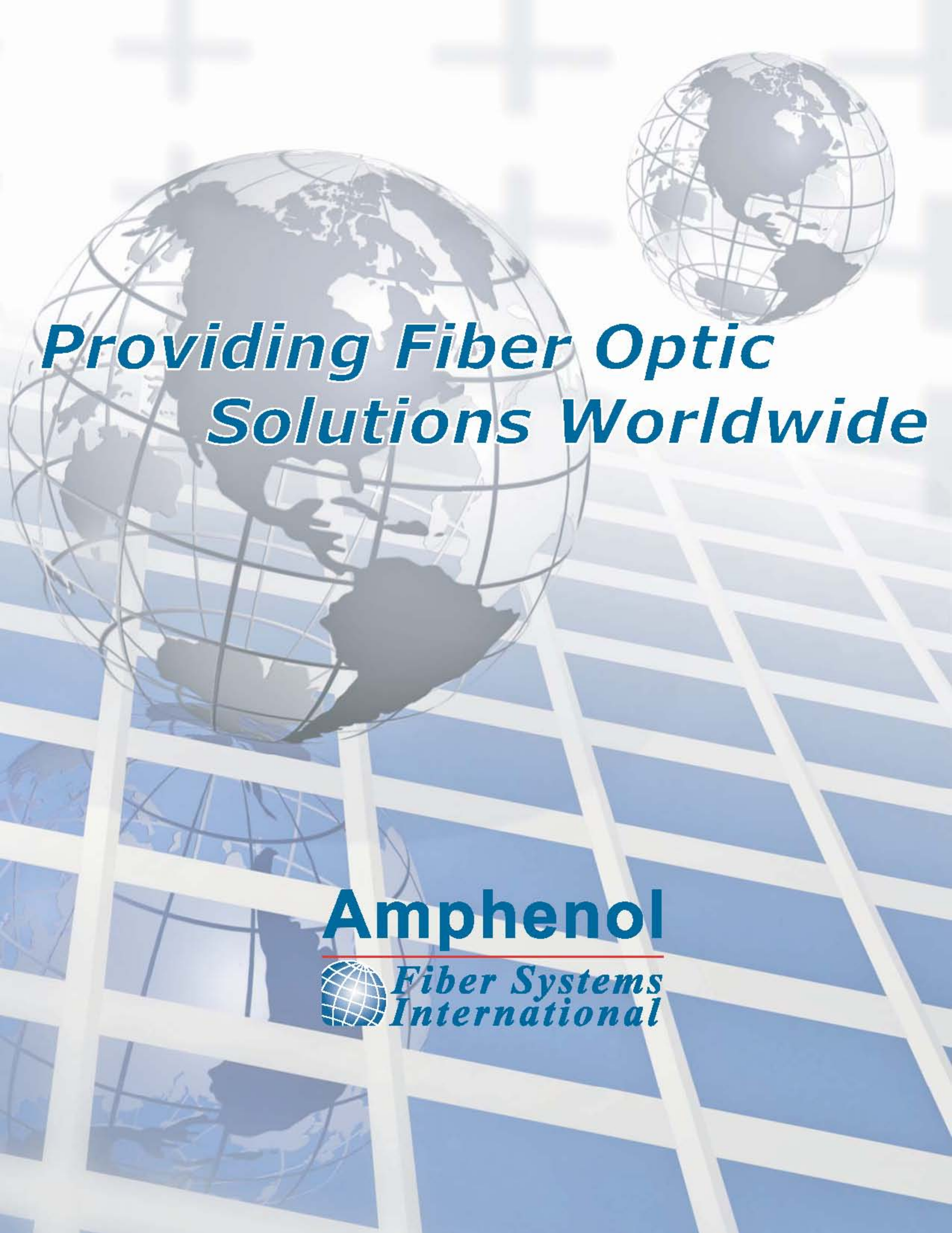

Providing Fiber Optic Solutions Worldwide

Amphenol

Fiber Systems International

About Amphenol Fiber Systems International

About AFSI

Amphenol Fiber Systems International (AFSI) designs manufactures, markets, and supports reliable and innovative fiber optic interconnect solutions designed to withstand the harsh environments of military, oil & gas, mining and broadcast applications. After more than a decade in business, AFSI continues to maintain its position as a global leader in fiber optic interconnect components and systems such as termini, M28876, MIL-ST, TFOCA and the patented TFOCA-II® connector. Altogether, AFSI has delivered millions of fiber optic connectors in more than 22 countries. Whenever there is a need for superior cost-effective fiber optic systems and products able to withstand demanding operating environments, you can rely on AFSI for engineering know-how, top-quality products and expert technical support.

