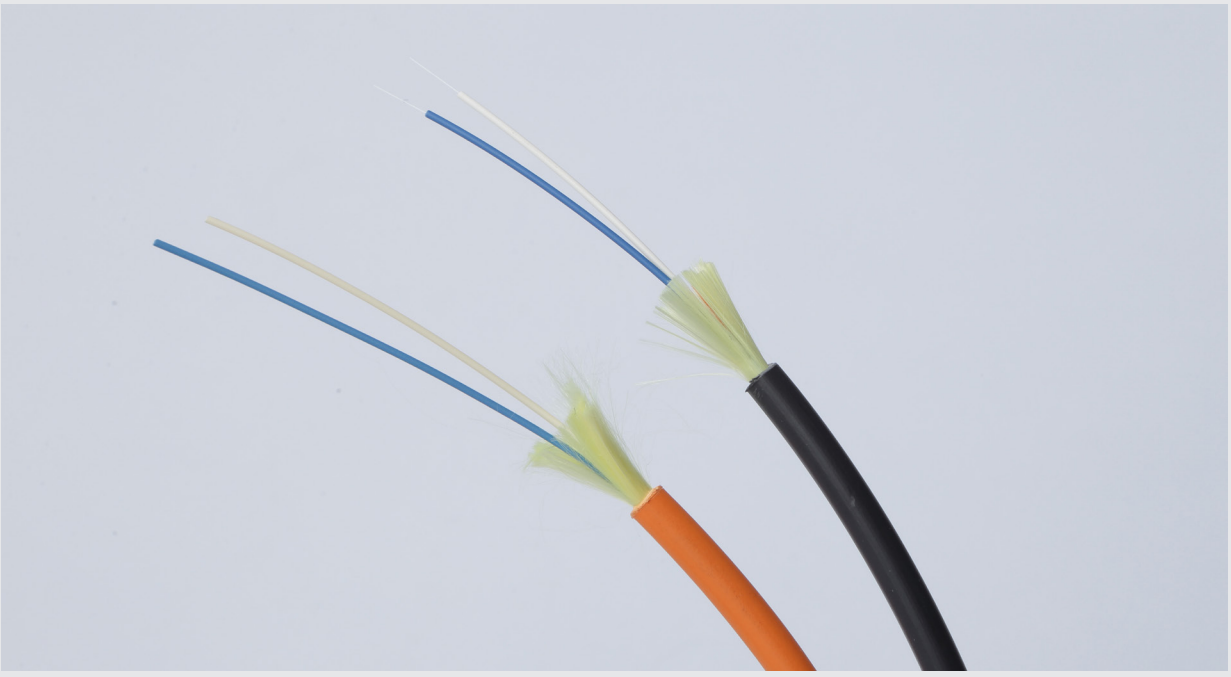
WEST PENN WIRE
AV, SECURITY & NETWORKING SOLUTIONS
Since 1971

Product Guide

# Understanding Fiber Optic

## Advantages, System Design and Fiber Cable Selection



## Fiber Optic Systems

Fiber Optics have many advantages over copper systems and provide an easier installation.
A Fiber Optic cables and system can handle Audio, Video and Data signals individually or simultaneously.

## Fiber Optic Standards

The EIA/TIA 568 standard for premises cabling is used by most manufacturers and users of premises cabling systems in the US. Internationally, IEC/ISO 11801 is very similar, although there are differences in various countries. TIA-568 has been under continual revision since its inception. The current version is "568 C." It includes some major changes from earlier versions for fiber optics.

Work is already starting on TIA 568.D in late 2012. Several new issues are being addressed including passive optical LANs based on FTTH PONs and the high component losses allowed, especially connector loss at 0.75dB, but the biggest problem with TIA 568.C, organization, is also promised to be addressed. Since the work on various issues addressed in the C revision were completed at different times, the document was released in parts as they were completed. As a result, the C version has many issues with changes in one document affecting others, requiring amendments and cross references that are very confusing. There is widespread knowledge of this problem and it has been said that it will be addressed, hopefully by waiting to release all documents together.

Since its beginnings in early 1990s, additions and changes To TIA 568 included:

1. Add 50/125 micron fiber (OM2, OM3, OM4) as an alternative fiber type and specifies performance.
2. Allows alternate connectors to the SC, esp. small form factor connectors.
3. Adds performance standards for all connectors.
4. Includes bend radius specifications for cables.
5. Specifies requirements for connecting hardware.

| Fiber Type | Wavelength (nm) | Max Attenuation dB/KM | Bandwidth Mhz/KM |
|---|---|---|---|
| 50/125 (OM2, OM3, OM4) | 850 | 3.5 | 500 OM2- 2000 OM3 - 3500 OM4 |
| | 1300 | 1.5 | 500 |
| 62.5/125 (OM1) | 850 | 3.5 | 160 |
| | 1300 | 1.5 | 500 |
| Singlemode (OS1, OS2) (Premises) | 1310 | 1.0 | NA |
| | 1550 | 1.0 | NA |
| Singlemode (OS1, OS2) (OSP | 1310 | 0.5 | NA |
| | 1550 | 0.5 | NA |

