Training Manual

for Certified Cable Installer (ACCI)

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CHAPTER 1 - INTRODUCTION

This Training Manual contains recommendations for planning, handling, installing and testing Aston copper and fiber cable products in enterprise environments. This document is designed to help and ensure a successful and safe installation.

Organization

The document consists of the following topics:

- Typical Infrastructure Components
- Media
- Standards
- Cable Installation
- Cable Termination and Splicing
- Testing and Measurement
- Safety

ASTON Premises Communications Cables

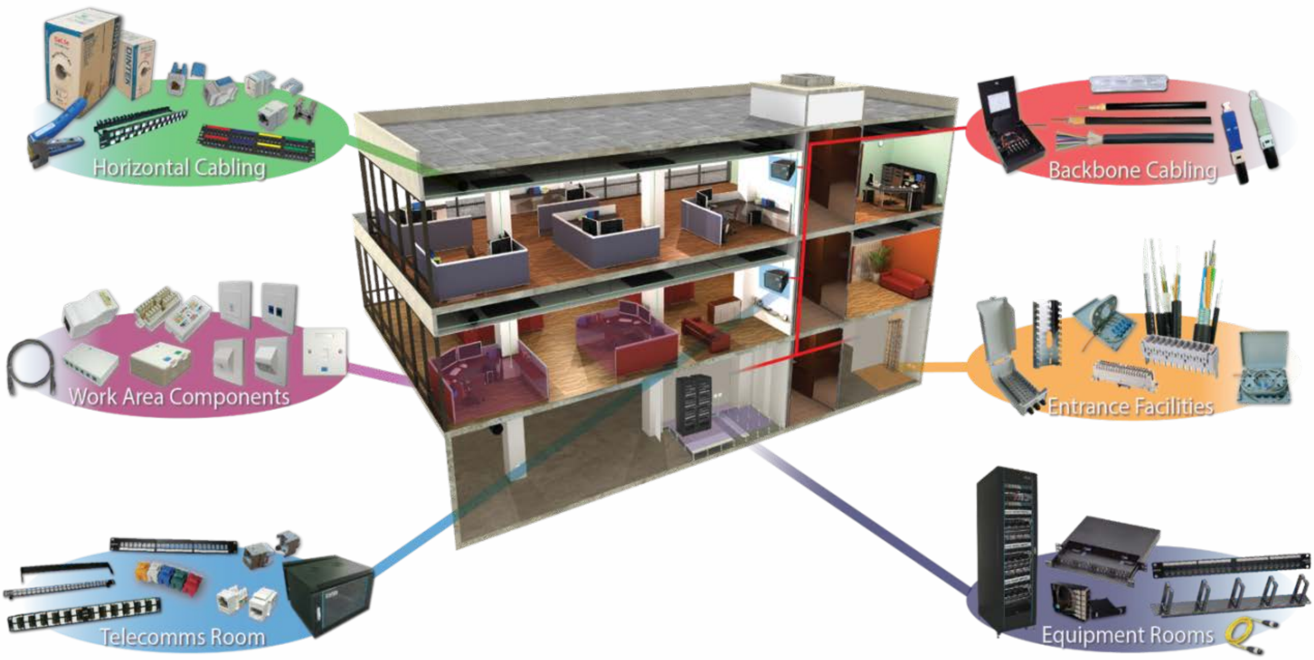
The premises cable product line from **Aston** includes nearly every type of copper and fiber cable used for voice and data communications inside buildings. From copper riser cable to high performance Category 7A and optical fiber cables, **Aston** is able to supply virtually all of the cabling needs for an enterprise or campus installation.

Aston premises cable products meet the rigorous performance standards expected by engineers and installers, and they include many unique benefits that translate into easier and faster installations

Aston manufactures the following Premises cable types:

- Building and Industrial Copper Cables
- Copper Data Cables (Internal & External)
- Central Office Tinned Copper Cables
- Tight Buffered Fiber Cables (Internal and Internal/External)
- Ribbon Fiber Cables
- Loose Tube Fiber Cables (Internal and Internal/External)
- External Armored Fiber and Copper Cables
- Fire Cables
- Coaxial Cables
- Composite Cable Designs: Copper/Fiber/Coax cable combinations

CHAPTER 2 - TYPICAL INFRASTRUCTURE COMPONENTS



As defined by TIA/EIA, a structured cabling system consists of six infrastructure subsections: Entrance Facility, Equipment Room, Telecommunications Room, Backbone Cabling, Horizontal Cabling and Work Area.

Entrance Facility

Entrance Facility (EF) refers to the entrance to a building for both public and private network service cables (as well as antenna transmission lines where applicable), including the entrance point at the building wall or floor, and continuing to the entrance room or entrance space.

The EF may include the following:

- Service entrance pathways
- Cables
- Connecting hardware
- Primary (electrical) protection devices
- Transition hardware
- Demarcation point

Equipment Room

The purpose of the Equipment Room (ER) is to provide space and preserve an appropriate operating environment for any size telecommunications equipment. ERs supply an entire building (or even a campus) while Telecommunications Room (TR) only serve one floor of a building or a portion of a floor.

ERs are used to:

- Accommodate portions of common control equipment such as voice, intrusion detection, data, video, fire alarm, energy management, etc.
- Provide work space for service employees.
- Provide for termination and cross-connection of backbone and horizontal cables.

Telecommunications Room

The Telecommunications Room (TR) houses the connection point between the building backbone and horizontal distribution pathways.

TRs are used to:

- Maintain a controlled environment for the telecommunications equipment, splice closures, and connecting hardware.

- Provide a point of termination for horizontal and backbone cables on compatible connecting hardware.

Backbone Pathways and Cabling

Backbone Pathways and Cabling, as the name suggests, carry the signals between the entrance facilities, equipment rooms and telecommunications rooms. Pathways are the vertical and horizontal route of the cable, including support structures. The backbone cabling system enables interconnections between EFs, TRs, ERs, and main terminal space. The distance between the terminations in the entrance facility and the MC should be documented and made available to the service provider.

The backbone also extends between buildings in a campus environment. It includes backbone cables, cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connections.

Horizontal Pathways and Cabling

Horizontal Pathways and Cabling provide the method of conveying signals between the telecommunications outlet/connector in the Work Area (WA) and the HC. This kind of cabling and its connecting hardware are known as a link. The cable is known as "horizontal" because that is the primary orientation of the cabling. However, horizontal pathways include the horizontal and vertical route of the cable, including support structures.

The distance between the terminations in the HC and the WA should be documented and made available to the service provider.

Work Area

The Work Area consists of the communication outlets (wall boxes and faceplates), wiring, and connectors needed to connect the work area equipment (computers, printers, etc.) via the horizontal wiring subsystem to the TR.

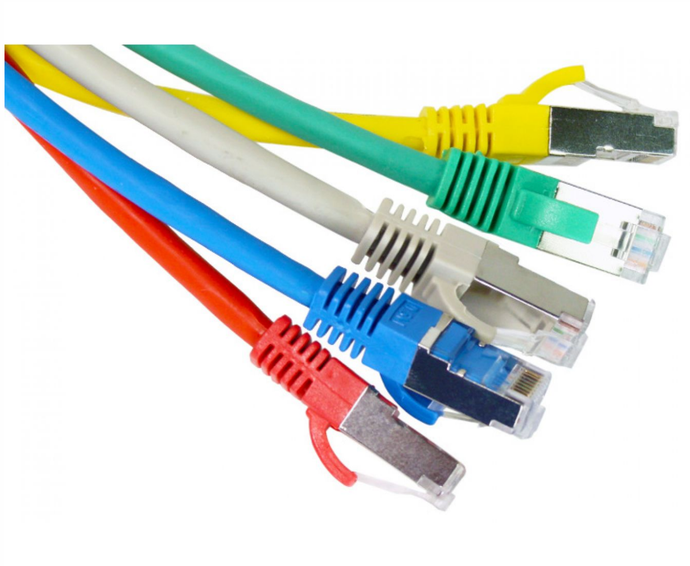
- The standard requires that a minimum of two outlets be provided at each wall plate - one for voice and one for data.
- Horizontal cable lengths must take into consideration the maximum length of work area cables to be utilized.
- Patch cords are designed to provide easy routing changes, and the equipment cords are considered to have performance equivalent to patch cords of the same kind and category.

Cross-Connect

Cross-connects facilitate the termination of cabling elements and their connections to other elements of the system. Cross-connects are housed in ERs and TRs. They are generally classified as follows:

- Main cross-connect (MC): Transition point between the entrance cables and backbone cabling.
- Intermediate cross-connect (IC): Transition point between the backbone cable of the MC and HC.
- Horizontal cross-connect (HC): Transition point between backbone cabling and horizontal cabling, typically serving a single floor or portion of a floor.

CHAPTER 3 - MEDIA



Some networks utilize only one type of cable, while other networks use a variety of cable types.The type of cable chosen for a network is related to the network's topology, protocol, and size. Understanding the characteristics of different types of cable and how they relate to other aspects of a network is necessary for the installation of a successful network.

Aston manufactures virtually every type of copper and fiber cable used for voice and data communications inside and between buildings. This section describes the primary media types referenced in the installation and testing guidelines. Media are listed within the following groups:

- **Balanced Twisted Pair Copper Cable**
  - Unshielded twisted-pair
  - Shielded twisted-pair
  - Patchcords

- **Optical Fiber Cable**
  - Multimode
  - Single mode

Balanced Twisted Pair Copper Cable Media

Balanced twisted pair cable is a form of wiring in which two conductors are wound together ("twisted") for the purposes of canceling out electromagnetic interference (EMI) from external sources and crosstalk from neighboring conductors."Balanced" twisted pair simply means that both conductors of a pair have matched electrical and physical properties. In premises applications, balanced twisted pair cable is typically selected based on performance categories specified in TIA/EIA-568.