We are ISO 9001:2000 certified and qualified to MIL-STD-790 requirements. Furthermore, AFSI is approved by the Electronics Technicians Association (ETA) to train and administer the Fiber Optics Installer (FOI) and the Fiber Optics Technician (FOT) certifications.

For more information about AFSI, please visit our website at www.fibersystems.com

About Amphenol

Amphenol was founded in 1932. The company is one of the largest manufacturers of electrical, electronic and fiber optic connectors, coaxial and flat-ribbon cable. Its activities are geared towards 7 majors markets: Military & Commercial; Aerospace; Automotive; Broadband Communication; Industrial; Information Technology & Data Communication; Mobile Devices and Wireless Infrastructure. Amphenol is headquartered in Connecticut, USA and employs more than 10,000 people on a worldwide basis with manufacturing and assembly operations in the Americas, Europe and Asia.

For more information about Amphenol, please visit our website at www.amphenol.com

Icons Indicate Application

Land Tactical | Shipboard | Avionics | Oil & Gas | Broadcast & Industrial | Mining

TFOCA-II® 4-Channel
Land Tactical Fiber Optic Connectors

M28876
Shipboard Fiber Optic Connectors

MiniTAC
2-Channel Hermaphroditic Connector

MTFP Termini
Termini used for TFOCA-II® Connectors

M29504 /14 & /15 Termini
Commercial version available

109 Series
4-Channel Hermaphroditic Connector
SMPTE 358M compliant

TFOCA-II® 12-Channel
Land Tactical Fiber Optic Connectors

M83522 MIL-ST
Commercial version available

TFOCA-II® for Armored & Sheathed Cable

TFOCA Connector
Tactical Fiber Optic Cable Assembly

NGConn
Next Generation Fiber Optic Connector

ProCLEAN
Rugged Fiber Optic Connectors with a Screw-On Insert Cap for easy cleaning

Fiber Optic Connectors for Harsh Environments

Icons Indicate Application

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FS4H 4-Channel
Available in Brass, Stainless Steel & Anodized Black

FS5H 24-Channel
Available in Brass, Stainless Steel & Anodized Black

D38999 Cable Assemblies

Optron Connectors
Fiber Optic & Electrical Contacts For Marine & Land Applications

DeepSight
Down-Hole Applications

FS6H 6-Channel
Available in Brass, Stainless Steel & Anodized Black

E-O-E System
Integrated Media Conversion Capability Active Plugs & Receptacles

FS8H 12-Channel
Available in Brass, Stainless Steel & Anodized Black

GoldRush®
XP Connectors for the Mining Industry MSHA Approved

TFOCA-III® 6-Channel

StapleMate®
For Longwall Mining Systems

Connector Adapters
Adapters for different types of connectors

Icons Indicate Application

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TFOCA-II® 4-Channel
4-Channel Connector with Integrated Patch Panel

Tactical High Density Connectors
48 & 72-Channels

TFOCA-II® 4-Channel Loopback Plug

TFOCA-III® 24-Channel

Fiber Optic Feedthru
High temperature, high pressure

CTOS Expanded Beam Connector

M29504 /4 & /5 Termini
Commercial version available

LimeLight Cable Assemblies
SMPTE 304M compliant

APC Termini
Suitable for harsh environments requiring low back reflection

FSAF Termini
1.25mm Tactical Termini

FS3H 4-Channel
4-Channel Hermaphroditic Connector
SMPTE 358M compliant

FS12
Available in Brass, Stainless Steel & Anodized Black

Fiber Optic Connectors for Harsh Environments

Icons Indicate Application

Land Tactical | Shipboard | Avionics | Oil & Gas | Broadcast & Industrial | Mining

Inspection Scope

Measurement Quality Jumpers

Termination Kits & Tools

Fiber Optic Training

Fiber Optic Test Set

AXOS

HMA*two* Expanded Beam Connector

Compatible with HMA Connectors

LC Field

MTRJ Field

RNJOP

MFM

TVOP

Cable Assemblies

Harsh environment fiber optic interconnect solutions are AFSI's specialty. To complement our industry leading connector product suite, we manufacture turnkey fiber optic cable assemblies and harnesses.

