light travels down the cable. MM uses a multiple paths, or modes, while SM uses a single mode. Due to the construction of the components, including the light sources themselves, SM has greater bandwidth and can be used for longer distances than MM FO. As the cost of the associated electronics drops, SM is becoming more the FO cable of choice for high performance networks. MM comes in 2 diameters which are 62.5 and 50 µm. This refers to the “core” diameter, or the center of the optical strand. This number is followed by a / and another number, written as 62.5/125. This indicates a fiber with a core diameter of 62.5 µm and a “cladding” or outer coating diameter of 125 µm. The cladding is what actually keeps the light in the core of the fiber. SM fiber is typically 8.3/125 µm. The 50 µm MM was intended to increase the bandwidth of MM while still allowing the use of MM electronics. As the cost of all facets of SM installation has fallen, SM fiber should be the fiber of choice for new installations. If there is legacy equipment that requires MM FO, a hybrid cable that contains both SM and MM FO should be considered.

FO Cable Jacketing

Just as there are different types of ScTP copper cable, there are different types of FO cable construction and jacketing materials. In a broad sense, there are three categories of cable jacketing. These are:

- Outside plant cable
- Indoor/outdoor cable
- Inside plant cable, which include plenum and riser versions

Outside plant cable is intended only for use outside buildings and is not a listed assembly by the NEC for use indoors. Its jacket is usually made of polyethylene (PE) and may include metallic armoring. Per Article 770.113 an unlisted cable may penetrate a building a maximum of 50’ (15 m) before it is required to be terminated, spliced to a listed cable, or enclosed in conduit. This is the most durable of the three jacket types.

Indoor/Outdoor cabling has a type of jacket that is UL listed for indoor riser and outdoor use, but cannot be used in a plenum airspace. This type of cabling typically has a polyvinyl chloride (PVC) jacket with ultra-violet (UV) stabilizers, and will also include some type of water blocking compound to enable it to be used outside. This is considered to be a medium duty cable and meets the requirements of NEC Article 770 as long as the building environment is classified as a riser as opposed to a plenum.

Inside plant cable can be a substantial assembly, but is not considered to be as rugged as a true outside plant or indoor/outdoor cable. An inside plant cable jacket is typically either PVC or Teflon, for plenum rated applications, and usually does not contain any water blocking mechanisms.

All types of jacketing are usually available in different armoring configurations, depending on site environmental requirements. It is important to be mindful of grounding requirements when using armored cable.

FO Cable Construction

There are generally two types of FO cable construction as far as how the actual optical fibers are placed in the cable:

- Loose tube
- Tight buffered

Loose tube refers to a type of construction where there are actual tubes within the cable that may contain up to 12 strands of fiber. This type of construction was originally developed for outside plant cables and often contained gel in the tubes as a water blocking device to protect the strands of fiber. This type of cable is more labor intensive to terminate because the tubes must be "broken out", which is to say that a device has to be secured to the end of the tube that fans out the individual fiber strands and protects that junction. The strands also have to be inserted in a tight buffer tube to protect them and provide something for the connector strain relief to attach to.

Tight buffered is typically the construction of choice today. In this type of cable, each strand has its own jacket extruded over it in the manufacturing process. Typically a water absorbing material will be used in place of gel as a water blocking mechanism. Because of this, it is much easier to prepare the cable for termination.

Additionally a central strength member is often manufactured into the cable. This can either be a fiberglass, nylon, or metallic strand in the center of the cable. It is recommended to avoid metallic strength members, because these make the cable an electrical conductor that must be properly grounded.