Data Cable Category

Standard (Name)	Maximum bandwidth	Maximum distance	Maximum data rate	Notes
Level 1 (CAT 1)	0.4MHz		1Mbps	Unsuitable for modern systems
Level 2 (CAT 2)	4MHz		4Mbps	Unsuitable for modern systems
Category 3	10MHz		10Mbps	Basic voice, 10BASE-T Ethernet
Category 4	20MHz		16Mbps	Not commonly used
Category 5	100MHz	100 metres	100Mbps	Not commonly used
Category 5e (Class D)	100MHz	100 metres	1Gbps	Still commonly used for residential applications and every day use
Category 6 (Class E)	250MHz	100 metres (55 metres)	1Gbps 10Gbps (limited distance)	Used in new buildings
Cateogy 6A (Class Ea)	500MHz	100 metres	10Gbps	Data centres and commercial
CAT7 (Class F)	600MHz		10Gbps	Fully shielded components. Non modular connectors
CAT7a	1000MHz		10Gbps	Fully shielded solution.
CAT8	1600-2000MHz		40Gbps	In development

Twisted Pair Cable Markings

Twisted pair cables designed for use in the premise must be marked in accordance with their fire resistance rating.

Defined by NEC article 800 and CSA flame test (FT) ratings.

- Plenum Cable (CMP)
- Riser Cable (CMR)
- Other Cable Markings
    - General Purpose Cable (CM)
    - Limited Use Cable (CMX)
    - Undercarpet Cable

Data Cable Design

U/UTP or UTP
Unshielded Twisted Pairs

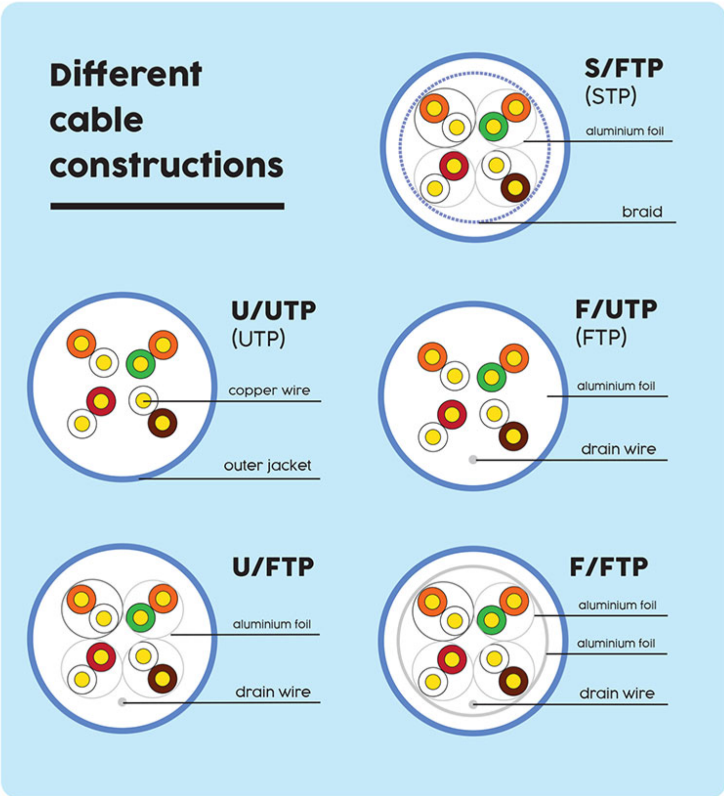
F/UTP or FTP
Foiled Twisted Pairs

SF/UTP or SFTP
Shielded and Foiled Twisted Pairs

U/FTP or STP
Shileded and individually foiled twisted pairs

F/FTP or FSTP
Foiled and individually foiled twisted pairs

S/FTP or SSTP
Shileded and individually foiled twisted pairs

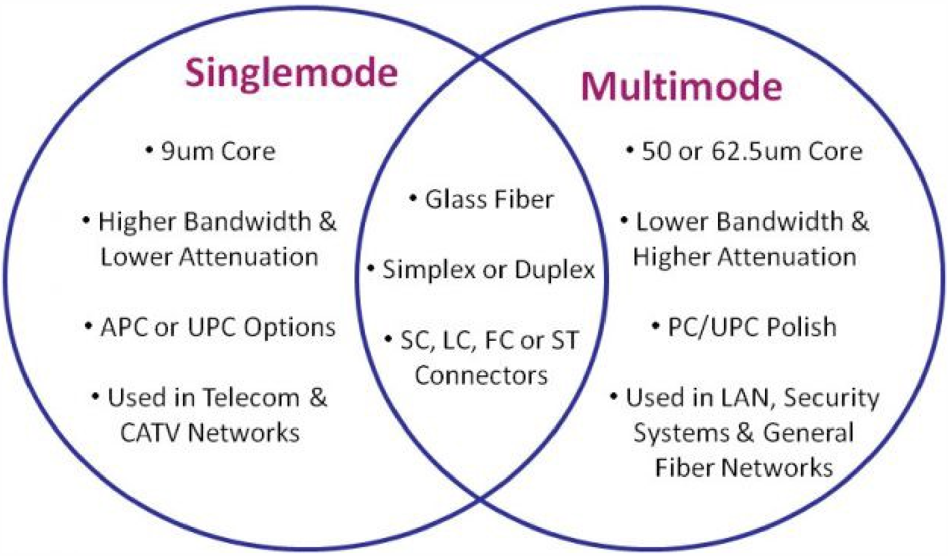


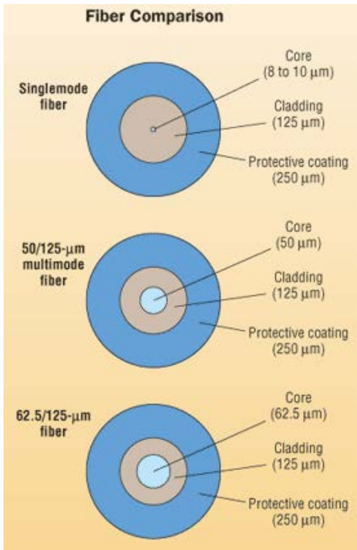
Optical Fiber Cable Media

An optical fiber is a single, hair-fine filament drawn from molten silica glass. These fibers are often used as the transmission medium in high-speed, high-capacity communications systems that convert information into light, which is then transmitted via fiber optic cable.

Optical fiber is composed of three key elements: Core, Cladding and Coating. The core is the innermost part of the fiber through which light pulses are guided. Cladding surrounds the core to keep light in the center of the fiber. The core and cladding are inseparable layers of glass. The coating is a layer of polymer that surrounds the cladding to protect the glass.

Optical fiber cable may be Single mode, Multimode or a hybrid of two or more media types.





Optical Fiber Cable Types

- **Tight-Buffered Cable**

  Tight-buffered optical fiber cable (single mode or multimode) protects the fiber by supporting each strand of glass in a coating, increasing the diameter to 900 µm. This cable is available with various jacket types to meet building codes requirements. Tight buffered construction is available for all fiber types.

- **Loose Tube Cable**

  Loose-tube optical fiber cable is used primarily outdoors. This cable allows fiber to expand and contract with changes in temperature. However, indoor/outdoor loose tube cables offer the double advantage of outdoor robustness and riser rating for easy transition from outdoors to indoors. Loose tube construction is available for all fiber types.

CHAPTER 4 - STANDARDS

A standard is a documented agreement containing the technical specifications or other precise criteria intended to be used systematically as rules or definitions of characteristics to ensure that materials, products, processes and services are suited to their employment.

The standards thus contribute to simplify our life and to increase the reliability and the effectiveness of the goods and services which we use.

In the world interconnection equipment, there are three organizations of standardization;

ISO (International Standardization Organization)
EIA/TIA (Electronic Industry Alliance/Telecommunication Industry Association)
EN (Cenelec)

ISO (International Standardization Organization)

9001 14001 45001

The international Organization of standardization is a world federation of national standards of approximately 130 countries, one of each country.

The ISO is a non governmental organization established in 1947. The mission of the ISO is to promote the development of standardization and the activities dependent in the world, in order to facilitate the international exchange of the goods and the services. The standards result from the co-operation of the spheres of intellectuals, and the scientific, technological and economic activity.Some of the ISO Standards mentioned below.

ISO/IEC 11801 edition 2 (2002) / edition 2.2 (2011)
Performances of the cabling system

ISO/IEC 14763-1
Administration, documentation, reports

ISO/IEC 14763-2
Installations rules

ISO/IEC 14763-3
Optical fiber test

IEC 61935-1
Copper system test

EIA/TIA (Electronic Industry Alliance/Telecommunication Industry Association)

Telecommunications Industry Association

Electronic Industries Alliance

The EIA is an association of 7 sectors of industry of electronics: TIA, CEMA, ECA, EIG, GEIA, JEDEC and EIF. The TIA is composed of the especially American and Canadian companies which provide products of technology information, hardware, systems, services of distribution and services professional. The TIA is the principal organization of standards affecting wiring of local area networks in North America. Common standards shown below.

ANSI/TIA/EIA 568-C.1
General Requirements for structured cabling

ANSI/TIA/EIA 568-C.2-x
100 ohms structured cabling system performances
(cable, connector, patch cords, permanent link, channel)

ANSI/TIA/EIA 568-C.3
Optical fiber

ANSI/TIA/EIA 568-C.4
Coaxial Cable

EN (CENELEC)

CENELEC (French: Comité Européen de Normalisation Électrotechnique; English: European Committee for Electrotechnical Standardization) is responsible for European standardization in the area of electrical engineering.

The CENELEC is a non governmental organization established in 1973. It forms the European system for technical standardization. Standards harmonised by these agencies are regularly adopted in many countries outside Europe which follow European technical standards

CHAPTER 5 - CABLE INSTALLATION

Preparing for Installation

Communications cables are designed with installation in mind. That being said, there are certain limitations to cable performance that must be respected during installation. In general, the four most critical characteristics to remain mindful of are tensile strength, bend radius, crush resistance, and temperature rating. These characteristics vary among cables types, sizes, and even manufacturers. It is critical for the designer and installer to be familiar with these criteria before the installation process begins.

Pre-Installation Testing

Aston communications cables are manufactured to high standards and tested rigorously in order to relieve end users of the burden of pre-installation testing.In normal situations, such testing is not necessary and the cable can be installed, as received, with confidence. However, pre-installation testing should be conducted if the customer specification requires it or if there is evidence of cable mishandling or damage.

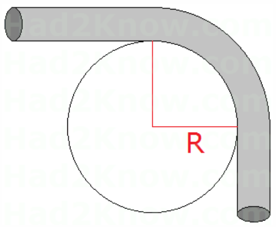
Pulling Tension

Many cables are pulled into position. When pulling a cable, it is critical to 1) attach the pulling line in the correct manner; 2) avoid exceeding the maximum tensile strength of the cable; and 3) relieve the pulling tension once the cables are in place.

