Fiber Optics

Cable Construction
Connectors
Splice
Assemblies
Testing
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 Proofing
• Greater amount of information carrying capacity (bandwidth)
• Easy installation - light weight, simplified 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 - MultiMode
   • 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 Optic Dispersion:

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:

<table>
<thead>
<tr>
<th>Material</th>
<th>Refractive Index</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1</td>
<td>Meaning Light travels 186,000 miles/second</td>
</tr>
<tr>
<td>Normal Glass</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Cladding</td>
<td>1.46</td>
<td>Doped to contain the light</td>
</tr>
<tr>
<td>Core</td>
<td>1.48</td>
<td>SingleMode - 1.47 to 1.48 different layers Mulit-Mode</td>
</tr>
</tbody>
</table>
Operating Wavelengths:

There are primarily three windows of opportunity to transmit light effectively and effectively through an optical fiber. These specific wavelengths are in the infrared 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 Multimode 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 Single Mode 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 buffer over the 250µm coating to help facilitate a connector.

**Indoor/Outdoor Fiber Optic Cables**
Indoor/Outdoor fiber optic cables are designed together to limit smoke vertically (Riser), or limit smoke and flame vertically and horizontally (Plenum). The cables are constructed with 900µm buffer 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 buffers that ride loosely within a tube that is filled with water-blocking gel. The Jacket is PE. A PE jacket cannot be brought indoors because of the flame and smoke it produces when flame is set to it. An outdoor cable has a limit of 50ft. entering a building to be terminated or spliced to an Indoor rated cable. Direct Burial Outdoor cables include a armored sheath for direct burial protection. A connector cannot be placed directly on an outdoor fiber because of the 250µm buffer. A fan-out kit, or splice with a pre-connected pigtail must be used.

**Fan out Kits:**
Fl-1100 - 6 Fiber Kit
**Fiber Optic Connector 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 OPTIMAX Connection Kit SUMMER 2012 BRILLIANCE

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

Offered in the OPTIMAX Connection Kit and 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 OPTIMAX Connection Kit and Brilliance Kit

OTHER CONNECTORS:
FC - Floating - SFF Connector
MTRJ - Mechanical Transfer Registered Jack - SFF Connector

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**Fiber Optic Connector Installation Kits**

*Optimax Kit - FI-3635*

The Optimax Kit will connect ST, SC, 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 Optimax Connectors offer premium quality ceramic ferrule with Physical Contact (PC) polish for Multi-Mode and Super Physical Contact (SPC) polish for Single-Mode

The Optimax installation consists of:
1. Cleave the Fiber
2. Insert the fiber into the connector
3. Pull the release Pin to activate the mechanical splice
4. Crimp the connector

**Specifications: OPTIMAX**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interconnection compatibility</td>
<td>LC/SC/ST</td>
</tr>
<tr>
<td>Field Assembly Time 900μm</td>
<td>1 Min.</td>
</tr>
<tr>
<td>Insertion Loss dB</td>
<td>.3dB</td>
</tr>
<tr>
<td>Storage Temp.</td>
<td>-40°F - 149°F</td>
</tr>
<tr>
<td>Operating Temp.</td>
<td>32°F - 145°F</td>
</tr>
<tr>
<td>Tensile Strength 900μm</td>
<td>3lbs.</td>
</tr>
</tbody>
</table>

Connectors are not reusable after pin has been released.