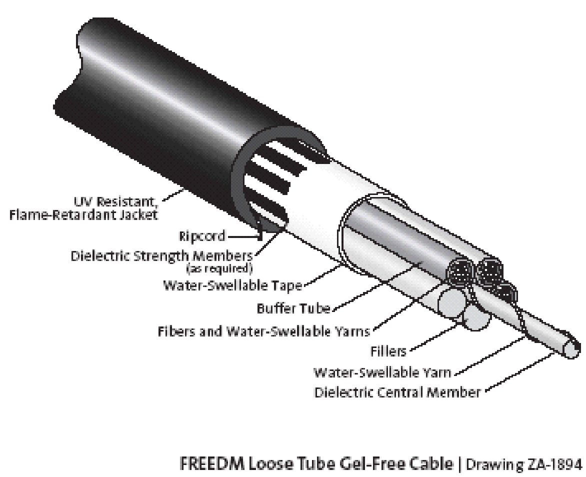

Figure 13 - Typical Loose Tube Fiber Optic Cable (Image courtesy of Corning Cable Systems)

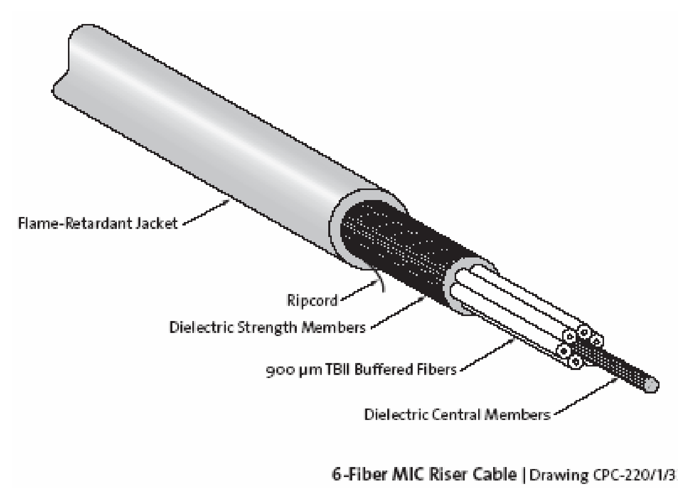

Figure 14 - Typical Tight Buffered Fiber Optic Cable (Image courtesy of Corning Cable Systems)

Air Blown Fiber

A completely separate technology is air blown fiber (ABF). ABF separates the conventional FO cable into its two components, the outer jacket and the FO strands. The outer jacket component is actually a tube that contains a number of smaller tubes within the outer jacket. The FO strand component is actually a foam covered bundle of FO strands. The FO bundle is literally “blown” along the tubes by either pressurized air or nitrogen. The advantage to this technology is the ability to install a minimum number of FO strands and then, at a later time, blow additional bundles in unoccupied tubes for either greater capacity or a different type of fiber. Costs of this technology initially are comparable with conventional fiber; however, adds, moves, and changes are much more cost effective providing the initial tube layout was done correctly. Honeywell has had success with this technology in the chemical, refining, and paper industries and can help customers determine if this system is appropriate for their particular sites.

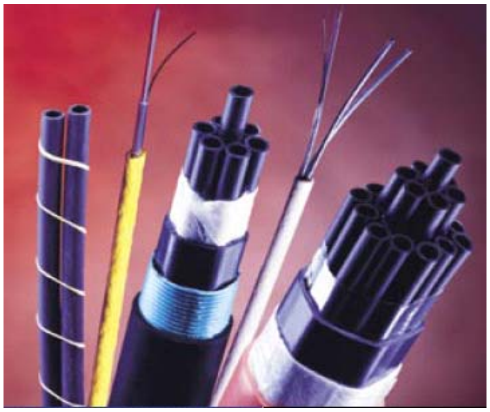

Figure 15 - Typical ABF Tube Cables and Fiber Bundles (Image Courtesy of Sumitomo Electric Lightwave Corp)

FO Patch Cables

FO patch cables are relatively light duty cables usually consisting of 2 FO strands within a duplex PVC jacket. Usually some Kevlar yarn is also added for strength. These cables are used for connecting the FO patch panel to a piece of equipment or simply for connecting different strands within a FO patch panel. Figure 16 shows a typical FO patch cable.