In premises applications, lubricants are generally not necessary or recommended. However, pulling tension may be significantly reduced by using lubricant and thus may be deemed necessary in longer pulls. If so, use one that is specifically designed for the task at hand. For twisted pair cables, use only thin film lubricants. Be aware that other types of lubricants may affect performance of twisted pair cables, although this effect is generally temporary.

Bend Radius

Cable is rarely installed perfectly straight from point to point. Accordingly, communications cables are designed to bend, but as with pulling tension, there are limitations to bend radius that must be observed.



Crush Resistance

Crush resistance is a very important attribute that is easily quantifiable in a test laboratory but difficult to predict in an installation environment. As similarly stated previously, communication cables are designed to withstand crush, but there are limitations that must be observed (although difficult to quantify).Crushing a cable can cause many issues from temporary, intermittent anomalies to permanent failure. Below are several caveats regarding the crushing of cables:

- Beware of the cable-tie/clamp.Over-zealous cinching of cable ties or clamps is certain to wreak havoc on communication cables. Use hook and loop fasteners instead, which should always be applied loosely.
- Avoid stepping on or running over cables with vehicles and equipment.
- Beware of other locations that may constrict cables or conductors and put them at risk for damage.
- Do not staple communications cable with standard staples which may crush the cable. Use properly-sized cable staples.

Temperature Rating

Installation & Operation temperature for premier cable should be checked and followed from the product data sheets. To ensure that all the cable materials are safely within the installation temperature ratings, cables may need to be temperature conditioned immediately prior to installation. The conditioning time required will vary with the temperature differential (greater differential means more conditioning time) and package size (bigger packages require more time).

Cable Lengths and Types

The cabling installer must verify the size and type of package on which the cable will be delivered and plan to accommodate. Many horizontal cables are packaged such that they can be carried by hand and dispensed right out of the package, whereas backbone cables often require forklifts and reel stands.

In addition, at the start of every installation, the installer should verify that the correct cable is being installed and that it is of sufficient length.

Fire Resistance

Most premises cable applications require some form of fire resistance rating. These ratings are typically specified and made law by local and national authorities, and ultimately enforced by the local Authority Having Jurisdiction (AHJ). It is the responsibility of the installer to ensure that properly rated cables are installed in all locations.

Special Situations

◆ Water

Most premises cables are designed for a dry environment. If there is reasonable chance that a cable will encounter water, use a cable that is designed for the purpose. Generally these are known as indoor/outdoor cables.

◆ On-Grade/Below-Grade Conduit

Slab-on grade construction where pathways are installed underground or in concrete slabs in direct contact with soil (e.g., sand and gravel) is considered a wet location.

◆ Sunlight

Most premises cables are designed to be used in areas shielded from direct sunlight. If there is reasonable chance that a cable will encounter direct sunlight, use a cable that is designed for the purpose.

◆ Paint

Do not allow premises cable to be painted. The National Electrical Code (NEC) requires that indoor communications cables be "listed" for the application and marked with the listing. Paint may alter the fire resistance and/or smoke generation properties of the cable, which are strictly defined by the NEC listing.The listing does not make allowance for paint to be added to the cables. Indoor rated communications cables are also intended for dry locations and thus feature minimal moisture blocking ability. Paints, water, and other liquid contaminants can soak into the cable materials, potentially altering the transmission properties of the cable, particularly those with metallic conductors. Any safety or performance failure due to such a contamination of the cable is not covered under any standard or extended warranty programs.

◆ Separation from Power Sources

Communications cables are, by design or necessity, often installed in close proximity and/or in the same pathway as power service cables. The electrical energy of the power cables can have significant effect on the performance and safety of the communications plant. Cable design and placement are very important to ensure that electromagnetic interference (EMI), or dangerous levels of electrical energy are not induced into telecommunication cables. When installing communication cables near power service cables, proper separation must be maintained.

Special Equipment and Tools

The type of equipment required to perform the pull depends on the direction of the pull. If pulling from the bottom up, a winch may be required. If pulling from top down, a reel brake may be required.

In any case, specialized cable-handling devices are required, which may include:

- Winches
- Cable reel brake
- Temporary take-up devices
- Bullwheels
- Pulleys
- Mesh grips
- Bull lines

Pull Strings

Pull strings (aka lines or ropes) are needed to pull cable into conduits and other enclosed areas.Conduits often come with pull strings pre-installed. Methods for installing the pull string or rope through a conduit include:

- **Fishtape Method**

  A fish tape is a tool used by electricians to route new wiring through walls. Made of a narrow band of spring steel, by careful manipulation, the tape can be "fished" (guided) through the confined spaces within wall cavities. Once guided through, the new wiring can be pulled into the wall by attaching it to the end of the fish tape and pulling the tape back from whence it came.

- **Air-Propelled Methods**
  - A vacuum is on one end and a foam ball is attached to the pull string on the other end.
  - A compressed air bottle or mechanical blower can be used to propel the pull string attached to the propellant object.

Installing Support Structures

Proper support structures are critical for proper installation of a cabling system. All cable support structures, such as conduit, outlet box, pull box, j-hooks, and cable trays must accommodate the limitations of the cable.

Guidelines for Cable Support Structures

Following are recommendations to follow when installing common cable support structures. This list is not exhaustive.

Conduit

- Bends must accommodate the bending radius of the cable.
- No more than two 90° bends in a cable run – pull boxes may be used to break up a run.
- Pull boxes must be installed in conduit runs exceeding 100 feet (30m).
- Conduit segment must not exceed the allowable permanent link length.
- Do not exceed maximum fill ratios.

J-Hooks/Cable Slings

- Must be of sufficient width to support the bend radius of the cable.
- J-Hooks should have beveled or rounded edges.
- Should be spaced randomly at 60" or less intervals for UTP cables (the greater the data rate, the more important this becomes).

Cable Tray

- Sized to accommodate cabling at no more than 50% fill.
- 12" free space above tray to allow access.
- Tray shall be grounded and bonded per ANSI/TIA 607-B and NEC.

Miscellaneous

- Any other structures, such as walls or joists that the cable passes through, must support the cable similarly (may require sleeves).
- Bundling
  - Cables of different categories should not be bundled together
  - Cable should not be tightly bundled anywhere.
  - Hook and loop straps are recommended; but traditional cable ties are not.
  - UTP cables should not be "dressed" or "combed", especially within 20 feet of the patch panel
- Slack Storage
  - Slack storage must not violate the minimum bend radius.
  - Twisted pair and coaxial cable slack should be stored in a Figure 8, "U" or "S" pattern. Coiling may degrade performance.

Pulling Cable

Do not exceed the minimum pulling tension as specified for cable rating. Before beginning the job of pulling cable, ensure complete raceway system is installed and all materials and equipment are in place so that the cables can be handled properly.

CHAPTER 6 - CABLE TERMINATION AND SPLICING

Correct cable termination and splicing practices are vital for the complete and accurate transfer of both analog and digital information signals. Proper procedures will save time and improve the quality of the job.

Although there are common standards to ensure interoperability between cable and connectivity, many connectivity and associated equipment features are manufacturer specific. Therefore, the following guidelines should be used in conjunction with the instructions/guidelines relevant to the connectivity solution being employed.

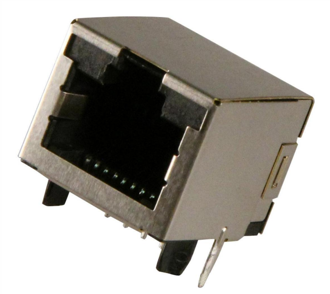
Balanced Twisted Pair Copper

In general, Insulation Displacement Connectors (IDCs) should be used for all balanced twisted pair connections. These connectors allow connections to be made without removal of the conductor insulation.

The wiring scheme of twisted pair conductors is such that the colors are consistent from one end of the system to the other, (i.e., dark blue to dark blue, light blue to light blue).

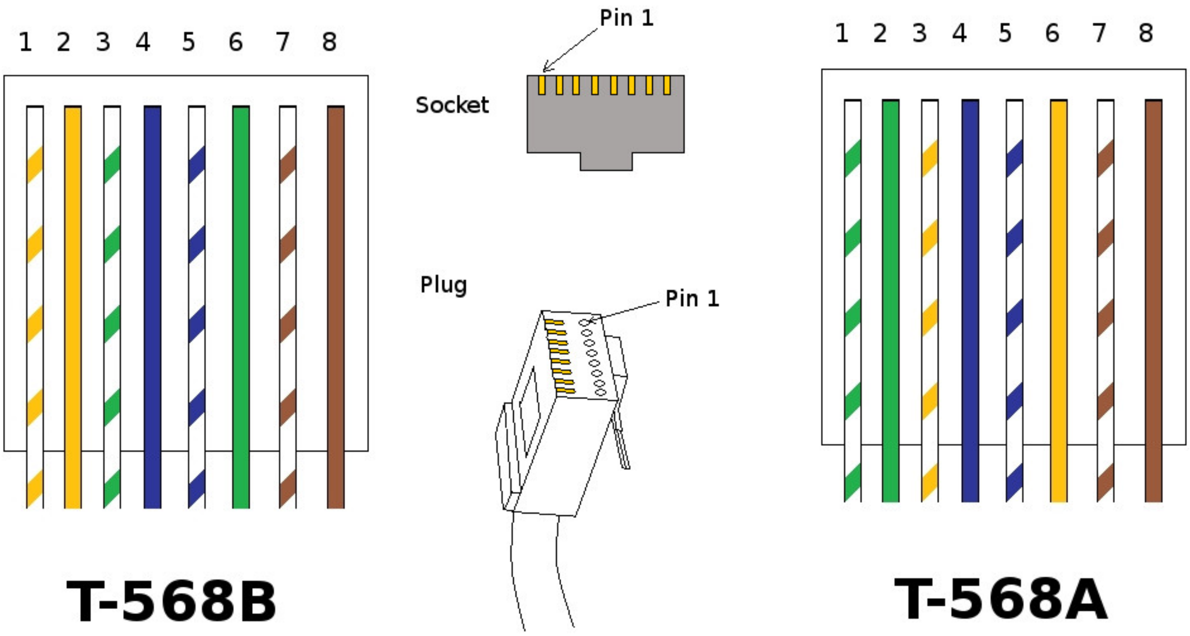
Four-Pair Horizontal

Four-pair horizontal cables primarily utilize the 8P8C modular jack or plug.