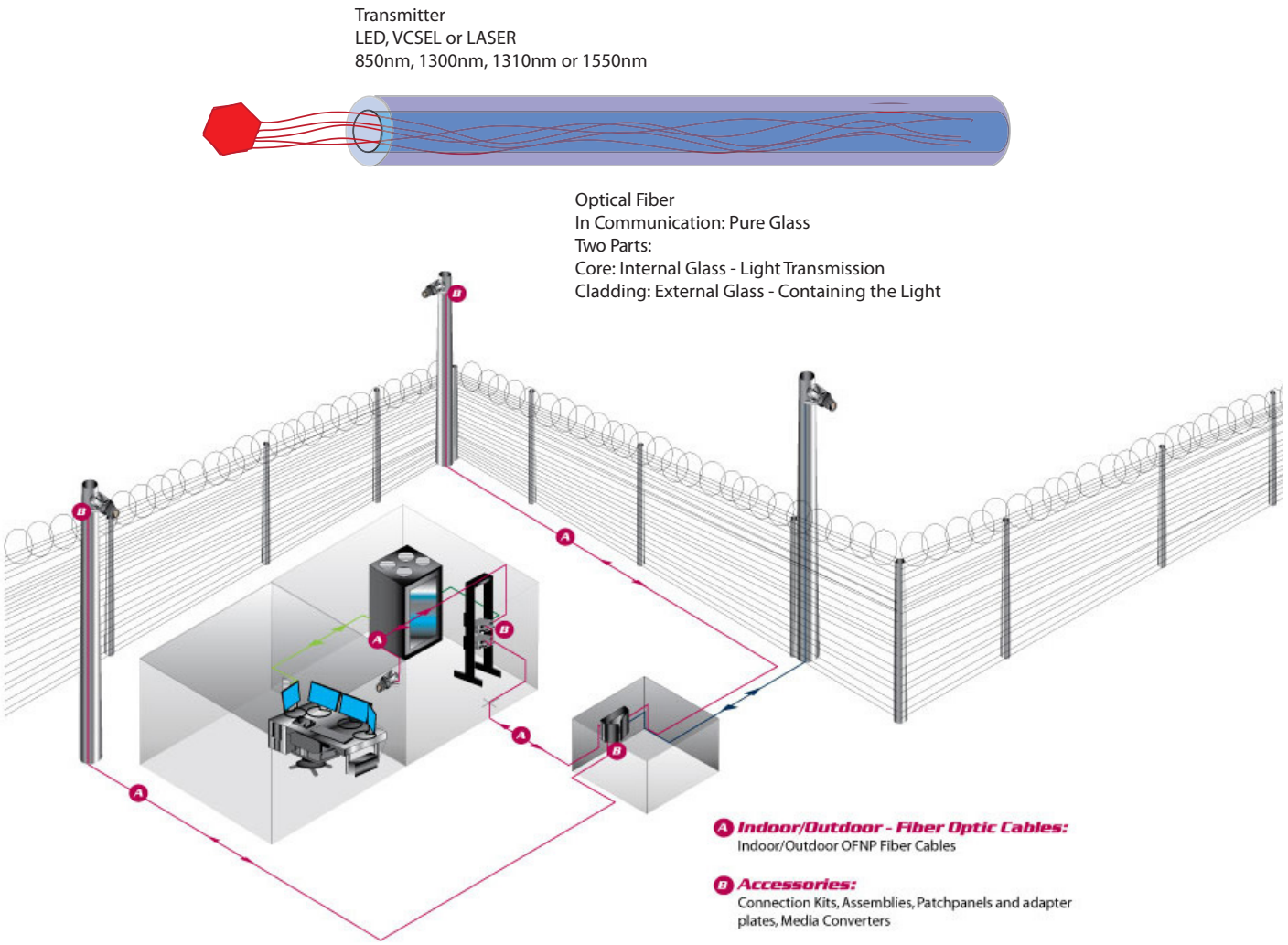
*TABLE OF CONTENTS*

*Fiber Opitc Communication* ..... *4*
*Fiber Opitc Installation Guidlines* ..... *5*
*Fiber Opitc System Advantages* ..... *6*
*Optical Fiber Design* ..... *7*
*Fiber Optic Modes* ..... *8*
*Operating Wavelengths* ..... *9*
*Fiber Optic Cable Design* ..... *10-11*
*Fiber Optic Connectors & Kits* ..... *12-13*
*Fiber Optic Assemblies & Pigtails* ..... *14*
*Fiber Optic Enclosures and Plates* ..... *15*

## *Fiber Optic Communication*

Fiber optic links are the communications pathways between devices. A link is bidirectional, usually with signals transmitted in two directions on two different fibers. Using two fibers is usually the cheapest way, since the optical fiber itself is now about as cheap as kite string and fishing line! (FTTx PON systems use one fiber in two directions so it can use one PON coupler transmitting and receiving for lower system cost.) The link connects electronic signals from two devices that need to communicate, just like a copper cable. The link has a transmitter that converts electronic signals from communications equipment to optics and a receiver that converts the signal back to electronics at the other end.