Figure 16 - Typical FO Patch Cable (Image Courtesy of Panduit Corp)

FO Connector Types

There are a number of standards compliant connector types available. Older cable plants typically utilize ST connectors. More recently installed cable may be terminated with SC or LC connectors. Unless matching an existing type of connector is necessary, the duplex SC connector is recommended for new FO installations. Very high density installations may call for a smaller connector such as the LC. The connector types mentioned here are specifically in reference to the horizontal cable plant. Electronics manufacturers often change the FO interfaces on their equipment. Because of this it is advisable to choose a particular connector type and standardize on that type for your facility. A Honeywell cable design professional can assist with this decision. Once that decision has been made, patch cables are used to transition from the horizontal cable to the network equipment interface.

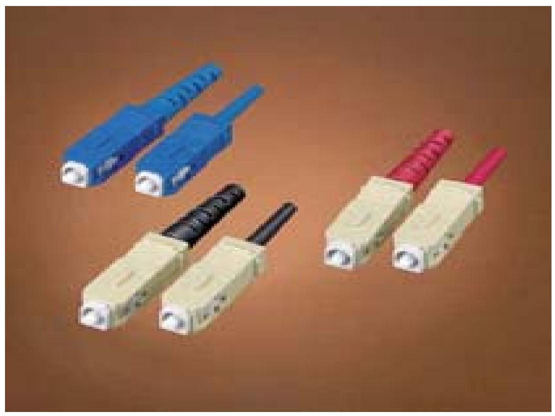

Figure 17 - Typical SC Connectors (Image Courtesy of Panduit Corp)

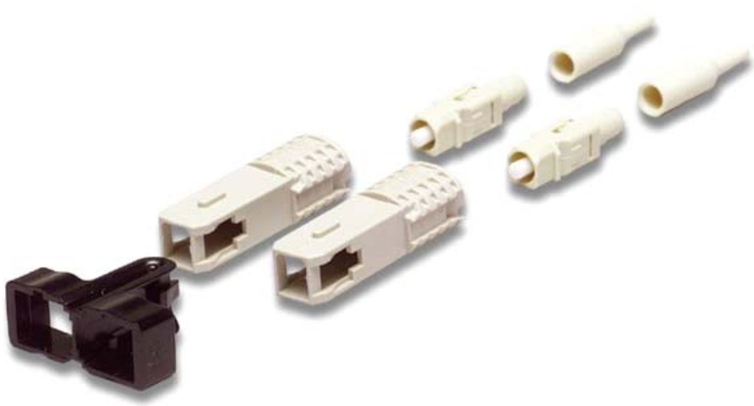

Figure 18 - Exploded View of a Duplex SC Connector
(Image courtesy of The Siemon Company)

Figure 19 - Typical ST Connector
(Image Courtesy of Panduit Corp)

FO Cable Path Design and Recommendations

Introduction

Fiber optic cable is the specified media for all inter building connectivity. This section discusses various pathway recommendations

FO Cable Path Design

Fault Tolerant Ethernet is built upon a traditional 802.3 CSMA/CD ethernet architecture. This means that a Level 2 switch is directly connected to a Level 2 backbone switch through the cable plant. Logically, it is a star network with the backbone switches at the center. The goal of cable plant design is to route the FO cable in a manner that allows for the greatest redundancy within the existing plant structure. It is recommended to separate the yellow and green fibers as much as physically possible. Assuming the plant infrastructure can support it, the optimal physical cable routing is to encompass as much of the facility as possible with additional cable runs bisecting the main route. In this design, the FO cable physically connects all the necessary facilities. One term for this type of design is a “mesh”. Figure 20 – Optimal FO Cable Routing is an example of this design. In the figure, all control rooms are connected by the black dashed lines representing physical cabling and there are additional cable runs from Control Room B to the Central Control Room. The yellow and green lines indicate the cable paths that are taken for FTE connectivity. At the various fiber patch panels, the cable can either be spliced or patched through.

Figure 21 – Typical FO Patch Panel shows a typical FO patch panel. By making use of this flexibility, any number of different routes can be created for a control room switch to connect back to a backbone switch. This design allows for maximum FTE redundancy by allowing the yellow connection from a switch to go one direction and the green to go the other direction as well as providing additional routes within the main route. If possible, the cable should enter and leave on opposite sides of a building. If this design can be implemented, even if the yellow and green fibers cannot be physically separated, it would take multiple cable failures in different areas of the plant in order to isolate a control room. There are few complications implementing this design using SM fiber. If using MM fiber, a detailed loss budget needs to be completed to account for cable loss due to distance as well as any loss incurred either by splices or patch cables.