In most scenarios, cabling is terminated on jacks and the plugs come pre-installed on patch cords to complete the connection. However, field-installable plugs are available and, if used, should be installed based on the manufacturer's instructions. Shielded connectors should be used with U/FTP or F/UTP cable.

TIA/EIA-568-B recognizes two pin/pair assignments for four-pair cable: T568A and T568B, with T568A as the primary and T568B if required to accommodate certain cabling systems. In practice T568A is used primarily in residential and government applications, while T568B is used primarily in commercial applications. The important point is that only one method be used within the network.



Backbone Twisted-Pair

Twisted-pair cables larger than four-pair are generally terminated on a termination block such as the 66 block or 110 block (pictured below). These blocks, like the 8P8C's above, utilize IDC technology for a quality connection.

Copper IDC Termination

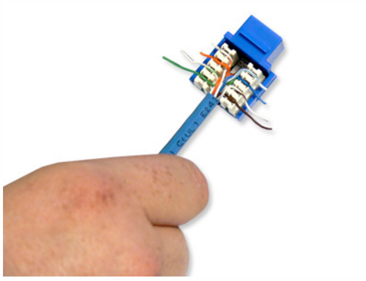
When terminating a twisted-pair cable, it is imperative to maintain the twist of the pairs as close as possible to the termination point. This becomes more crucial as the performance level increases (i.e., less important on CAT 3 and extremely crucial on CAT 6A/7). The best practice is to maintain the twist all the way to the termination point.

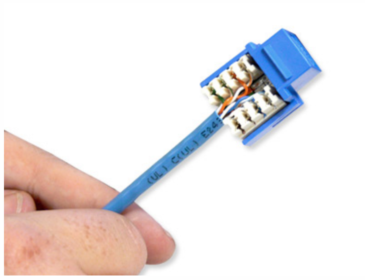
Following are the maximum allowable amounts of untwisting:

Twisted Pair Cable Type	**Twisted Pair Cable Type**
Category 3	3"
Category 5e	½"
Category 6	½"
Category 6A	¼"
Category 7	¼"

The cable jacket should also be left intact as close as possible to the termination point.

For some terminations, it is critical to punch pairs down in order, so that the other pairs can be kept out of the way. Attempting to position all pairs before commencing punch down will lead to crushed conductors.





Splicing Twisted-Pair Cable

Twisted-pair copper cable splicing is allowed only in backbone pathways. Cable in horizontal pathways should not be spliced. As a reminder, although there are common standards to ensure interoperability between cable and hardware, many hardware features are manufacturer specific. Therefore, the following guidelines should be used in conjunction with the instructions/guidelines relevant to the splicing solution being employed.

Optical Fiber

Optical fiber cable for premises applications comes in many varieties of construction. When terminating or splicing these cables, the cable ends must be prepared to provide access to the fiber. If unfamiliar with the proper procedure for a particular design, consult the manufacturer's guidelines.

Fiber Cable Termination

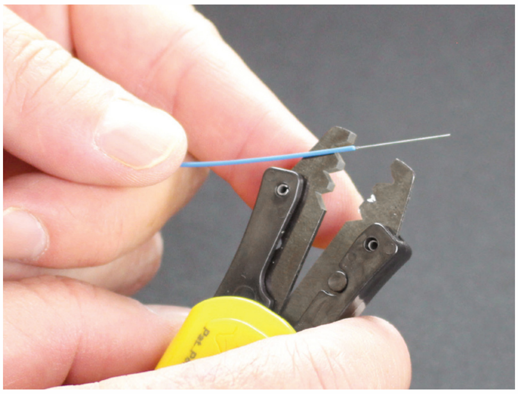
Listed below are various methodologies for optical fiber termination. Each has advantages and disadvantages, including the skill level required. Most methods are available for all connector styles (SC, ST, FC, LC, etc.).As with other connectivity components, procedures are rather component specific. Installers should refer to the applicable procedures.

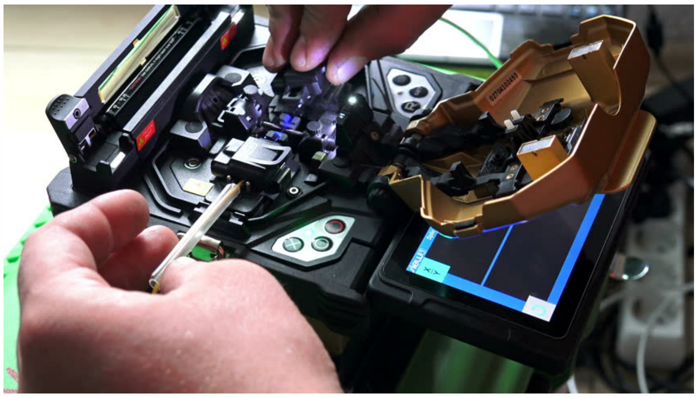
Termination Method	Typical Field Termination Time (Minutes)	Typical Time Available to Insert Fibre	Curing Method
Heat Cured Epoxy	10+30 Curing Time	2 Hours	Oven
Ambient Temperature Epoxy	10+120 Curing Time	15 Minutes	Air Temperature
UV Adhesive	5	30 Seconds	UV Light
Anaerobic Adhesive	3	5 Seconds	Accelerant
Acrylic Adhesive	2.5	30 Seconds	Activator
Crimp	2	No Limit	Not Applicable
Pre-polished Connector	3	No Limit	Not Applicable
Pigtail	5	No Limit	Not Applicable
Pre-terminated Cable Assemblies	0	Not Applicable	Not Applicable

Fiber Cable Splicing

In general, splices are best avoided and often can be due to the relatively short distances typical of premises networks. If splices are required, fusion splices are recommended due to lower attenuation. However, mechanical splices are allowed.

All fusion splices should be protected by a splice sleeve. All splices should be housed in a splice tray. All outdoor splices should be stored in an environmentally suitable splice closure. As a reminder, although there are common standards to ensure interoperability between cable and hardware, many hardware features are manufacturer specific.





CHAPTER 7 - TESTING & MEASUREMENT

Testing verifies that installation has been completed in accordance with all of the terms and conditions of the contract and industry standards. The complete testing process consists of three distinct phases: visual verification; test measurements; and documentation.

1. Visual Verification

Visual verification includes inspection of all pathways and spaces (where possible), telecommunications closets, and equipment rooms. At minimum, the following elements are inspected: infrastructure, grounding and bonding, cable placement, cable termination, equipment and patch cords, and the proper labeling of all components.

2. Test Measurements

Although there are common standards to ensure interoperability between cabling and test equipment, many test equipment features are manufacturer-specific.Therefore, test measures should be used in conjunction with the instructions/guidelines relevant to the test equipment being employed.

3. Documentation

Once testing is complete, it is highly recommended to document test results. Documentation is vital to establishing long-term performance and integrity of cable networks by revealing problems not detected during installation and providing a baseline for comparison to future measurements.

Test Equipment

Field test equipment is used as most appropriate and cost-effective for the type of cables being installed. Many test sets are capable of performing all required tests, while others are designed to perform a few tests or even a single specific test. A comprehensive listing of test equipment can be found in the BICSI Telecommunications Cabling Installation Manual.

Pre-Installation Testing

As mentioned in Chapter 6: Cable Installation, Aston communications cables are manufactured to high standards and tested rigorously to relieve end users of the burden of pre-installation testing. In normal situations, pre-installation testing is not necessary; however, such testing should be conducted if the following conditions exist.

- The customer specification requires pre-installation testing.
- There is evidence of cable mishandling or damage, including but not limited to the following.
  - Physical damage to the cable or packaging
  - Cable reels delivered or stored on their sides
  - End caps missing on OSP cables, particularly non-filled copper cables

Balanced Twisted Pair Copper Cable Testing

Balanced twisted pair copper cable testing evaluates the proper installation and functioning of horizontal and backbone copper cabling. Test methods for Backbone copper cabling depend on the category of cabling employed. Test methods for Horizontal copper cabling vary depending on the category as well as whether the permanent link or the entire channel is being tested.

The Permanent Link configuration is the permanent portion of the overall cable run, and consists of up to 90 m (295 ft) of horizontal cabling and one connection at each end and may also include an optional transition/consolidation point connection.

The Channel Link encompasses the entire cable run, including all patch cords and cross connections. The channel link test configuration is more comprehensive, in that the quality of the additional components, the proper installation, and the network equipment all play a role in the transmission performance of the entire network.

Testing Guidelines and Procedures

This section contains general guidelines and descriptions for each of the tests in the previous table. Specific instructions and associated calculations can be found in the BICSI Information Transport Systems Installation Methods Manual and TIA/EIA-568, along with its various addenda.

- **Set the Proper NVP**

Many test sets contain cable libraries that allow the user to select a generic cable type (such as Category 6 UTP) and/or specific cable (such as Aston Cat6 UTP, CMP, UL rated) that automatically loads pre-set cable parameters, including NVP. However, parameters are subject to change and should be verified against the applicable product data sheet. This is especially true of NVP which has significant affect on length measurement. To ensure the most accurate length measurement, verify and set the proper NVP for the cable being tested.

◆ **Wire Map or Continuity Testing**
Continuity Testing is the most basic test to establish proper cabling installation. It is also referred to as a Wire Map test when utilizing handheld testers. Continuity testing evaluates the following elements:

- Open circuits
- Short circuits
- Improper termination
- Drain wire continuity (if applicable)

◆ **Length Testing**

In Length testing, verify the following:

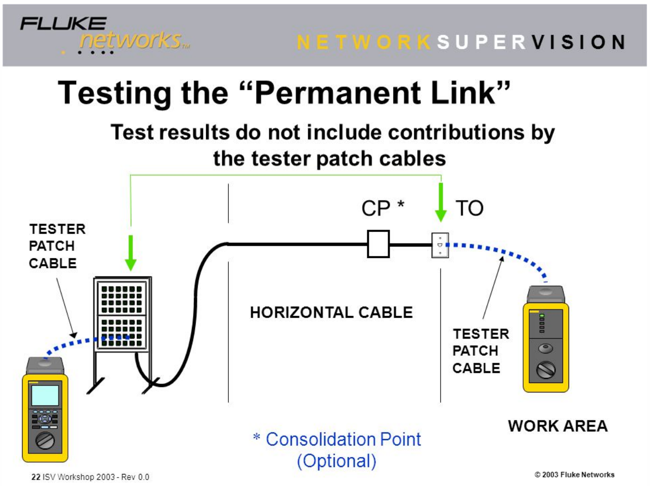
- The maximum permanent link length is 90 m, plus 2 m at each end for leads, and an additional 10%, for a total of 103.4 m. The tester will not fail any length up to 104.4 m.