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**Optimax Tools and Accessories**

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI-3635</td>
<td>OPTIMAX Complete Kit</td>
</tr>
<tr>
<td>FI-3634</td>
<td>Installation Tool- ST</td>
</tr>
<tr>
<td>FI-3641</td>
<td>ST Compatible Crimp Tool</td>
</tr>
<tr>
<td>FI-8829</td>
<td>Fiber Cleaver</td>
</tr>
<tr>
<td>FI-8832</td>
<td>Microscope</td>
</tr>
<tr>
<td>FI-8835</td>
<td>ST 900um Connector - 62.5/125um</td>
</tr>
<tr>
<td>FI-8837</td>
<td>ST Universal connector- 62.5/125um</td>
</tr>
<tr>
<td>FI-1075</td>
<td>ST 900um Connector - 50/125um</td>
</tr>
<tr>
<td>FI-1074</td>
<td>ST Universal connector- 50/125um</td>
</tr>
<tr>
<td>FI-0028</td>
<td>SC Universal connector- 62.5/125um</td>
</tr>
<tr>
<td>FI-0029</td>
<td>SC 900um connector- 62.5/125um</td>
</tr>
<tr>
<td>FI-1077</td>
<td>SC 900um connector- 50/125um</td>
</tr>
<tr>
<td>FI-1076</td>
<td>SC Universal connector- 50/125um</td>
</tr>
<tr>
<td>FI-1791</td>
<td>ST Single-Mode 900um connector</td>
</tr>
<tr>
<td>FI-1792</td>
<td>SC Single-Mode 900um connector</td>
</tr>
<tr>
<td>FI-1793</td>
<td>ST- Accessory Kit For Jacketed Single-Mode</td>
</tr>
<tr>
<td>FI-1794</td>
<td>SC- Accessory Kit For Jacketed Single-Mode</td>
</tr>
<tr>
<td>FI-1981</td>
<td>LC 900um connector- 62.5/125um</td>
</tr>
<tr>
<td>FI-1982</td>
<td>LC 900um connector- 50/125um</td>
</tr>
<tr>
<td>FI-1983</td>
<td>LC 900um connector- Single-Mode</td>
</tr>
<tr>
<td>FI-1984</td>
<td>LC- Accessory Kit For Jacketed Single-Mode Fiber</td>
</tr>
</tbody>
</table>

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*CABLE WITH CONFIDENCE*  
*WEST PENN WIRE*
1. Assemble Connector boot to boot body. Slide assembled boot onto cable.

2. Strip 40mm (1.25”) of jacket and coating. Strip in 5mm (.250”) increments.

3. Mark Fiber 9mm from the bare glass. Clean the fiber.

4. Load the connector body into the installation tool with release pin up. Keep dust cap boots on.

5. Cleave the fiber at 7mm. Using tweezers, discard waste fiber into waste container.

6. Remove dust cap. Carefully insert bare fiber into the stem of the connector until you feel fibers making contact. Pen mark should be at the edge of the stem.

7. Depress the installation tool plunger. Ensure it hooks the release wire. Then release Pin.

8. Crimp Using .068” Crimp Die

9. Slide boot onto connector body.
Fiber Optic Connector Installation Kits
Brilliance Field Kit - FI-4270

The Brilliance Field Kit will connect SC, 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 30 seconds). 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
Field Assembly Time 900µm 30 sec.
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.
Brilliance LC Installation

1. Strip fiber (24” or less length)
2. Mark Ferrule Zone
3. Close Ferrule
4. Close Ferrule at 20 psi
5. Assemble Ferrule Tab
6. Pull Ferrule Tab
7. Insert Fiber into Ferrule
8. Insert Ferrule Tab
9. Pull Ferrule Tab
10. Insert Ferrule Tab

FiberExpress Brilliance®

1. 2. Slide Activator Tab to the Open Position
2. 3. Insert Fiber into Connector
3. 4. Create box and Slide Activator Tab to the Closed Position

Installation Card

- Push connector activator tab towards the front using the small line indicator as a seating reference.
- If using a VFL in the connection process, a red light will appear in the connector window.
- Align the fiber tip with the rear housing by bringing both hands together for stability. Insert until you reach the buffer mark.
- When fully inserted, the buffer mark should be near the edge of the rear housing of the Brilliance Connector. If not, gently back off and reseat the fiber.
- During insertion an optional Support Handle™ can be used to improve stability.*
- Create a bow by bending the fiber as shown. Hold in position until activator tab is closed. To close the activator, pull connector activator tab towards rear using the large line indicator as a locating reference.
- When using VFL, the red light in the VFL Light Window should go out or dim substantially.