FO Cable Distance Limitations

Also critical to the design is physical cable distance. If using MM FO cable and 100 Mb interfaces, the cable distance can be as great as 2 km. If using LX/LH Gigabit interfaces the following distances apply:

- When using 62.5/125 µm, MM FO distances should not exceed 550 meters
- When using 50/125 µm, MM FO distances should not exceed 550 meters
- When using SM FO, distances can be as great as 10 kilometers without using high powered long distance interfaces

A typical Cisco SFP interface is shown in Figure 22 – Typical Cisco SFP Fiber Optic Transceiver. Of course all published distance data is dependent on the physical condition of the cable and connections.

If using 62.5/125 µm MM cable with an LX/LH interface and the cable length is less than 300’ (100 m) or over 900’ (300 m), a mode conditioning cable must be used. This is a special cable assembly that precisely offsets the laser launch of the transmitter to mimic a multi mode launch.

Optimal FO Cable Routing

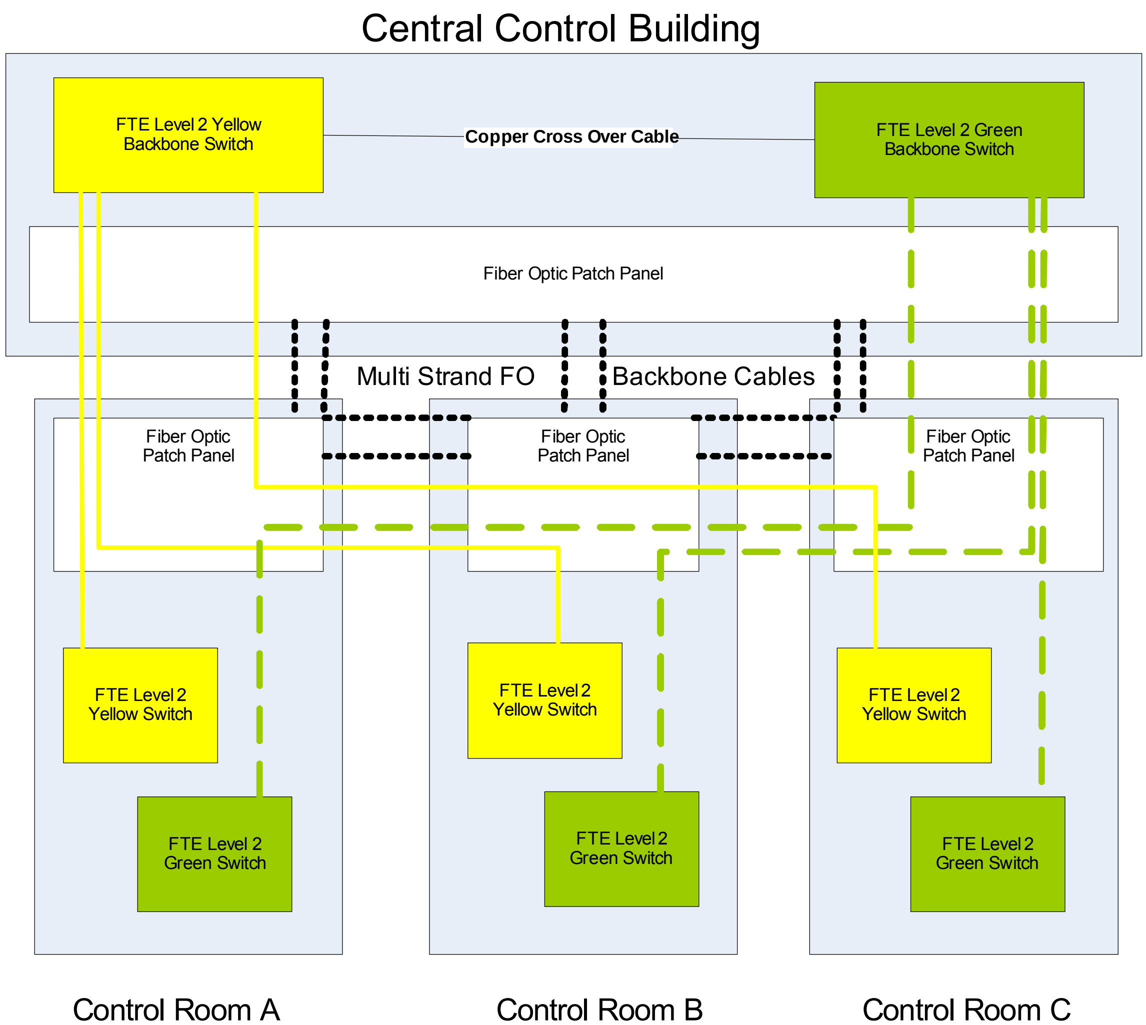

Figure 20 - Optimal FO Cable Routing

Figure 21 - Typical FO Patch Panel (Image courtesy of The Siemon Company)

Figure 22 - Typical Cisco SFP Fiber Optic Transceiver (Image Courtesy of Cisco)

FO Cable Management

When installing FO cable it is important to properly manage:

- Cable identification
- Cable bend radius
- Cable pulling tension

FO Cable Identification

Cable identification refers specifically to cable labeling. This includes the actual cable and the patch panels. This should always be done with a label printer designed for printing permanent labels using the appropriate labeling tape. Outdoor cable may require either a UV stabilized plastic label or a stainless steel label depending on the environment. TIA/EIA 606 – A contains detailed recommendations for labeling cable plants. Some of the more important points for inter – building FO cables are:

- It is recommended that a labeling scheme be created and standardized on. It should include the same number of characters so that, should a software based cable management solution be implemented, it will be easier to create and populate the data fields
- Cable labels are the same at both ends of the cable. Altering the label in to indicate which end of the cable is closer only means that there will be twice as many cable numbers to manage.