Fiber optic transmitters use LEDs or semiconductor lasers to convert electronic signals to optical signals. LEDs, similar to those used everywhere for indicators, except transmitting in the infrared region beyond human perception are used for slower links, up to about 100 million bits per second (Mb/s), for example fast Ethernet LANs. Faster links use infrared semiconductor lasers because they have more bandwidth, up to tens of billions of bits per second (Gb/s). Lasers have more power, so they can also go longer lengths, as in outside plant applications such as long distance telecom or CATV.
As noted, transmitters use infrared light. Infrared light has lower loss in the fiber, allowing longer cable runs. Typically multimode glass fibers use light at 850 nm - 1300nm, referred to as "short wavelength" and singlemode fiber operates at 1310, or 1550 nm, called "long wavelength."



## *Fiber Optic Installation General Guidelines*

Conduct a Site Survey
The purpose of a site survey is to recognize circumstances or locations in need of special attention. For example, physical hazards such as high temperatures or operating machinery should be noted and the cable route planned accordingly. If the fiber optic cable has metallic components, it should be kept clear of power cables. Additionally, building code regulations, like the National Electric Code (NEC)** must be considered. If there are questions regarding local building codes or regulations, they should be addressed to the authority having jurisdiction, such as the fire marshal or city building inspector.

Develop a Cable Pulling Plan
A cable pulling plan should communicate the considerations noted during the site survey to the installation team. This includes the logistics of cable let-off/pulling equipment, the location of intermediate access points, splice locations and the specific responsibilities of each member of the installation team.

Follow Proper Procedures
Because fibers are sensitive to moisture, the cable end should be covered with an end cap, heavy tape or equivalent at all times. The let-off reel must never be left unattended during a pull because excess or difficult pulls, center-pull or backfeeding techniques may be employed.

Do Not Exceed Cable Minimum Bend Radius
Every Belden® cable has an installation minimum bend radius value. During cable placement it is important that the cable not be bent to a smaller radius. After the cable has been installed, and the pulling tension removed, the cable may be bent to a radius no smaller than the long term application bend radius specification.

The minimum bend radii values still apply if the cable is bent more than 90 degrees. It is permissible for fiber optic cable to be wrapped or coiled as long as the minimum bend radius constraints are not violated.

Do Not Exceed Cable Maximum Recommended Load
While fiber optic cables are typically stronger than copper cables, it is still important that the cable maximum pulling tension not be exceeded during any phase of cable installation. In general, most cables designed for outdoor use have a strength rating of at least 600 lbs. Belden fiber optic cables also have a maximum recommended load value for long term application. After cable placement is complete the residual tension on the cable should be less than this value. For vertical installations, it is recommended that the cable be clamped at frequent intervals to prevent the cable weight from exceeding the maximum recommended long term load. The clamping intervals should be sufficient to prevent cable movement as well as to provide weight support.

Leave Extra Cable
A common practice is to leave extra cable at the beginning and at the end of the cable run. Also, extra cable should be placed at strategic points such as junction boxes, splice cases and cable vaults. Extra cable is useful should cable repair or mid-span entry be required.

Document the Installation
Good record keeping is essential. This will help to ensure that the cable plant is installed correctly and that future trouble shooting and upgrading will be simplified. All Belden fiber optic cables have a unique lot number shown on the shipping spool. It is important that this number be recorded. Cable pre- and post- installation test data should be recorded in an orderly and logical fashion.

## *Fiber Optics: Fiber Cables*

### *Fiber Optics*

Fiber Optic use started in the early 1970's. Corning Glass Works developed a fiber optic cable with a loss of 20dB/km, today many fiber optics have extremely low loss- .5dB/km for Single-Mode. During the 1980's telephone companies began to deploy fiber throughout their networks. By implementing a fiber network, telecom companies could future proof their systems backbone.

Fiber Optics is used in many applications such as: Telecommunication, High bandwidth Data, Video signaling, long distant CCTV, Communication between fire alarm panels, and much more.

### *Fiber Optics- Advantages*

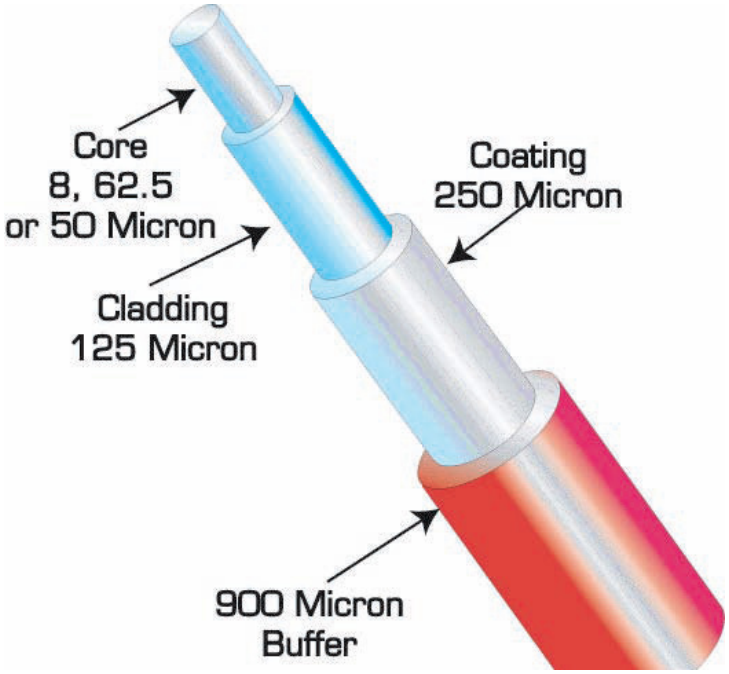
- Maintaining signal integrity in high EMI/RFI applications
- Long distant installations
- Security Issues
- Future Proofng
- Greater amount of information carrying capacity (bandwidth)
- Easy installation - light weight, simplifed termination