AFSI will custom design your assembly or build to your print. Our complimentary design services include specifying the cable, connector, labeling and spooling to meet your application and budget for your project.

All AFSI cable assemblies are manufactured by expert technicians in our state-of-the-art, ISO 9001:2000 certified facility. This ensures that our processes and practices are optimized for the unique requirements of fiber optic cable assemblies rather than one-size-fits-all electrical assemblies.

Allen, Texas Production Facility

AFSI has experience connectorizing a myriad of cable types (e.g., radiation hardened, interlocking armor, QFCI). In addition to our harsh environment connectors (TFOCA, TFOCA-II®, M28876), we offer rugged cable assemblies with 38999 and SMPTE 304M connectors. We can also connectorize the receptacle with any of the popular commercial connectors (SC, LC, FC, etc.) in either ultra polish or angle polish.

Technicians trained to MIL-STD-2042B and a variety of other procedures critical to manufacturing harsh environment fiber optic cable assemblies aim to exceed customer requirements with every assembly. An optical test report is included with every cable built. If additional tests are required, AFSI is capable of testing in-house or contracting with one of our test laboratory partners.

AFSI takes pride in its industry leading customer support and turnaround times. Our valued customers include nearly every major defense company, many major geophysical companies, and numerous broadcast equipment and service providers.

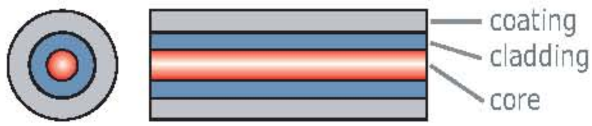




Understanding Fiber Optics

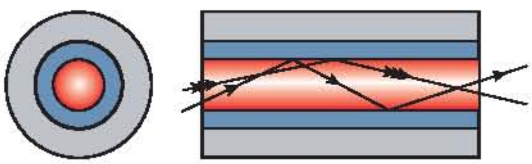
WHAT IS AN OPTICAL FIBER?

- **Fiber structure and fiber types -** An optical fiber is made of 3 concentric layers:



- **Core:** This central section, made of silica, is the light transmitting region of the fiber.
- **Cladding:** This is the first layer around the core. It is also made of silica, but not the same composition as the core. This creates an optical waveguide which confines the light in the core by total internal reflection at the core-cladding interface.
- **Coating:** It is the first non-optical layer around the cladding. The coating typically consists of one or more layers of polymer that protect the silica structure against physical or environmental damage.

• Multimode fiber



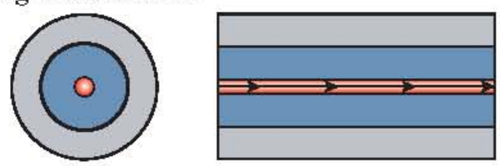
This type of fiber is called "multimode." Light travels through the fiber following different paths called "modes."

Typical Multimode fiber

50 / 125 or 62.5 / 125

- cladding diameter in microns (µm)
- core diameter in microns (µm)

• Single mode fiber



This type of fiber is called "single mode" because only one mode is propagated. It travels "straight" through the fiber. The core diameter is typically 9µm.

Typical Single mode fiber

9 / 125

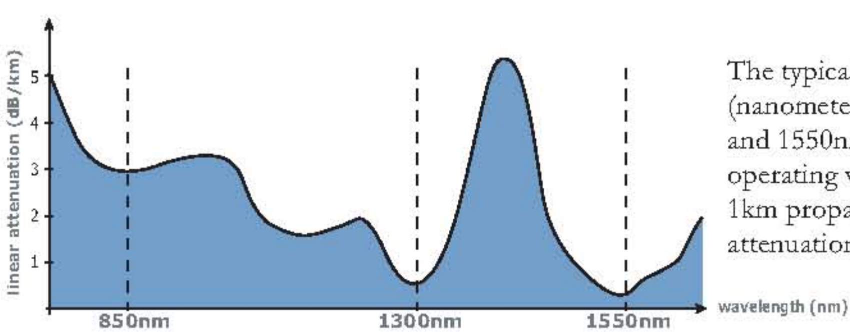
- cladding diameter in microns (µm)
- core diameter in microns (µm)

CHARACTERISTICS OF OPTICAL FIBER

- **Attenuation and wavelength**

Light is gradually attenuated when it travels through fiber. The attenuation value is expressed in dB/km (decibel per kilometer). Attenuation is a function of the wavelength (λ) of the light.