- The label should include an indicator of where both ends of the cable terminate and a unique cable identification number.

20-CCB-CRA is an example of a standard cable label. In this case, 20 is the cable number. It goes from the Central Control Building to Control Room A. Additional characters may be added to indicate whether the cable is MM or SM or the number of strands in the cable.

FO Cable Bend Radius and Pulling Tension

All cable has minimum bend radius and pulling tension guidelines published by the cable manufacturer. Outside plant FO cable shall have a minimum pulling strength of 600 lbs/foot and have a minimum bend radius of 10 times the cable diameter at rest and 20 times the cable diameter under load. Air blown fiber, discussed on page 3 has its own bend radius requirements that are related to the tube that the fiber bundles are installed in. This data can be obtained from the manufacturers

It is important to adhere to minimum bend radius requirements when dressing in patch cables in a cabinet, since over bending a cable can distort the fiber optic strands and impede performance. Also, when tie wrapping cables it is important not to distort the cable. Tie wraps should be snug, but not so tight that they indent the cable jacket. The newer Velcro tie wraps are much more effective at managing patch cables than a plastic tie wrap.

General FO Safety Guidelines

When working around equipment with FO interfaces or FO patch panels, never look directly into an interface or port. Doing so may result in permanent eye damage. All unused fiber ports and interfaces should have their protective caps in place. Also, unless you are trained in the handling and installation of fiber, do not handle the actual fiber optic strands as these can break and become lodged in your skin.

Cable Testing

Copper Cable Testing

Introduction

This section details the testing requirements for installed copper network cabling. Typically this only applies to a structured cable solution, as the test equipment is not designed to test short patch cables in the field. This is another reason that patch cables should not be field assembled and should be purchased from a manufacturer that does 100% testing of their cables. Additional information can also be found in TIA/EIA-568-B.1.11.2 and TIA/EIA-568-B.2-1 Annex B.