Fiber Optics- Disadvantages

- Expensive overall installation cost
- Can not carry electrical power

## *Fiber Optics: Fiber Cables*
## *Optical Fibers*

A glass optical Fiber is made of three components:




1. Core - Light Carrier of the optical fiber. It is made from a doped glass(Silica). The silica material of the core allows the light signals to be carried efficiently and effectively across the fiber.
  Sizes of the Core:
    - 8µm (8.3 or 9µm) Single Mode
    - 50µm - MulitMode
    - 62.5µm - MultiMode

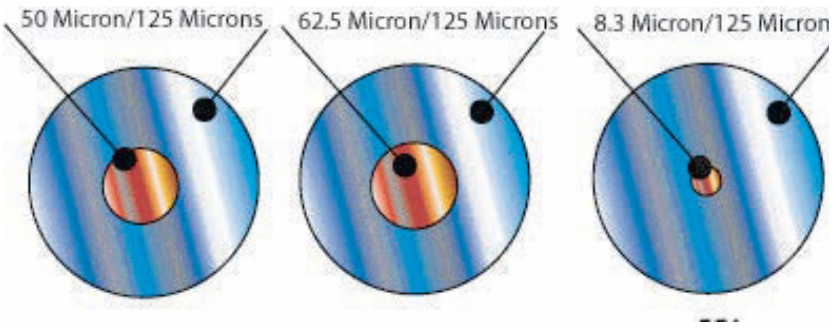
    µm - microns - 1000microns =1mm

2. Cladding - Surrounds the Cladding, it is also made from a different type of silica. The glass of the cladding is made to contain the light within the core.
  Sizes of the Cladding:
    - 125µm

3. Plastic Coating - Surrounds the Cladding and acts as a protector for the glass. The coating is implemented to protect the glass while it is shipped to the Fiber Optic Cable Manufacturers. The Coating is normally clear (color), but for all Outdoor cables the coating is color coded to help identify the individual fibers. The coating has to be removed to connect the fiber to a connector or splice.
  Sizes of the Coating:
    - 250µm

Single-Mode Fibers - 8/125µm
Single mode or path of light from a laser source.
Long Haul installations.

Multi-Mode Fibers- 50/125µm or 62.5/125µm
Multiple modes or paths of light from the LED source.
Shorter Installation




Both Single-Mode and MultiMode will handle Audio,Video, and Data simultaneously.

## *Fiber Optics: Fiber Cables*
## *Optical Fibers*

### *Single-Mode Fiber Cables*

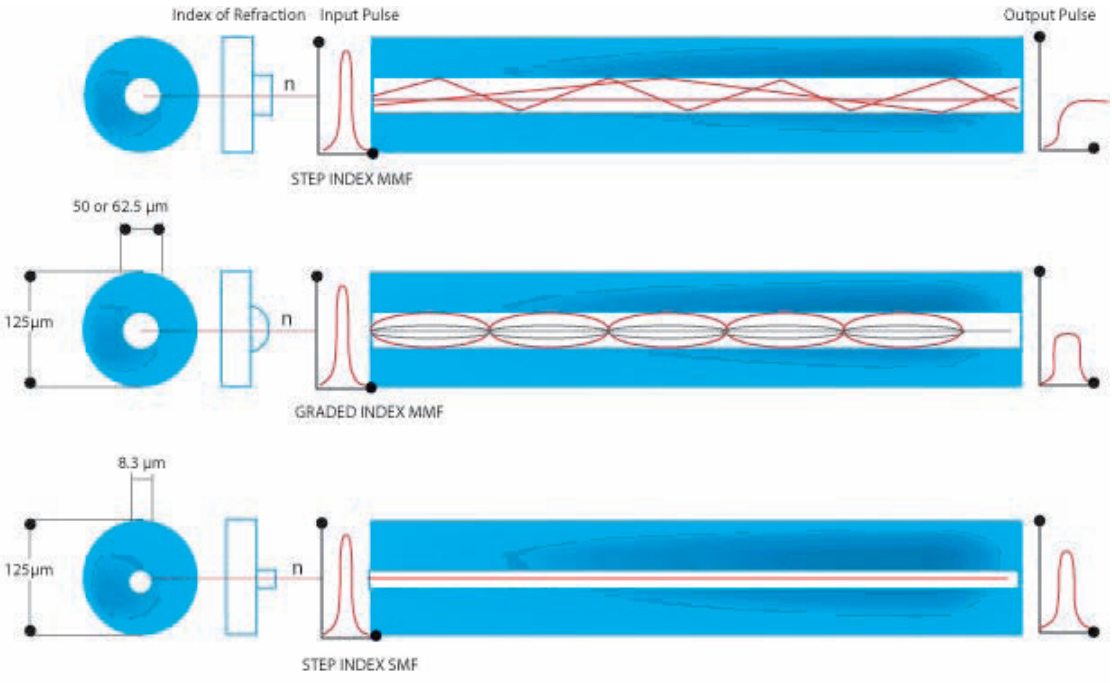
The Single-Mode core is 10th the size of a human hair. This fiber type uses a LASER to transmit the signals. The fiber is designed as a step index, meaning that the core has only one refractive index to carry the light signal. There is some dispersion over long distances. Chromatic dispersion is caused by the intense LASER filtering into the cladding causing pulse overlap and distorted signals.