This graph shows the attenuation as a function of the wavelength:

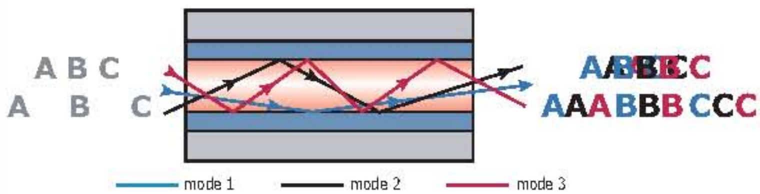


The typical operating wavelengths are 850nm (nanometers) and 1300nm in multimode, and 1310nm and 1550nm in single mode. Example: For an 850nm operating wavelength, there is a 3dB attenuation after 1km propagation (according to the graph). 3dB of attenuation means that 50% of light has been lost.

- **Bandwidth**

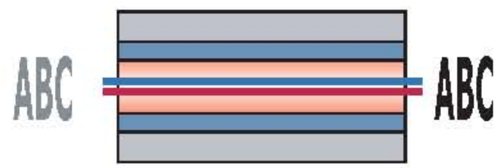
Bandwidth is a measure of the data-carrying capacity of an optical fiber. It is expressed as the product of frequency and distance. For example, a fiber with a bandwidth of 500 MHz•km (Mega-Hertz kilometer) can transmit data at a rate of 500 MHz along one kilometer of fiber. Bandwidth in single mode fibers is much higher than in multimode fibers.

• **Multimode case**



Information (A B C) is propagated in fiber according to N modes or paths, as if it were "duplicated" N times (for example, on the diagram above, the mode 3 path is longer than the mode 2 path, which are both longer than the mode 1 path). If information is too close, there is a risk of overlapping the information, and then it will not be recoverable at the end of the fiber. It is necessary to space the data sufficiently to avoid overlap, i.e. to limit the bandwidth.

• **Single mode case**



Information (A B C) is propagated in fiber according to only one mode. Therefore, it is possible to pack information much closer together because it does not overlap other modes.

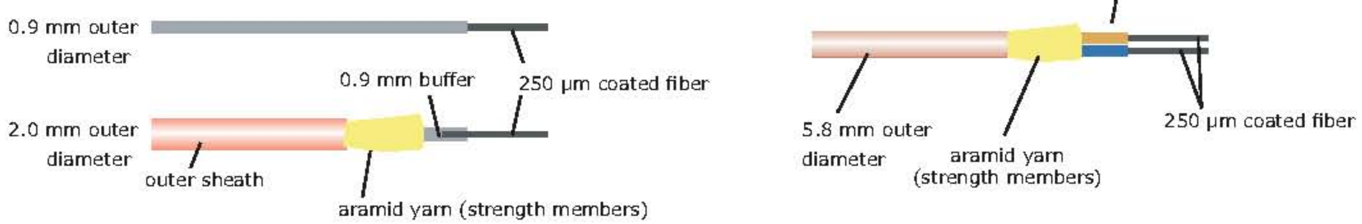
WHY CHOOSE FIBER OPTICS?

The main advantages of fiber optics are:

- **Lower loss:** Optical fiber has lower attenuation than copper conductors, allowing longer cable runs and fewer repeaters.
- **Increased bandwidth:** The high signal bandwidth of optical fiber provides significantly greater information-carrying capacity. Typical bandwidths for multimode fibers are between 200 and 600 MHz•km, and > 10 GHz•km for single mode fibers. Typical values for electrical conductors are 10 to 25 MHz•km.
- **Immunity to interference and detection:** Optical fibers are immune to electromagnetic interference and emit no radiation.
- **Electrical isolation:** Fiber optics allows transmission between two points without regard to the electrical potential between them.
- **Decreased cost, size and weight:** Compared to copper conductors of equivalent signal-carrying capacity, fiber optic cables are easier to install, require less duct space, weigh 10 to 15 times less and cost less than copper.

FIBER OPTIC CABLES

The coated fiber has a typical external diameter of 250 microns and is fragile. It is usually necessary to build cables to reinforce the fiber to make it more durable and easier to handle. There are many different cable constructions (see examples below).



HOW TO LINK TWO OPTICAL FIBERS

■ **Two methods to link two optical fibers:**

1 - Fusion splice
This operation consists of directly linking two fibers by welding with an electric arc or a fusion splicer.