*For complete details on this procedure refer to Installation Guide (FX105234),
**When using a field cleaner remove 40 mm of buffer.
***Visual Fault Locator

A copy of the Guide is supplied with each installation kit, or visit www.belden.com
1. Load the 3M-2529 into the 3M-2501 Installation Tool.

2. Strip fiber cables approx. 40mm (1.25"), be sure to remove the jacket and the coating. Clean the bare fiber. Cleave the Fibers 12.5mm for indoor.

3. Insert fibers in the mechanical splice. Once inserted gently move the fibers back and forth to assure center placement. Load the fibers into the holding brackets and put equal bows to hold the fiber in place.

4. Rotate the lid down on the mechanical splice - until a click.

**Splice Tray: Mechanical Splice**
FI-SPTRME
Fits into West Penn Wire Wall Mount Enclosures

**Wall Mount Enclosures**
FI-WM12 - 12 Port
FI-WM24 - 24 Port
FI-WM48 - 48 Port
FI-WM100 - 100 Port

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Strip the central tub away - expose individual 250µm Fibers
Trim away the kevlar

2. Take a towel or rag and remove the water-blocking gel.
Apply talc or baby powder and continue to remove gel.

3. Apply more powder to clean coated 250µm fibers.
4. Feed individual fibers into the color coded slots on the fiber insertion block.

5. Apply clamping hood to the central tube. Secure brackets using needle nose pliers.
6. Place fiber insertion block into the clamping hood.
7. Apply the closure hood onto the clamping hood.

8. Optional - apply electrical tape around the fan-out kit and overall jacket.
9. Cable is now prepared at 900µm to assemble a connector

**Fan-out Kit**
Fan out kit is used to move a 250µm outdoor fiber to a 900µm fiber for connector assembly.
FI-1100 - 6 tube fan-out kit
FI-1101 - 12 tube fan-out kit

**West Penn Wire**
Cable with Confidence
**Fiber Optic Assemblies**

Types: ST, SC, LC other MTRJ  
Glass Types: SingleMode and Multi-Mode 
Simplex or Duplex Design

### ST Fiber Optic Assemblies

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI-X001-xx</td>
<td>Simplex ST to ST Replace xx with:3,6,10,15,30</td>
</tr>
<tr>
<td>FI-X002-xx</td>
<td>Duplex ST to ST Replace xx with:3,6,10,15,30</td>
</tr>
</tbody>
</table>

### SC Fiber Optic Assemblies

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI-X001-xxSC</td>
<td>Simplex SC to SC Replace xx with:3,6,10,15,30</td>
</tr>
<tr>
<td>FI-X002-xxSC</td>
<td>Duplex SC to SC Replace xx with:3,6,10,15,30</td>
</tr>
</tbody>
</table>

### LC Fiber Optic Assemblies

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FI-X001-xxLC</td>
<td>Simplex LC to LC Replace xx with:3,6,10,15,30</td>
</tr>
<tr>
<td>FI-X002-xxLC</td>
<td>Duplex LC to LC Replace xx with:3,6,10,15,30</td>
</tr>
</tbody>
</table>

### ST to SC Fiber Optic Assemblies

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>FI-X001-xxST/SC</td>
<td>Simplex ST to SC Replace xx with:3,6,10,15,30</td>
</tr>
<tr>
<td>FI-X002-xxST/SC</td>
<td>Duplex ST to SC Replace xx with:3,6,10,15,30</td>
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### SC to LC Fiber Optic Assemblies

<table>
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<th>Catalog No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>FI-X001-xxLC/SC</td>
<td>Simplex SC to LC Replace xx with:3,6,10,15,30</td>
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<tr>
<td>FI-X002-xxLC/SC</td>
<td>Duplex SC to LC Replace xx with:3,6,10,15,30</td>
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</table>