### *Multi-Mode Fiber Cables*

The Multi-Mode core is larger and can gather more light. This fiber uses an LED or VCSEL to transmit the light signals. A Multi-Mode core has a broader aperture over SingleMode fibers. A Multi-Mode fiber also has dispersions over longer distances. This dispersion is called Modal dispersion. A Mulit-mode core is set up with multiple rings with different refractive index characteristics. These rings allow the light to be traveled over longer distances without loss of continuity of light, but these signals can become compromised if the distance is increased too much.

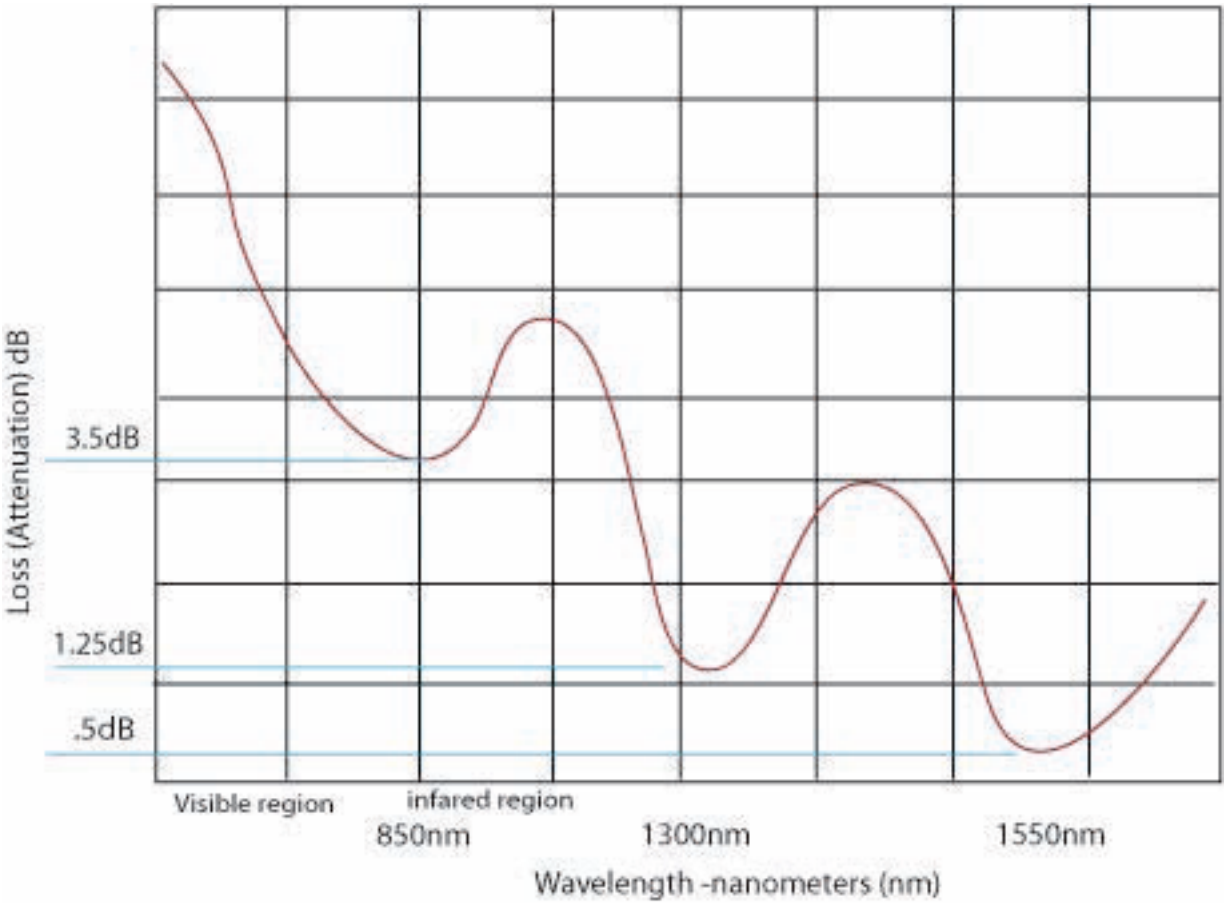
Refractive Index:

| | |
|---|---|
| Air = | 1 Meaning Light travels 186,000miles/second |
| Normal Glass = | 1.5 |
| Cladding = | 1.46 Doped to contain the light |
| Core = | 1.48 SingleMode - 1.47 to 1.48 diferent layers Mulit-Mode |



### *Operating Wavelengths:*

There are Primarily three windows of opportunity to transmit light effectively and effectively through an optical fiber. These specific wavelenths are in the infared region.
Visible light starts with Blue - approx. 400nm to Red 700nm. nm=nanometers.