Advantages:
- This linking method is fast and simple
- Light loss generated by fusion splicing is very low

Drawbacks:
- Link is relatively fragile
- Link is permanent
- Initial cost of a fusion splicer is high

2 - Use of connectors
A connector terminates the optical fiber inside a ceramic ferrule using epoxy to hold the fiber in place. The connectors can be mated and unmated at any time.

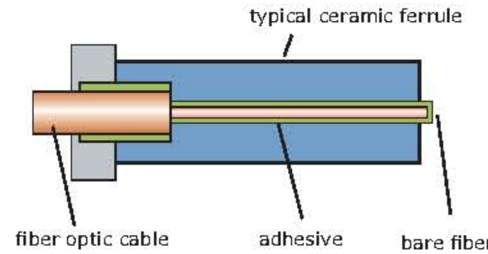
Advantages:
- Connection is robust
- Connector can be chosen according to the application
- Connection is removable; it is possible to connect and disconnect two fibers hundreds or even thousands of times without damaging the connectors

Drawbacks:
- Connectorization takes longer than fusion splicing and requires specific tools
- Light loss due to connection can be higher than in fusion splicing solution

CONNECTOR TYPES

Physical contact

Physical contact connectors utilize fiber in a tightly toleranced ceramic ferrule. This allows easy handling of the fiber and protects it from being damaged.

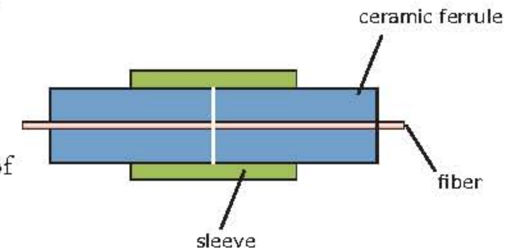


The different steps to terminate the fiber in the ferrule are:

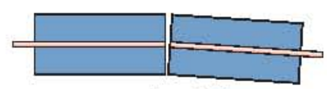
- Stripping the fiber coating(s).
- Bonding the fiber into the ceramic ferrule with epoxy.
- Polishing the end of the ceramic ferrule to get a smooth finish so the light can easily pass from one fiber to the next.

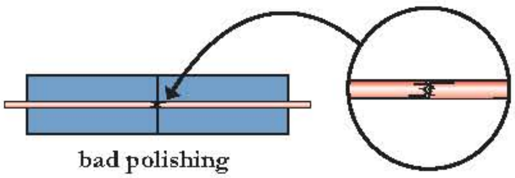
Physical contact technology

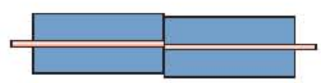
Principle:
The principle of the physical contact connectors is the direct contact of polished fibers within two ceramic ferrules. The ferrules are aligned using a ceramic alignment sleeve.

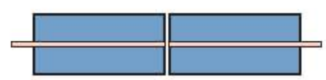


Limitations:
Signal loss is a function of the alignment accuracy and the polish quality.


angular shift


bad polishing


transverse shift


air gap (bad contact)

Physical contact connector characteristics:

- The loss of light generated by a connection is called Insertion Loss (IL). For physical contact connectors, the IL is generally low (approximately 0.3 dB).
- This is the most common fiber optic connection. It is rugged, repeatable, easy to clean, cost-effective, and performs well.
- This connection performs well against particle contaminates (dust, mud, etc.) and is usually insensitive to liquid contaminates (water or oil). The physical contact pushes liquid out of the way and the liquid does not degrade the connection.
- Physical contact connectors are cleaned by wiping the ferrule with a clean cloth or wipe, spraying with a cleaner, or washing with water.

Physical contact connector examples:

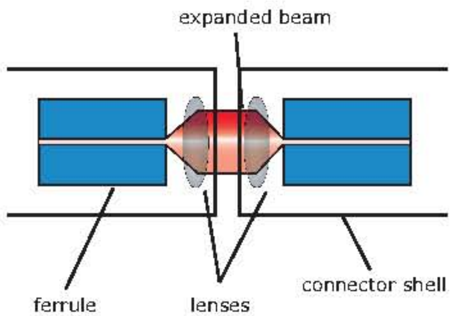

ST (single channel)


TFOCA-II® (4-channels)

CONNECTOR TYPES

■ Expanded beam technology

Principle:
The principle of the expanded beam connectors consists of placing a lens at the exit of each fiber widening and collimating the light. In this configuration, there is an air gap between the two optical fibers (lens).