Test Equipment

It is important to test the installed cable plant using a cable tester designed for that purpose. As stated in the introduction, TIA/EIA standards define the test parameters for installed data cabling and the performance requirements for the testers used for this purpose. The tester chosen should be a minimum of a Level III tester as defined by TIA/EIA-568-B.2-1. This simply means that the tester is certified to the latest test standards. Many of the testers on the market today have an "Autotest" feature that automatically tests for the required parameters and displays a pass/fail reading at the completion of the test. A few of the most basic test parameters included are:

- Wire mapping. This verifies that the cable is terminated properly at each end
- Length. This verifies that the cable does not exceed the maximum length per the standards
- Near End Crosstalk (NEXT). This also verifies that the cable has been installed and terminated properly so that its manufactured electrical characteristics are able to cancel out crosstalk between adjacent cable pairs near the transmitting source.

The testers can also be set to test for either Cat 5e or Cat 6 and will use the correct test parameters for the installed system. Fluke Corporation markets one line of testers.

Test Results

Test results should be reviewed against the passing levels and saved for future reference. Installers can provide these records either electronically or in hard copy. Verify that the data has not been tampered with, usually shown by an asterisk, and that all appropriate information is included in the testing such as jack number and location in addition to pass or fail.

Test Procedure

The testers operate as a pair with one device attached to each end of the installed cable. The technician enters in the number of the cable and begins the test. It is recommended that a "link" test be performed. This test only tests the permanently installed horizontal cable from jack to jack. This test is sufficient when the cable plant has been properly designed and properly certified patch cables have been purchased from a reputable source.

The other type of test described in the standards is a "channel test" in which the actual patch and station cables are used to connect the testers to the jacks. Since these cables become part of the test, it is important to keep them identified with those particular jacks even if nothing is going to be plugged in at the time of testing. This is the reason that link testing is usually recommended over channel testing.

Fiber Optic Testing

Introduction

This section details the testing requirements for installed FO cabling. Typically this only applies to a structured cable solution, as the test equipment is not designed to test short patch cables in the field. This is another reason that patch cables should not be field assembled and should be purchased from a manufacturer that does 100% testing of their cables. Additional information can also be found in TIA/EIA-568-B.1.11.3, TIA-526-7 and TIA-526-14-A.

Test Equipment

As a minimum, all installed horizontal or backbone fiber optic cable should be tested with one of the new cable test devices designed for both copper and fiber testing, such as the Fluke DTX series tester. This device will test both fiber and copper using an “Autotest” procedure for a number of standards based parameters and is sufficient for most installations. Figure 23 shows a Fluke DTX tester. To achieve a higher degree of accuracy, a loss test set is used. These devices are more accurate than the multi test devices due to the higher quality transmitters and receivers used in the device. While multi test devices include a length measurement, longer outside plant fiber installations should be verified with an Optical Time Domain Reflectometer (OTDR). This specialized device visually displays the installed cable as a wave form showing any “events”, or changes to the cable such as splices or kinks, and provides the more accurate length measurement compared to a multi test device. If a multi test device is used for testing, it should be set on the “Autotest” setting for the appropriate fiber type and tested using the default auto test setting for Gigabit over single or multi mode fiber. Additionally, an Optical Time Domain Reflectometer (OTDR) is recommended to verify the length and optical quality of the installed fiber. The electronic test results including OTDR traces should be provided to the cable plant owner upon completion of the testing.

Figure 23 - Fluke DTX Tester (Image courtesy of Fluke Networks)

Figure 24 - Corning OTDR (Image courtesy of Corning Cable Systems)

Test Procedure

When using a multi test device to test fiber, a tester is connected to each end of the cable under test and the Autotest sequence is started. Usually the tester will prompt to switch the fiber strands partway through the test. This reverses the transmit and receive strands so that the cable is tested in both directions. When using a loss test set, there is usually no Autotest function and all measurements are taken manually. The loss test set consists of two units, a light source and a light detector. The two units are connected together in order to be calibrated; then one unit is connected to each end of the fiber. The measurement displayed on the screen is the loss of the cable and connectors, usually measured in dBs. Typical loss budgets for Cisco interfaces are around 9 dB, depending on the actual interface, but generally loss of more than 4 dB should be investigated. TIA allows .75 dB of loss for each connector, plus the loss inherent in the fiber which is usually measured in dBs per kilometer.