850nm - 3-4dB of loss/km. The least expensive transmitting device. Found on lower speed, shorter distant applications such as CCTV, Fire Alarm communication devices. ( LED)
Used with Mulit-Mode fibers

1300nm (1310nm) - 1-1.5dB of loss/km. The second window of opportunity. Used for higher speed, longer distant Multi-mode applications. 1310nm is used for Single-Mode shorter distant applications. LED or VCSEL.

1550nm - .5dB of loss/km. This is the second window of opportunity for SingleMode transmission. This wavelength is used for extremely long distant high bandwidth applications.

## *Fiber Optic Cable Types*

### *Indoor Fiber Optic Cables*

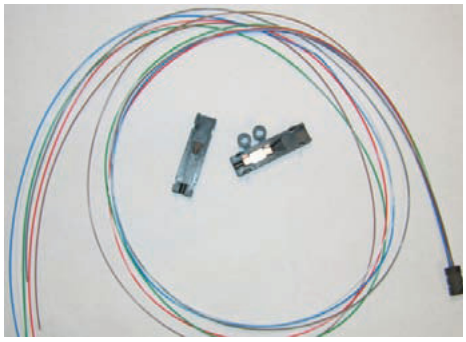
Indoor fiber optic cables are designed to either limit smoke vertically (Riser), or limit smoke and flame vertically and horizontally (Plenum). The cables are constructed with 900µm bufer over the 250µm coating to help facilitate a connector.

### *Indoor/Outdoor Fiber Optic Cables*

Indoor/Outdoor fiber optic cables are designed together limit smoke vertically (Riser), or limit smoke and flame vertically and horizontally (Plenum). Te cables are constructed with 900µm bufer to help facilitate a connector. They also provide water-blocking material.

### *Outdoor Fiber Optic Cables*

Outdoor fiber cables are designed to withstand the environmental elements. They are constructed with 250µm bufers that ride loosely within a tube that is flled with waterblocking gel. The Jacket is PE. A PE jacket can not be brought indoors because of the flame and smoke it produces when flame is set to it. A outdoor cable has a limit of 50ft. entering a building to be terminated or spliced to a Indoor rated cable. Direct Burial Outdoor cables include a armored sheath for direct burial protection. A connector can not be placed directly on an outdoor fiber because of the 250µm bufer. A fan-out kit, or splice with a pre-connected pigtail must be used.



Outdoor Cables require for the Bufer/Coating of 250µm to be enlarged to 900µm to put a connector on the cable will require a Fan-Out Kit - See FI-1100

Individual Fiber Color Code:

| | |
|---|---|
| 1. Blue | 2. Orange |
| 3. Green | 4. Brown |
| 5. Slate | 6. White |
| 7. Red | 8. Black |
| 9. Yellow | 10. Violet |
| 11. Rose | 12. Aqua |

## *Fiber Optic Cable Types*

### *West Penn Wire Bulk Fiber Optic Cables*

West Penn Wire offers Indoor/Outdoor Plenum Rated cables to reduce the amount of inventory and SKU Numbers.

Part Number Structure:
WP9X043T - The X in the PN has to be with B, C or W to get to the appropriate OM Size ( Fiber Optic Size).

| Fiber Type | Code Replace (X) | Wavelength (nm) | Max Attenuation dB/KM | Bandwidth Mhz/ KM |
|---|---|---|---|---|
| 62.5/125 OM1 | B | 850 | 3.5 | 200 |
| | | 1300 | 1.25 | 500 |
| 50/125 OM3 | C | 850 | 3.5 | 1500 |
| | | 1300 | 1.25 | 500 |
| 8/125 SingleMode | W | 1310 | .8 | NA |
| | | 1550 | .5 | NA |

West Penn Wire Fiber Optic Cables

| Environment | 2 Fiber | 6 Fiber | 12 Fiber | 24 Fiber |
|---|---|---|---|---|
| Indoor/Outdoor Plenum OFNP | WP9X043T | WP9X045T | WP9X048T | WP9X611T |
| Outdoor OSP | WP9X150 | WP9X152 | WP9X155 | |
| Outdoor Direct Burial | | WP9X172 | WP9X175 | |

## *Myth Busting*

Installers are worried about Pulling, and terminating fiber optics. DO NOT WORRY!!

Pull Tension:

| | |
|---|---|
| 6 Fiber Optic Cable: | 300lbf. |
| Cat 5E | 25lbf. |
| RG59/U | 45lbf. |

Optical Fiber have the same tensile stregth of a piece of steel the same size.
Bend Radius:

| | |
|---|---|
| Fiber Optic | 10 x Cable OD |
| Category Cable | 4 x Cable OD |
| Coaxial Cable | 10 x Cable OD |
| Audio Cable | 10 x Cable OD |

Fiber Optic cables have the same bend radius of Coaxial Cables.

| | |
|---|---|
| Fiber Optic Termination Time: | 1 Min. (Brilliance Field Kit) |
| Category 5E Plug | 2 Min. |
| Crimp BNC | 3 Min. |

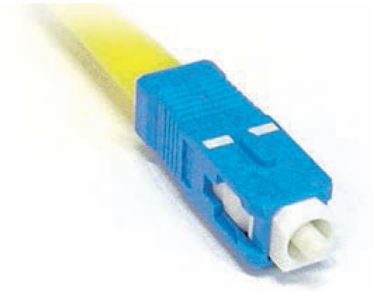
### *Fiber Optic Connector and Splice Types*

90% of the Market consists of ST, SC and LC Connector Types

### *ST - Straight Tip*

- Used mostly in Security Applications (CCTV) because of the design is similar to a BNC Coaxial connector
- Keyed locking bayonet style
- Loss- .5-1dB per connection

Offered in the BRILLIANCE Kit.