- The maximum channel link length is 90 m, plus 10 m for all patch leads, fly leads and equipment leads, and an additional 10%, for a total of 110 m. The 10% is to allow for NVP (Nominal Velocity of Propagation) uncertainty.

Limits are stricter for the permanent link since there are fewer components. It is important to set the tester to the correct type of link being tested.

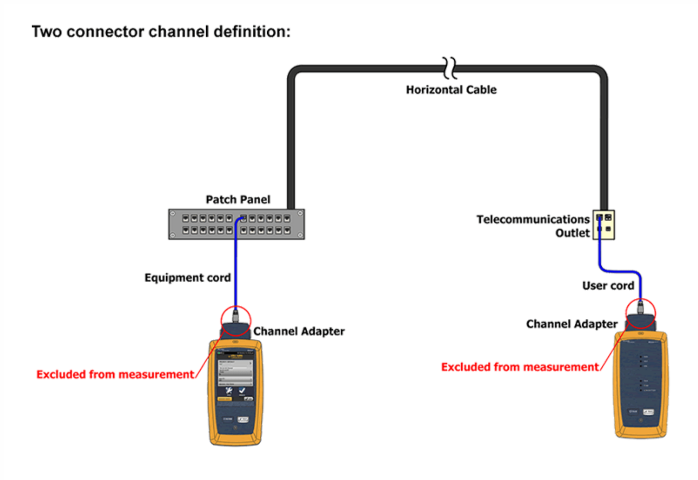
Data Cable Testing

Test configuration : Permanent Link (90m)



- Test the performance of the system without the patch cords.
- Define which will never 'move'.
- This test configuration is made for the installers.
- The configuration PERMANENT Link was defined to qualify the fixed installations
- Must be tested during construction or during the phase of reconfiguration
- Must be tested with the PERMANENT LINK cords

Test Configuration : Channel (100m)



- Test the performance of the system with the patch cords.
- Each patch cords must be identified to each location of outlets
- Defined the complete channel of connection and maximum 4 connectors at the ends.
- Must be tested with the Channel adapters.
- The standards networks are defined on a Channel configuration.

Consolidation Point

Stranded or Solid

The consolidation point can be in stranded cable or in solid cable.
The most important is that the final link pass the required electrical parameters.

Length

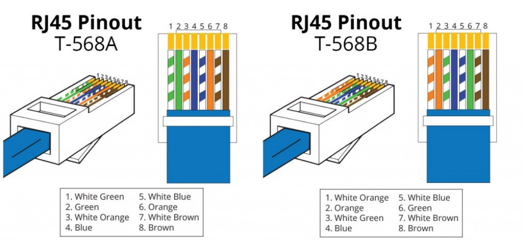
If we consider the different standard, each length of the different consolidation cable need to be calculated using equations.

In practice, the maximum length from the consolidation point is 20 meters.

Electrical Parameters & Measurements

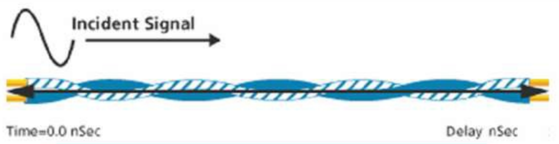
Wiremap

BE CAREFUL OF THE CHOOSEN CABLING DIAGRAM



The Horizontal cabling must be 'STRAIGHT', that is to say the both extremities need to have the same cabling diagram.

Length Measurements

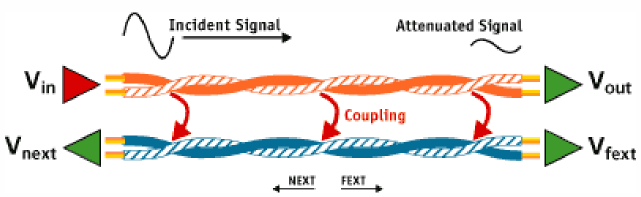


$$\text{LENGTH} = \frac{\text{Delay A-R} \times \text{NVP} \times \text{C}}{2}$$

- The length varies in function of the NVP.
- Commonly, the NVP need to be calibrated
- The length is different according to the Pairs ("twist" of different length)
- Limits
  - Permanent Link : 90 meters
  - Channel : 100 meters

NVP = Nominal Velocity Propagation (expressed in % of C)
C = Speed of light in the vacuum (300000Km/s)

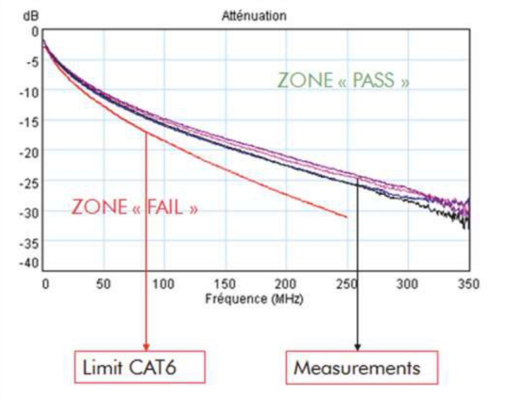
Insertion Loss Measurements (dB)



Insertion Loss = Attenuation

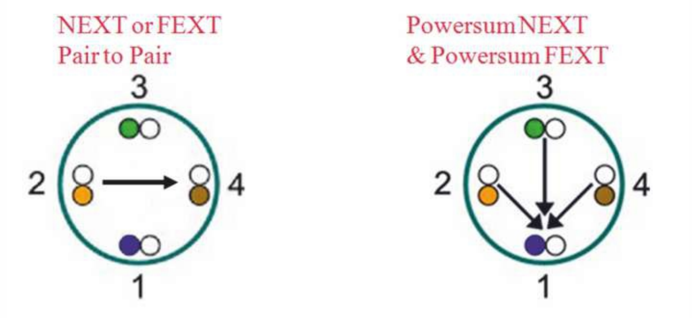
Increase with the frequency
Increase with the length
Increase with the temperature
Adding of the connector and cable losses

Insertion Loss Measurements: Example



The loss must be the smallest as possible

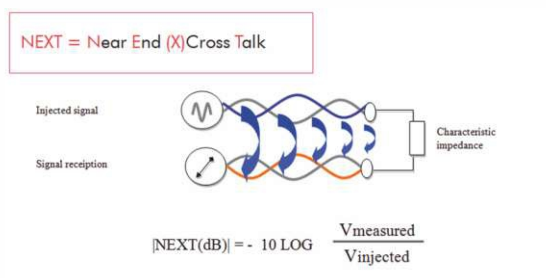
Measurements of Crosstalk

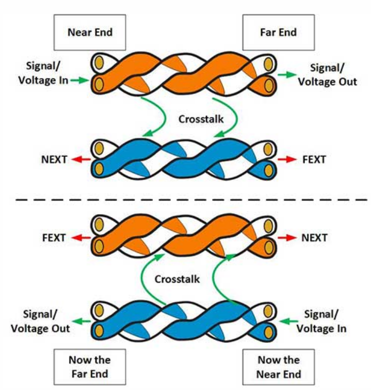


- 6 combinations.
- Essential measurement for the networks using two pairs.
- It is necessary from category 5 and ISO class D

- 4 combinations.
- Essential measurement for the networks using 4 pairs.
- Required in Cat 5e and higher.
- More demanding than even measurement in crosstalk pair to pair

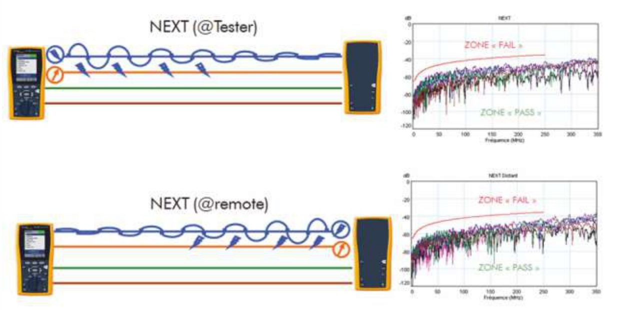
NEXT (dB)



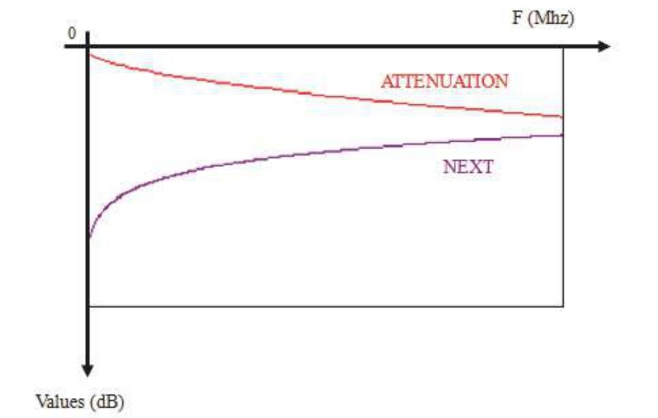


NEXT = Signal Emission on one side of the Link and measured on one other pair of the same side.