### Fiber Optic Assembly Glass Size

<table>
<thead>
<tr>
<th>Replace X with:</th>
<th>Core Glass Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50um</td>
<td>Standard 50micron Fiber optic glass type Multi-Mode</td>
</tr>
<tr>
<td>2</td>
<td>62.5um</td>
<td>Standard 62.5micron fiber optic glass type Multi-Mode</td>
</tr>
<tr>
<td>3</td>
<td>8um</td>
<td>8micron Single Mode fiber optic glass type SingleMode</td>
</tr>
<tr>
<td>4</td>
<td>50um LOF</td>
<td>OM3 Laser Optimized 50micron Multi-Mode</td>
</tr>
</tbody>
</table>

Replace xx with: 3, 6, 10, 15, 30 Feet

**SingleMode 15ft. LC to LC Assembly**
Fiber Optics in the AV World:

Optical Power Budget:
- Cable: 50/125μm
- Wavelength: 850nm
- No. of Fibers: 2 - 50/125μm
- Termination: Coax- RGBHV (5 BNC) and VGA (HD15) to Fiber SC
- Power Budget: 7dB

Distance Calculations:

850nm - 1km = 3.00dB
SC Connectors (2) = 1.50dB
System Safety Margin = 3.00dB
Total Loss = 7.50dB theoretical number

Note:
- Extron Distance
  - 8/125μm: 30Km (18.75miles)
  - 50/125μm: 1Km (3280ft)
  - 62.5/125μm: 300m (985ft)

Optical Characteristics:

<table>
<thead>
<tr>
<th>Glass Type</th>
<th>Code (X)</th>
<th>Operating Wavelength (nm)</th>
<th>Min. Bandwidth (MHz-km)</th>
<th>Max. Attn. (dB-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50/125μm Multimode</td>
<td>A</td>
<td>850nm/1300nm</td>
<td>500/500</td>
<td>3.50/1.25</td>
</tr>
<tr>
<td>62.5/125μm Multimode</td>
<td>B</td>
<td>850nm/1300nm</td>
<td>200/500</td>
<td>3.50/1.25</td>
</tr>
<tr>
<td>8/25μm SingleMode</td>
<td>W</td>
<td>1300nm/1550nm</td>
<td>—</td>
<td>.80/50</td>
</tr>
</tbody>
</table>

CABLE WITH CONFIDENCE

WEST PENN WIRE
Fiber Optics in the Security World:

Security World Fiber Optics:

CCTV
Fire Alarm Panel Communication
Access Control Panel Communications
Intrusion Detection
Audio
Data/Control

Most fiber optic security applications utilize multimode fiber combined with ST terminations.

Example 1: CCTV Video

Optical Power Budget:
Cable: 62.5/125μm
Wavelength: 850nm
No. of Fibers: 1 or 2 - 62.5/125μm
Termination: Coax- BNC, Fiber Optics - ST
Power Budget: 12dB

850nm - 2.5km = 7.50dB
ST Connectors (2) = 1.50dB
System Safety Margin = 3.00dB

Total Loss - 12.00dB theoretical number

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Testing Methods:

**Continuity Check**
Flashlight - to check Continuity
FI-5000
First test done to see if light is passing through the connection points

**Power Meter/Light Source**
Checks fiber power budget reference
FI08513 - 850/1300/1550nm PM
FI-8513 - 850/1300nm LS
FI-1550 - 1550nm LS
This test provides information compared to an optical power budget. If your power budget is for example: 12dB and the reading is 11dB - this system will operate. Checks total loss of the fiber link.

**Optical Time Domain Reflectometer (OTDR)**
Sends a pulse down a line of fiber optic cable. It measures the reflections created by fiber loss, splices and connectors. An OTDR will precisely indicate where a problem is occurring.

Expensive equipment: WPW has access.