### *SC - Square or Subscriber*

- Used mostly in Data Applications because of the design is similar to a RJ45 modular plug.
- Push/Pull with foating ferrule - no disconnect
- Loss- .5-1dB per connection

Offered in the Brilliance Kit.

### *LC - Lucent or Little*

- Used mostly in Data Applications because of the design is similar to a RJ45 modular plug. SFF - Small Form Factor connector
- Push/Pull with clipping hood
- Loss- .5-1dB per connection

Offered in the Brilliance Kit

### *Mechanical Splice*

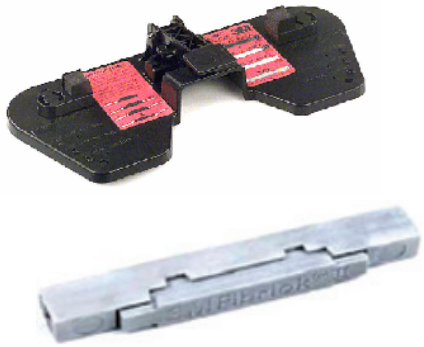
Mechanical Splices are used in Low-Voltage Shorter Distant fiber optic applications. The mechanical splice has a loss of approx. 1 - 1.5 dB/ Splice.

A mechanical splice can be used for a transition from an outdoor cable to an indoor cable, or for any fiber cable that is damaged.

Once a Splice is terminated, a splice tray may be used to protect each splice.

Other Splices such as Fusion Splice offer lower loss (.05 to 1dB) depending the the type of Fusion Splicer.

| Catalog PN | Description |
|---|---|
| 3M-2501 | 3M Mechanical Splice Tool |
| 3M-2529 | 3M Mechanical Splice |
| SPL-MSPL6 | Metal Splice Tray 6 Fibers |
| SPL-MSPL12 | Metal Splice Tray 12 Fibers |
| SPL-WS12A | Plastic Splice Tray 12 Fibers |



## *Fiber Optic Connector Installation Kits*

Brilliance Field Kit - FI-4270


The Brilliance Field Kit will connect SC, ST and LC Connector Types.

The Kit is a unique design that incorporates factor polished fiber stub in a splice mechanism which provides a fast, secure and reliable termination of fiber optic cables.

The Brilliance Connectors offer premium quality ceramic ferrule. The patent-pending design offers the quickest termination in the industry (less than 30seconds). The Brilliance connectors can be used up to 5-6 times.

The Optimax installation consists of:
1. Cleave the Fiber
2. Open connector cavity - activation tab
3. Insert the fiber into the connector
4. Release activation tab on the connector body.

Specifications: Brilliance Connector
Interconnection compatibility LC/SC/ST

| | |
|---|---|
| Field Assembly Time 900µm | 30 sec. with Setup<br>1 Min. |
| Insertion Loss dB | .3dB |
| Storage Temp. | -40˚F - 140˚F |
| Operating Temp. | -40˚F -167˚F |
| Tensile Strength 900µm | 1.12lbs. |

Connectors are reusable up to 6 times.

| Catalog PN | Description |
|---|---|
| FI-4270 | Fiber Optic Brilliance Field Kit |
| LC Connectors | |
| FI-4240 | LC - 900µm, Multimode Beige Connector, 62.5um |
| FI-4241 | LC - 900µm, Multimode Black Connector, 50um |
| FI-4242 | LC - 900µm, Multimode Aqua Connector, 50um |
| FI-4243 | LC - 900µm, Single-mode Blue Connector, 8um |
| SC Connectors | |
| FI-4244 | SC - 900µm, Multimode Beige Connector, 62.5um |
| FI-4245 | SC - 900µm, Multimode Black Connector, 50um |
| FI-4246 | SC - 900µm, Multimode Aqua Connector, 50um |
| FI-4247 | SC - 900µm, Single-mode Blue Connector, 8um |
| ST Connectors | |
| FI-4248 | ST - 900µm, Multimode Beige Connector, 62.5um |
| FI-4249 | ST - 900µm, Multimode Black Connector, 50um |
| FI-4250 | ST - 900µm, Multimode Aqua Connector, 50um |
| FI-4251 | ST- 900µm, Single-mode Blue Connector, 8um |

## *Fiber Optic Assemblies and Pigtails*

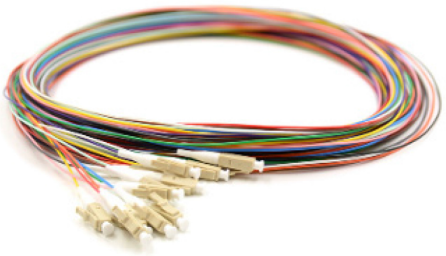
Types: ST, SC, LC
Glass Types: SingleMode and Multi-Mode
Simplex or Duplex Designs