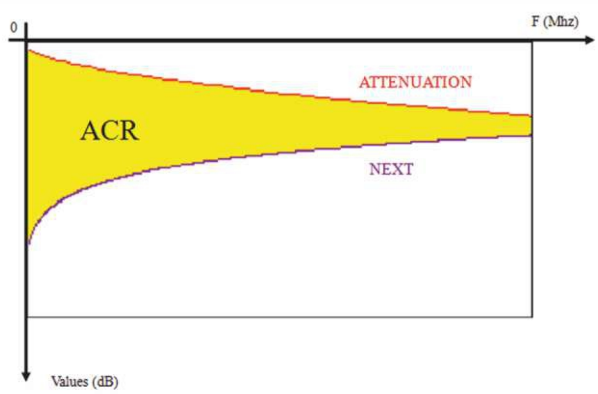
Two measurements of NEXT at the both extremities of the Link



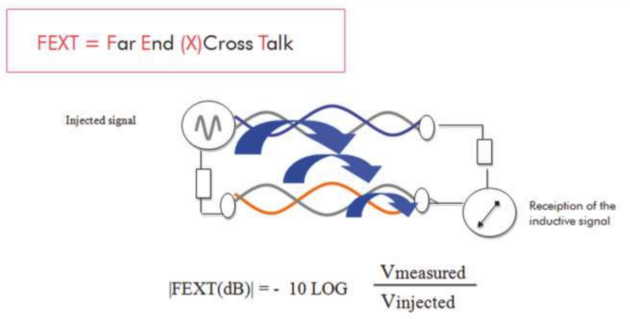
ACR (Attenuation to Crosstalk Ratio)

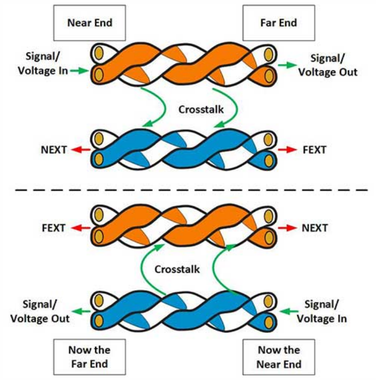


$$ACR_{(dB)} = NEXT_{(dB)} - ATTENUATION_{(dB)}$$



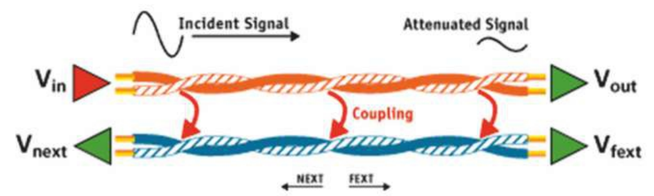
FEXT (dB)





FEXT = Signal Emission on one side of the Link and measured on one other pair of the other side

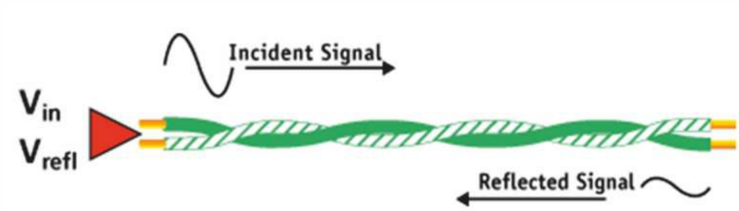
Difference Between FEXT & ELFEXT



The ELFEXT (Equal Level FEXT)is a calculated result, not a measurement

$ELFEXT_{(dB)} : FEXT_{(dB)} - ATTENUATION_{(dB)}$

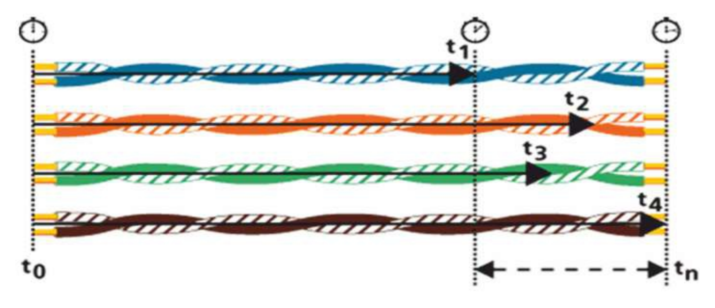
Return Loss Measurements

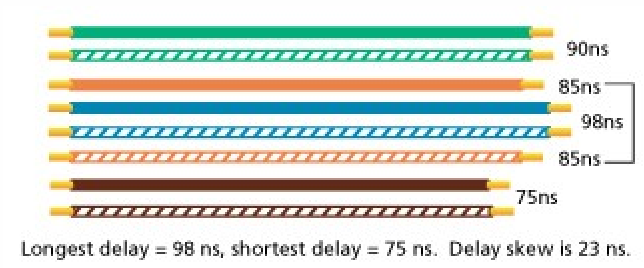


Measures power of the echoes of the signal considered due to the losses of impedance adaptability along the cable.

This echo is a source of additional noise which obstructs the recovery of data

Propagation delay & Skew



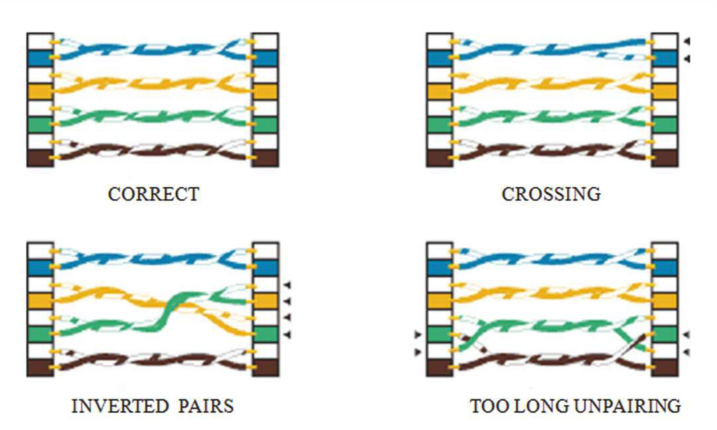


The excessive times of propagation prevent the simultaneous transmissions.

For this reason, a limit of Skew was defined for the networks 100 Base T4, 100 VG, Gigabit and 10 Gigabit

Resolve the errors

Cabling Diagram Errors



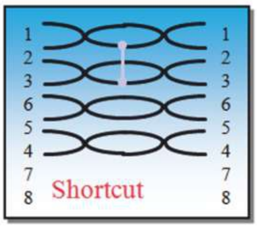
Mistakes in Cabling diagram & length

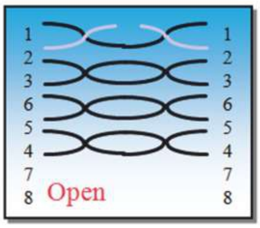
CABLING DIAGRAM

- Shorting
- Opened Pairs
- Drain Wire Not Well Connected (shielded components)

LENGTH

- Uncorrect Nvp
- Shorting & Open Circuit
- Too Long Link





Errors in NEXT or FEXT

- Problem of connection assembly
- Unpairing
- Cable injuries
- External Noise (Ambient Noise)
- Bad quality of the patch cords(when CHANNEL is tested)
- Grounding problem (Shielded system)

Failure in insertion Loss

- Excessive length
- Too High temperature
- Assembly of the connector
- Mismatch of the different components

Fail in Return Loss

- Problem of conector assembly
- Cable insulation crushed
- Cable geometry affected
- Bad patch cords
- Impedance Mismatch of the components

Optical Fiber Cable Testing

Proper testing of Optical Fiber Cable increases the system's longevity, minimizes system downtime, reduces maintenance needs, and supports system upgrades and reconfiguration.

Fiber optic cable is tested for continuity and attenuation. Three test methods are commonly performed for Optical Fiber:

- Visible Light Source
- Power-meter-and light-source (One Jumper Method)
- Optical Time Domain Reflectometer (OTDR)

◆ Visible Light Source Testing

Visible Light Source tests continuity in optical fiber stands. Optical fiber communication systems operate in the infrared region of the electromagnetic spectrum which is invisible to the human eye. However, (red) visible light sources are available for testing and troubleshooting optical fiber systems. They are also referred to as visual fault finders, visual fault locators, among other names.

◆ Power-Meter-and-Light-Source Testing

Power-meter-and-light-source (also known as the One Jumper Method) is the most accurate way to measure end-to-end signal loss of the fiber, referred to as attenuation. Listed below are TIA/EIA-568 insertion loss limits for the various components. Specific installations or protocols may impose stricter limits.

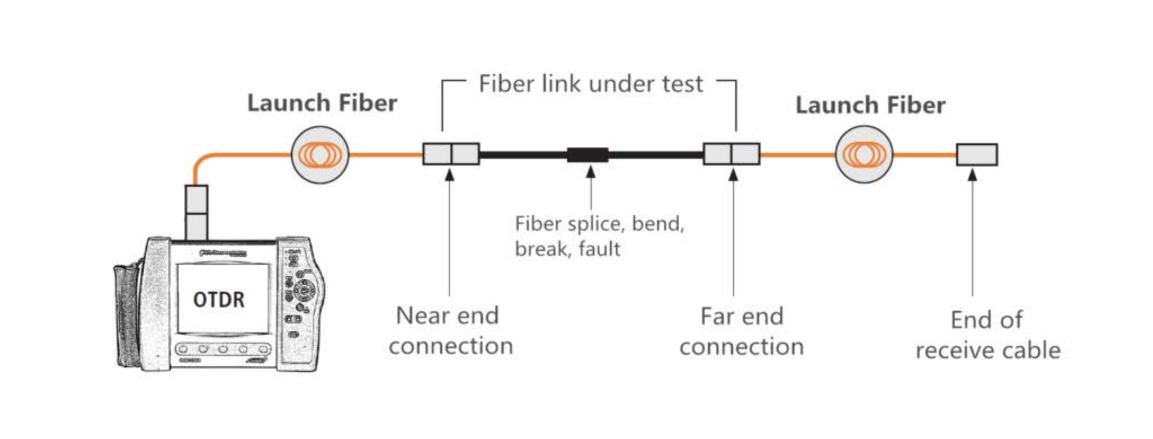
Test results should be compared to the link attenuation allowance calculated as follows:

Link Attenuation Allowance (dB) = Cable Attenuation Allowance (dB) + Connector Insertion Loss Allowance (dB) + Splice Insertion Loss Allowance (dB) where:

- ◆ Cable Attenuation Allowance (dB) = Maximum Attenuation* (dB/km) x Length (km)
- ◆ Connector Insertion Loss Allowance (dB) = Number of Connector Pairs x Connector Loss Allowance (dB)
- ◆ Splice Insertion Loss Allowance (dB) = Number of Splices x Splice Loss Allowance (dB)

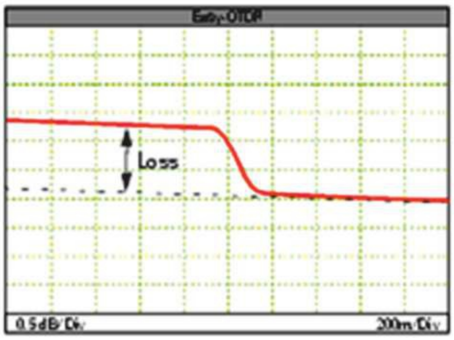
Optical Time Domain Reflectometer (OTDR) Testing

Optical Time Domain Reflectometer (OTDR) measures the fiber cable length, attenuation, and "events" along the length of the fiber. Events can be splices, breaks, or stress points (often called "kinks" or "steps") that cause excessive attenuation. The OTDR does this by sending light pulses down the cable and measuring the timing and power of light reflected back to the OTDR by the events and the fiber itself. It uses this information to display a "trace", which is a graph of power versus distance. An OTDR only requires access to one end of a fiber for testing. Because an OTDR is an indirect measurement method, it is not as accurate as a light source and power meter for measuring attenuation. However, due to its ability to display a graph of the fiber, it is particularly useful in troubleshooting. Like a power meter and light source, an OTDR tests at specific wavelengths (generally 1310 nm and/or 1550 nm for single mode and 850 nm or 1300 nm for multimode).