An OTDR is a single device that is connected to the test cable using a “launch cable”, which is just a long fiber jumper. The OTDR transmits a constant light signal and measures the amount of that signal that is scattered off the inside of the fiber back to the OTDR. Since the OTDR knows the properties of the particular fiber (inputting that data is part of the set up of the OTDR), it can calculate the actual length of the cable and other characteristics from its measurements. If the cable plant is tested with an OTDR, the trace should be saved for future reference.

Summary

Copper Cabling

The copper cable installed for FTE should have the following characteristics:

- Cat 5e or better and screened
- If lengths over 33’ (10 m) are required, a structured cable solution should be installed
- Patch and workstation cables shall have stranded copper conductors
- If site conditions allow, the yellow and green cables should be physically separated as much as possible
- Horizontal cable in a structured cable solution shall have solid copper conductors
- Connectors shall be 8 pin RJ45 style modular plugs and jacks
- Patch and workstation cables shall either have yellow and green jackets or connector boots

FO Cabling

The FO cabling installed for FTE should have the following characteristics:

- Either 62.5/125 µm MM or SM cable can be used
- ST or SC style connectors are recommended, but can be varied based on site requirements
- FO cable routes should be physically separated as much as possible

Definitions

Definitions	
Approved Ground	A ground that has been approved for use by the authority having jurisdiction.
Armoring	Cable protection, usually made of corrugated steel or PVC for protection against severe outdoor environments, rodents, or other physical damage.
Bandwidth	A range of frequencies, usually the difference between the upper and lower limits of the range, expressed in Hz. It is used to denote the potential capacity of the medium, device, or system. In optical fiber cabling, the bandwidth decreases with increasing length.
Building Industry Consulting Service International (BICSI)	A telecommunications professional's organization that provides training, input to standards bodies, and recommended best practices for the telecommunications industry.
Electronic Industries Alliance (EIA)	An association organized along specific electronic product and market lines which develops and publishes industry guidelines.
Ethernet	The most widely used wired local area network. Ethernet uses carrier sense multiple access (CSMA) to allow computers to share a network and operates at 10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps depending on the physical layer used.
Gigabit Ethernet	A carrier sense multiple access with collision detection LAN standard developed by the IEEE 802 group operating at one Gb/s.
Horizontal Cabling	The cabling between and including the work area telecommunications outlet/connector and the horizontal cross-connect in the telecommunications room.
IEEE	Institute of Electrical and Electronic Engineers. A professional society serving electrical engineers through its publications, conferences, and standards development activities. The body responsible for the Ethernet 802.3 and wireless LAN 802.11 specifications.
Infrastructure	The wired Ethernet network
Micron (µm)	One millionth of a meter (0.000001 meter).
Modular Jack	A female telecommunications connector usually comprised of either 6 or 8 pins used for voice and data communications.
National Fire Protection Association (NFPA)	Association that writes and administers the National Electrical Code (NEC), also known as NFP 70.
Optical Time Domain Reflectometer (OTDR)	A device used for accurately measuring the length and characteristics of a fiber optic cable.
Patch Cord/Work Station Cable	A length of copper or fiber optic cable with connectors on each end used to either connect two circuits in the telecommunications closet or connect equipment to the horizontal cabling.
Registered Communications Distribution Designer (RCDD)	A BICSI certification awarded to cable plant design professionals who have demonstrated industry experience and have passed a rigorous certification exam. The RCDD designation is widely recognized in the telecommunications industry and is often required in order to bid on commercial and government contracts.
Telecommunications Industry Association (TIA)	A standards association that publishes telecommunications standards and other documents.
Workstation	A computing device with an installed client adapter

More Information

For more information on any of Honeywell's Products, Services, or Solutions, visit our website www.honeywell.com/ps, or contact your Honeywell account manager.

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WP-07-01-ENG
May 2007

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