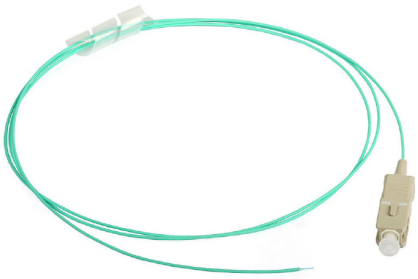
| Catalog PN | Description |
|---|---|
| ST Assemblies | |
| FI-X001-xx | Simplex ST to ST<br>Replace xx with:3,6,10,15,30 |
| FI-X002-xx | Duplex ST to ST<br>Replace xx with:3,6,10,15,30 |
| SC Assemblies | |
| FI-X001-xxSC | Simplex SC to SC<br>Replace xx with:3,6,10,15,30 |
| FI-X002-xxSC | Duplex SC to SC<br>Replace xx with:3,6,10,15,30 |
| LC Assemblies | |
| FI-X001-xxLC | Simplex LC to LC<br>Replace xx with:3,6,10,15,30 |
| FI-X002-xxLC | Duplex LC to LC<br>Replace xx with:3,6,10,15,30 |
| SC to LC Assemblies | |
| FI-X001-xxLC/SC | Simplex LC to SC<br>Replace xx with:3,6,10,15,30 |
| FI-X002-xxLC/SC | Duplex LC to SC<br>Replace xx with:3,6,10,15,30 |

REPLACE (X)
2 - 62.5/125 OM1
3 - 8/125 SINGLEMODE
4 - 50/125 OM3

## FIBER OPTIC PIGTAILS

| Catalog PN | Description |
|---|---|
| FP12-51-9-003M | LC 12 FIBER OM3 3M |
| FP12-6-2-003M | ST 12 FIBER OM1 3M |
| FP12-9-2-003M | ST 12 FIBER SINGLEMODE 3M |
| FP12-9-9-003M | LC 12 FIBER SINGLEMODE 3M |
| FP1-51-4-003M | SC SINGLE OM3 3M |
| FP1-51-9-003M | LC SINGLE OM3 3M |
| FP1-6-4-003M | SC SINGLE OM1 3M |
| FP1-9-4-003M | SC SINGLE SINGLEMODE 3M |
| FP1-9-9-003M | LC SINGLE SINGLEMODE 3M |
| FP6-51-4-003M | SC 6 FIBER OM3 3M |
| FP6-51-9-003M | LC 6 FIBER OM3 3M |
| FP6-6-4003M | SC 6 FIBER OM1 3M |
| FP6-9-4-003M | SC 6 FIBER SINGLEMODE 3M |
| FP6-9-9-003M | LC 6 FIBER SINGLEMODE 3M |





## *Fiber Optic Enclosures, Panels, and Adapter Plates*

### *Rack Mount Panels*

| Catalog PN | Description |
|---|---|
| PP-W1U1 | 1 RU Rack Mount Holds 3 plates |
| PP-W2U1 | 2 RU Rack Mount Holds 6 plates |
| PP-W4U1 | 4 RU Rack Mount Holds 12 plates |

### *Wall Mount Panels*

| Catalog PN | Description |
|---|---|
| PP-WM1S | 1 Adapter Plate - Wall Mount 7”x6”x1.5” |
| PP-WM2S | 2 Adapter Plate - Wallmount 15.625”x13”x2.125” |
| PP-WM4S | 4 Adapter Plate - Wallmount 15.625”x15”x3.5” |

### *Adapter Plates*

| Catalog PN | Description |
|---|---|
| AS-WC06M | SC Simplex Multimode - 6 Fiber |
| AS-WC06G | SC Simplex 10G Multimode - 6 Fiber |
| AS-WC06S | SC Simplex SingleMode - 6 Fiber |
| AS-WC12M | SC Simplex Multimode - 12 Fiber |
| AS-WC12G | SC Simplex 10G Multimode - 12 Fiber |
| AS-WC12S | SC Simplex SingleMode - 12 Fiber |
| AS-WT06M | ST Simplex Multimode - 6 Fiber |
| AS-WT06S | ST Simplex SingleMode - 6 Fiber |
| AS-WT12M | ST Simplex Multimode - 12 Fiber |
| AS-WT12S | ST Simplex SingleMode - 12 Fiber |
| AS-WL12M | LC Simplex Multimode - 12 Fiber |
| AS-WL12G | LC Simplex 10G Multimode - 12 Fiber |
| AS-WL12S | LC Simplex SingleMode - 12 Fiber |
| AS-WC24M | LC Simplex Multimode - 24 Fiber |
| AS-WC24G | LC Simplex 10G Multimode - 24 Fiber |
| AS-WC24S | LC Simplex SingleMode - 24 Fiber |

### *Cassette Plates*

| Catalog PN | Description |
|---|---|
| DM-1MLCB24 | 24 LC SINGLEMODE |
| DM-1MSCB12 | 12 SC SINGLEMODE |
| DM-4MLCC12 | 12 LC OM3 |
| DM-4MLCC24 | 24 LC OM3 |
| DM-4MSCC12 | 12 SC OM3 |

WEST PENN WIRE
AV, SECURITY & NETWORKING SOLUTIONS
Since 1971

2833 West Chestnut Street
Washington, PA 15301
Toll Free: 800-245-4964
sales@westpennwire.com