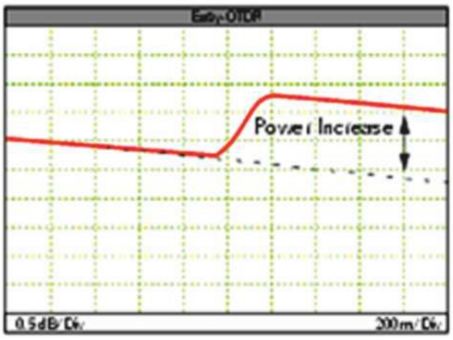


The principal parameters which must be checked are:

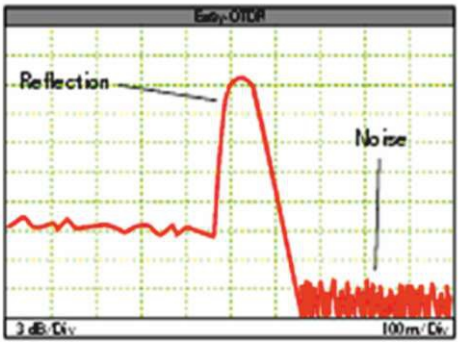
- Length of the connection
- Localization of the constraints undergone by fiber
- Total Attenuation of the link
- Attenuation of each component
- Reflectance of certain components



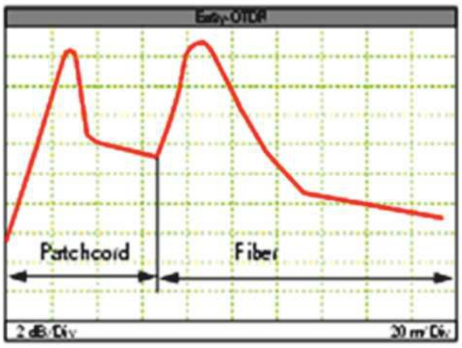
No-reflective defect: The signal loses power



Reflective defect: The signal gains power but this power is characterized by a noise



Strong reflective defect then more signal but of the noise. Interpretation: Broken fiber



Influence of a patch cable on connection fiber.

If using an OTDR for certification testing in a premises cable environment, there are several important factors to consider:

- Though OTDR's can test from a single end, all fibers should be tested from both ends to ensure the fiber is compliant end to end. OTDR's have a blind spot at the measuring end (which can hide problems). Also, because the OTDR is measuring reflected light, it may be impossible to tell if an event at the far end is the actual end of the fiber or a fault.
- If measuring individual splice loss with an OTDR, always measure the splice from both directions and average the two measurements (known as a bidirectional average).
- The shorter the measurement distance, the less accurate the attenuation measurement becomes. This varies based on the specific OTDR. Check the manufacturer's specifications.

CHAPTER 8 - SAFETY

When installing any type of wire or wiring system, there is always risk involved. These risks of course include harming yourself, someone else or loss of property if the wires are not properly installed or necessary precautions are not taken.

There are a few proactive measures we should take while working with or installing wires. Keeping the following tips in the forefront will help us to make sure not to cause any harm to property and keep us safe at the same time

Make Sure the Power is Off

Check the breaker or power source and make sure the power is always off before starting any electrical work. Lock the breaker if possible or if cannot, make sure everyone in the area knows it is turned off for a reason and leave an easily noticeable note that you are working on the electricity. It's logical but critical for a safe work environment.

Wear Safety Glasses and Protective Clothing

Covering your eyes is a must when dealing with electricity. You do not want sparks or other debris to get in your eyes. Also, wearing long shirts, pants, gloves, and thick soled shoes are also a good idea. If the environment is outdoor or large scale, a hard hat may also be needed along with other construction environment safety gear.

Always Test First

Use a voltage tester to test the wires and connections before you begin working on them to make sure they are indeed dead. This will allow you to accurately judge the work that needs to be done and select the product and tools you need to use.

Have the Right Tools On Hand

As with any job, we need the correct tools to complete it properly and do it with safety in mind. Having the right tools for a wire installation is detrimental. Some tools include: a voltage tester, wire cutters, wire and cable strippers, needle nose pliers, continuity tester, and others.

Check Your Work

Electrical fires are known to spark at any time and cause considerable damage and tragedy. Pull on the connections to make sure they are secure. Turn on the electricity and make sure everything works correctly and starts up without incident. Also, check the casings with a voltage tester to make sure they are not electrified. Use the right insulators for longer life spans too.

Other Safety Tips

- Obey all warning signs; read equipment warning labels before use
- Cables and wiring for emergency equipments, lightings, communication and signal should be kept away from spaces like galley, laundries, machinery space of category A & other high risk areas.
- Special precautions are to be taken for cable installation in hazardous area as it might lead to explosion in case of electrical fault.
- Terminations and joints are to be made in such a manner that it should retain its original fire resisting properties.
- Avoid cable for damage and chaffing during installation.
- Fireproof glands to be used in case of cable passing through the bulkhead as it would prevent fire from one compartment to other
- Use disposable dust masks for protection from inhalation of dust in dusty environment.
- Always ensure adequate insulation when touching powered circuits.
- Proper grounding should be done in all racks/devices.
- The standing surface must be insulated from ground with insulating material (rubber mat or insulated tiles or, when these are not available, dry wood, dry canvas, dry phenolic material).
- Ensure good lighting at workplace
- Keep tools away from walk area where you and others could fall over them
- The working area must be properly ventilated
- Keep chassis area clean and dust free
- Floor covering must be non-skid
- Never wear jewelers or items such as metal fittings or metal rivets on items of clothing
- When working on the installations always dieback long hair.
- Do not wear loose clothing that could get caught in the chassis
- Untidiness at the work place involved the risk of injuries
- Personnel Training about safety at work site should be given to all personnel's in the workplaces

GLOSSARY

- **110-type Connecting block** — The part of a 110-type cross connect that terminates twisted pair wiring and can be used with either jumper wires or patch cords to establish circuit connections
- **Alien Crosstalk** — Disturbing noise generated by signal energy on adjoining, and especially, hybrid cables
- **ANSI** — American National Standards Institute. ANSI develops and publishes technical standards
- **ASCII** — American Standard Code for Information Interchange. It is a seven-bit code, developed by ANSI, using 128 different characters
- **Attenuation** — Amount of signal loss (measured in dBs) from transmitting node to receiving node
- **Attenuation-to-Crosstalk Ratio(ACR)** — The part of a 110-type cross connect that terminates twisted pair wiring and can be used with either jumper wires or patch cords to establish circuit connections.
- **AUI Cable** — Attached Unit Interface Cable. A four-pair twisted cable used in the Ethernet network that connects a device to an external transceiver.
- **Backbone** — A facility (e.g. pathway, cable or conductors) between telecommunications closets, the floor distribution terminals, the entrance facilities, and/or the equipment rooms within or between buildings.
- **Backbone Cable** — Cable found in the backbone. See backbone.
- **Back scattering** — The return of a portion of light, in the opposite direction of its original prorogations, back to the transmit end of a fiber.
- **Balanced Cable** — A cable consisting of one or more metallic symmetrical cable elements.
- **Bandwidth** — The difference (range) expressed in Hertz, between the two limiting frequencies of a band.
  The information capacity of a channel
- **Baseband** — A form of modulation in which data signals are pulsed directly onto transmission medium without frequency division.
  A method of communication in which a signal is transmitted at its original frequency without being impressed on a carrier.
- **Baud** — A measure of the speed of data transmission. Baud represents the number of occurrences of the signal level per second. While baud rate often equals bit rate, it is not necessarily the case and the two must not be assumed to be the same.
- **BER- Bit Error Rate** — The ratio of incorrectly transmitted bits to correctly transmitted bits
- **Equipment Room** — A centralized space for telecommunications equipment that serves the occupants of the building. An equipment room is considered distinct from a telecommunications closet because of the nature of complexity of the equipment.

- **Blind Zone** — Area of an OTDR trace where events can not be seen- varies with each other OTDR manufacturer and model
- **Bus** — A common connection where all workstations receive data from the network. Ethernet is considered a bus network.
- **Cable** — An assembly of one or more conductors or optical fibers within enveloping sheath, constructed so as to permit use of the conductors singly or in groups.
- **Cabling** — A combination of all cables, cords, and connecting hardware.
- **Channel** — A configuration of cabling consisting of up to 90 meters of horizontal cable, a work area equipment cord, a telecommunications outlet connector, and optional transition point, and two cross- connections. Overall total maximum length, including all of the above, is not to exceed 100 meters.
- **Cladding** — The outer concentric layer that surrounds the fiber core and has a lower index of refraction.
- **Cleave** — The process of separating an optical fiber by a controlled fracture of the glass, for the purpose of obtaining a fiber end, which is flat, smooth, and perpendicular to the fiber axis.
- **Core** — The central, light carrying part of an optical fiber; it has an index refraction higher than that of the surrounding cladding.
- **Cross-connect** — A facility enabling the termination of cable elements and their interconnection, and/or cross-connection, primarily by means of a patch cord or jumper.
- **Crosstalk** — When a signal traveling on one pair of wires (disturbing circuit) is electrically coupled onto an adjacent pair (disturbed circuit) causing a signal disturbance.
- **Data Rate** — The number of bits of information in a transmission system, expressed in bits per second (bps), and which may or may not be equal to the signal rate.
- **Decibel** — A standard logarithmic unit for the radio of two powers, voltages, or currents.
- **Distribution Rack** — A device where telecommunications cables are connected and communications equipment are mounted.
- **Electromagnetic Interference (EMI)** — The ratio of incorrectly transmitted bits to correctly transmitted bits
- **ELFEXT (Equal Level Far End Crosstalk)** — A measurement of the crosstalk that occurs between the injected signal at the near end and the disturbed pair at the far end relative to the received signal level measured on that same pair.
- **Entrance Facility** — An entrance to a building for both public and private network service cables including the entrance point at the building wall and continuing to the entrance room space.