Limitations:
The mechanical interface between the connectors must be precise. Dust and dirt must not interfere with the alignment of the optical elements. Expanded beam connectors are less susceptible to particle contaminates such as dust and dirt, but they perform poorly with liquids and films on the lenses. They can also be very difficult to terminate in the field.

Lens connector characteristics:
- The loss generated by an expanded beam connection is more than a physical contact connector due to the lenses, mechanical alignment, and sometimes protective windows (approximately 0.8 to 2.5dB typical).
- This type of connection performs well against particle contamination on the lens because the beam is expanded to be much larger than what comes directly from a fiber. However, any liquid or film (such as a fingerprint) on a lens creates significant loss in an expanded beam connector. Expanded beam connectors are also very sensitive to alignment of the lenses. Connectors must always be tightly coupled and kept clean on the mating surface in order to work properly. Cleaning an expanded beam connector must be done with care as any liquid (water, alcohol or another cleaner) that is trapped inside the connector may migrate to the surface of the lens and can cause an unacceptable increase insertion loss.

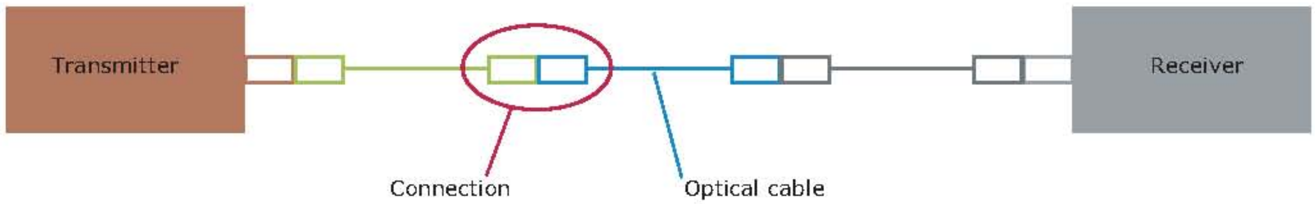
Lens connector examples:


Expanded Beam with Window


Expanded Beam with Ball Lens

CHARACTERISTICS OF FIBER OPTIC LINKS

This sketch depicts a typical fiber optic interconnection system:



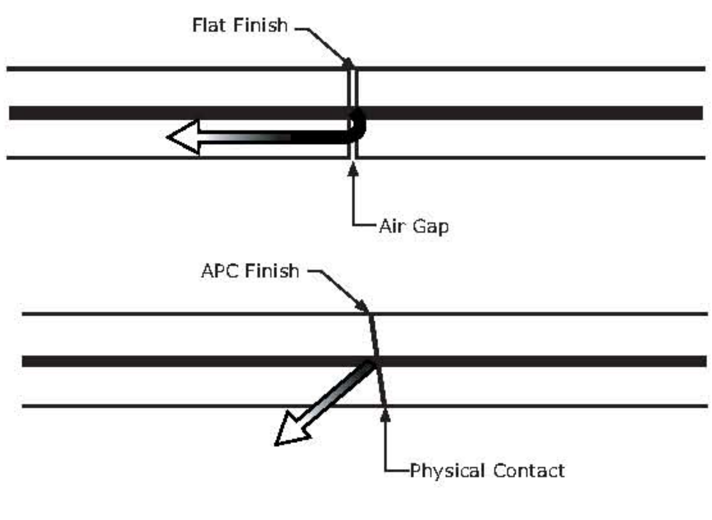
It is comprised of the following elements:

Transmitter and Receiver (Transceiver)
A transmitter contains a light source. The receiver is a light detector. To design a good fiber optic system, it is important to know:

- The type of light source (LED or type of laser)
- The operating wavelength (1300 nm, for example)
- The optical power of the light source
- The type of the light detector
- The type of connector at the light source output

One or more optical patchcords
Patchcords are defined by:

- The fiber optic cable described by its length, the number of channels, and the fiber type (single mode, multimode 50/125 or 62.5/125).
- The connectors used in cable terminations
- The Insertion Loss expressed in dB
- The Return Loss expressed in dB. Return Loss is usually specified for single mode systems and patchcords only. Return Loss is the quantity of light which is reflected back by the connector versus the light that continues through. Some laser sources used in single mode applications are sensitive to this phenomenon.



Return Loss Phenomena

Notes

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