- **Ethernet, 802.3** — The IEEE 802.3 official standard. A network architecture that uses a bus topology and CSMA/CD at 10 Mbps.
- **FDDI** — Fiber Distributed Data Interface. A high speed networking standard utilizing optical fiber, and the topology is a dual-attached, counter-rotating ring.
- **Hertz (Hz)** — International term for cycles per second
- **Horizontal Cabling** — The cabling between the telecommunications outlet/connector and the horizontal cross-connect.
- **Horizontal Cross-Connect** — The cabling between the telecommunications outlet/connector and the horizontal cross-connect.
- **Hybrid Cable** — An assembly of two or more different types of cables, or categories, in the same overall sheath.
- **IDC** — Insulation Displacement Contact. A termination technique whereby insulated wire is forced into a slot on a contact that removes the insulation and allows electrical contact with the wire conductor.
- **IEEE** — The Institute of Electrical and Electronic Engineers. A group that develops and publishes several of the network standards.
- **Impedance Mismatch** — The condition in which the impedance of a source does not match or equal the impedance of the connected load, causing reflection, which in turn, reduces power/signal level.
- **Index- matching Material** — A material used at an optical interconnection, having a refractive index close to that of the finer core, used to reduce Fresnel reflections.
- **Index of Refraction** — The ratio of the velocity of light in free space to the velocity of light in a given material. Symbolized by n.
- **Impedance** — An opposition to current flow, usually measured in ohms.
- **Insertion Loss** — The difference between the received power before and the received power after connectors, cables or other passive devices are added to a cabling segment.
- **Intermediate Cross-Connect** — A cross-connect between 1st level and 2nd level backbone cabling.
- **LAN** — Local Area Network. A pre-planned network linking computers, terminals, and other equipment over a local geographic area.
- **Launch Fiber** — An optical fiber used to couple and condition light from an optical source into an optical fiber. Often the launch fiber is used to create an equilibrium modal distribution in multimode fiber. Also referred to as Launching Fiber.
- **Link** — A configuration of cabling consisting of up to 90 meters of horizontal cabling and one connection at each end.

- **Main Cross-connect** — A cross-connect for 1st level backbone cables, entrance cables, and equipment cables.
- **Mbps** — Megabits per second (one million bits per second)
- **Media Adapter** — A device that allows the connection of one medium to another (i.e. fiber to copper, vice-versa).
- **Megahertz (MHZ)** — A measure of frequency or bandwidth
- **Microbending** — Curvatures of the fiber which involve axial displacements of a few micrometers and spatial wavelengths of a few millimeters, causing loss of light and consequently, increasing attenuation
- **Micron** — Another term for micrometer - a unit of measurement equal to one millionth of a meter.
- **Multimode Optical Fiber** — An optical fiber that will allow many modes of light to propagate. The fiber many be either a graded- index or step index fiber.
- **Nanometer (nm)** — A unit of measurement equal to one billionth of a meter
- **NEXT (Near End Crosstalk)** — A measurement of the amount of crosstalk that occurs at the end of the cable where the signal was injected.
- **Node** — Any network hardware station.
- **Numerical Aperture (NA)** — The "light gathering ability" of a fiber, defining the maximum angle to the fiber axis at which light will be accepted and propagated through the fiber.
- **Optical Return Loss** — The ratio (expressed in units of dB) of optical power reflected by a component or an assembly to the optical power incident on a component port when that component or assembly is introduced into a link or system.
- **OSI** — A design in which groups of protocols, or rules for communicating, are arranged as layers. Each layer perform a specific data communications function. In order, the seven layers are: physical, datalink, network, transport, session, presentation, and application. The first three layers are concerned with data transmission and routing. The last three layers focus on user applications. The fourth layer provides an interface between the first and last three layers.
- **Patch Panel** — A cross-connect system of mutable connectors that facilitates administration, and allows interchangeability.
- **Pathway** — A facility for the placement of telecommunications cable
- **Pigtail** — A short length of fiber permanently attached to a component, such as a source, detector, coupler, or connector.

- **Plenum** — The air handling space between walls, under structural floors, and above drop ceilings, which can be used to route intra building cabling.
- **Plenum Cable** — A cable whose flammability and smoke characteristic allow it to be routed in a plenum area without being enclosed in conduit.
- **Propagation delay** — The delay between the time a signal enters a channel and the time it is received
- **Propagation delay Skew** — The difference in propagation delay between the fastest and slowest pairs within the same cable sheath.
- **Protocol** — A set of rules governing the transmission of information over a data channel.
- **PSNEXT** — A measurement of crosstalk from multiple transmitters at the near end coupled into a pair measured at the far end of the cable relative to the received signal level measured on the pair
- **Pull tension (tensile Load)** — The maximum pulling force that can be safely applied to a cable without damage.
- **Return Loss** — Attenuation caused by characteristics inherent in the cabling medium. (i.e. impedance mismatch, impurities, etc.)
- **Riser** — A backbone cable running vertically between floors
- **Sheath** — The outer covering of a jacket over the insulated conductors to provide mechanical protection for the conductors.
- **Shield/Shielding (Cable)** — A conducting envelope, composed of metal strands, which enclose a wire, group of wires or cables so constructed that substantially every point on the surface of the underlying insulation is at ground potential or at some pre-determined potential with respect to ground.
- **Singlemode Optical Fiber** — An optical fiber that will allow only one mode to propagate; this fiber is typically a step index fiber.
- **Splice** — An interconnection method for joining the ends of two optical fibers in a permanent or semi-permanent fashion.
- **STP** — Shielded Twisted Pair. Twisted pair wire with each pair surrounded by a foil or mesh shield to reduce interference. Typically 150 Ω Impedance cable
- **Star Quad** — A cable element that comprises four insulated conductors twisted together.
- **Step index Fiber** — An optical fiber, either multimode or single mode, in which the core refractive index is uniform throughout so that sharp step in refractive index occurs at the core-to-cladding interface.
- **Strength Member** — That part of a fiber cable composed of kevlar aramid yarn, steel strands, or fiber glass filaments that increase the tensile strength of the cable.

- **Telecommunications Closet** — An enclosed space for housing telecommunications equipment, cable terminations, an cross-connect cabling. The closet is the recognized location of the cross-connect between the backbone and horizontal facilities.
- **Telecommunications Infrastructure** — A collection of those telecommunications components, excluding equipment, that together provides the basic support for the distribution of all information within a building.
- **Telecommunications Outlet/Connector** — A connecting device in the work area on which horizontal cable terminates
- **Tensile Strength** — The amount of tension that can be placed on a cable during installation without damage to the cable or conductor. Also called pull strength.
- **Transceiver** — A communication device, capable of both transmitting and receiving messages, that serves as the interface between a user device and a network. A transmitter and receiver combined in one package.
- **UTP** — Unshielded Twisted Pair cable
- **Velocity of Propagation** — The speed of electromagnetic energy or light in a medium as compared to its speed in free space.
- **Wavelength** — The distance a wave travels in a single cycle - or- the distance between the same points on two consecutive waves.
- **Work Area** — The area of premises cabling where users are located. The area from the telecommunications outlet to the workstation.
- **Workstation** — A computer, printer, fax, etc. that performs local processing and accesses network services.

ACRONYMS and ABBREVATIONS

- **ACR** — Attenuation to Crosstalk Ratio
- **ANSI** — American National Standards Institute
- **BD** — Building Distributor
- **BEF** — Building Entrance Facilities
- **BOM** — Bill of Materials
- **CDDI** — Copper Distributed Data Interface
- **CENELEC** — European Committee for electro-techical standardiztion
- **CM** — Communications general purpose cables
- **CMP** — Communications Plenum cable
- **CMR** — Communications Riser cable
- **CAN** — Centralized Network Administration/architecture
- **CO** — Central Office
- **CP** — Consolidation Point
- **dB** — Decibel
- **EIA** — Electronic Industries Association
- **EMC** — Electromagnetic compatibility
- **EMI** — Electromagnetic Interference
- **EF** — Entrance Facility
- **ER** — Equipment Room
- **FD** — Floor Distributor
- **FDDI** — Fiber Distributed Data Interface
- **FTP** — Foil Twisted Pair
- **FttH** — Fiber to the Home
- **Gbps** — Gigabytes per second
- **Ghz** — Gigahertz
- **IC** — Intermediate cross-connect
- **IDC** — Insulation Displacement contact

- **IEC** — International electrotechnical Commission
- **IEEE** — The Institute of Electrical and Electronics Engineers
- **ISO** — International Organization for Standardization
- **LASER** — Light amplification by the Stimulated Emission of Radiation
- **LSZH** — Low Smoke Zero Halogen
- **Mbps** — Megabits per seconds
- **MC** — Main Cross-connect
- **MUO** — Multi-User Outlet
- **MUTO** — Multi-User telecommunications Outlet
- **NEXT** — Near End Crosstalk
- **OEM** — Original equipment Manufacture
- **OFN** — Non-conductive optical fiber general purpose cable
- **OFNP** — Non-conductive Optical Fiber Plenum cable
- **OFNR** — Non-conductive Optical Fiber Riser cable
- **OTDR** — Optical Time Domain reflectometer
- **PVC** — Polyvinyl chloride
- **STP** — Shielded Twisted-Pair
- **TC** — Telecommunication Closet
- **TDM** — Time-Division Multiplexing
- **TIA** — Telecommunication industry Association
- **TO** — Telecommunication Outlet
- **TP** — Transition Point
- **TP-PMD** — Twisted Pair - Physical Media Dependent
- **TSB** — Telecommunications System Bulletin
- **UL** — Underwriters Laboratories
- **UTP** — Unshielded Twisted-Pair
- **X** — Cross-connect

Notes:

ASTON, LONDON, UNITED KINGDOM