



Fiber Optic Connectors

There is a plethora of fiber optic connectors from which to choose for use in your applications. Since the first connectors in the 70's, many different designs have come and gone. The early designs were used with fiber bundles and large-core single fibers. Some of the more "not ready for prime time" connectors included the "jeweled ferrule" and the "wet lens" designs. These, among many others, served their purpose well for the time but, as singlemode fibers became available and the environments became more varied and hostile, these designs were not able to meet the rugged requirements.

Over time, a number of connector types have evolved and withstood the test of time to become standard in the fiberoptics industry for all applications. These types include: ST, FC, SC, and LC. Other application-specific connector designs include expanded beam, fiber ribbon array, and hermaphroditic styles.

Entire books and untold numbers of articles have been written on all aspects of fiber optic connectors. This article touches on the very basics of optical connectors and some of the key factors that differentiate them.

Optical connectors provide the mechanical connection between different fiber cables or patch cords and to active devices in transmitters and receivers. The ideal optical connector holds the fibers in perfect alignment, in 3 axes. This alignment must be maintained over hundreds or thousands of connect-disconnect cycles to provide stable, repeatable, low-attenuation characteristics. Some of the key features of optical connectors include:

- Yield repeatable, low loss optical connections with low reflectance
- Physically rugged, be large enough to handle but small enough for running through ducts, etc.
- Good mechanical strength and strain relief
- Easy to clean
- Repairable in the field
- Cost effective
- Compatible with standard fibers and patch cords

Figure 1 illustrates the various parts of any optical connector and associated alignment sleeve. The most important element of the connector plug is the ferrule, which provides the precise alignment and centering of the optical fiber. Ferrules can be made of ceramic, metal, glass, or plastic. Ceramic ferrules with metal inserts are most widely used, providing the best tolerances and durability.

The body of the plug holds the ferrule, the coupling mechanism and the boot. The body contains either a threaded, push-pull, or bayonet coupling mechanism that mechanically holds the plug with the mating receptacle and also provides a keying function that allows the connector to mate in only one position. Strain relief of the cable is usually by a crimp sleeve which firmly secures the aramid fibers in the cable to the plug body. Strain relief can also be provided by adhesives that permanently bond the cable buffer materials to the plug body. At the rear of the plug body is the "boot" which functions as a bend radius limiter for the cable entering the plug body.

Another critical component is the mating adapter and its internal sleeve that aligns the two mating ferrules. Like the ferrule, sleeves are most often made from ceramic and can be either a split or solid construction. The alignment sleeve must precisely align the two precision ferrules by means of the ferrules outside diameters. This alignment must be done while providing a low-friction fit over a wide temperature range.

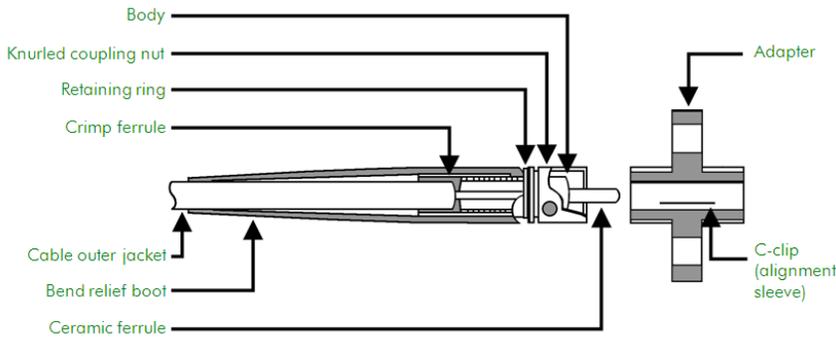


Figure 1
Connector Cut Away

Basic Connector Specifications

Two standards bodies have created specifications for connector attenuation. The ITU-G.671 standard specifies a maximum attenuation of 0.5 dB per mated pair, while the Telcordia GR326 standard specifies a 0.4 dB maximum. Both standards are focused on singlemode connectors where the fiber itself has attenuation levels of 0.3 dB per kilometer. For premises and other multimode applications, the TIA/EIA 568 standard specifies a mated connection of 0.75

dB maximum. Reflection specifications are important when transmitting data at high data rates. Excessive optical reflections from a connector interface can adversely affect the performance of the transmitter's laser, thus compromising the overall performance of the optical link. Optical connectors have different types of end surfaces to help minimize both attenuation and reflections. The discussion of connector termination, repeatability, optical reflections, connector end faces, and other key parameters are beyond the scope of this article.

Connector Types



Figure 2
ST Optical Connector

The most common of optical connectors is the **ST** style shown in Figure 2. This simplex fiber connector evolved from previous designs and was finally introduced by AT&T in the mid-late 1980s. It has become the de-facto standard in the security market and is commonly used in the AV market on such products as HDS DI, RGB/DVI, and others. It is available in both multimode and singlemode versions. It is relatively easy to terminate in the field, has good strain relief and good, but not exceptional attenuation characteristics.

The **LC** connector developed by Lucent Technologies (no, LC does not stand for Lucent Connector) has become the ubiquitous optical connector for telecom applications and is used in conjunction with small form pluggable (SFP) optical transceivers. These SFP devices are now becoming very common in Pro AV applications for such products as HDMI, DVI, audio, optical distribution amplifiers, optical/electrical/optical (OEO) switches, and so forth. The LC connector is smaller than all other connectors and is a push-pull design instead of the twist lock as in the ST connector. Figure 3 shows an LC connector. Being small, the LC connector has limited strain relief and is more easily prone to damage.

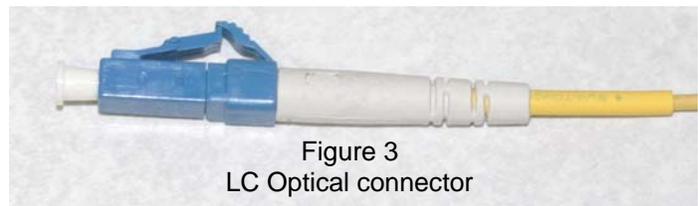


Figure 3
LC Optical connector

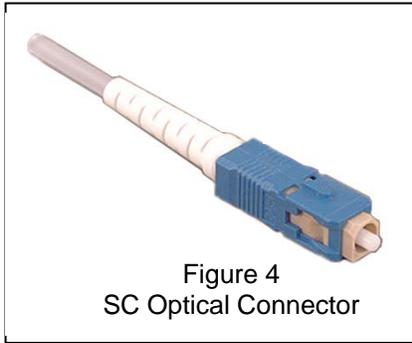


Figure 4
SC Optical Connector

SC connectors (see Figure 4) are common in datacom applications and are more robust than the LC style connector. Like the LC, this too is a push-pull design and is also commonly used in patch panels that act as the connector interface between the main field cable and smaller patch cords connected to the fiber transmission equipment. Some manufacturers of fiber AV equipment also use SC connectors in conjunction with their optical emitter and detector devices.

The **Expanded Beam Connector**, an example of which is shown in Figure 5, is a rugged connector typically used in harsh environments where dirt and rough handling are constant problems. Expanded beam connectors use a ball lens inside the connector ferrule to expand the beam exiting the fiber to 10 to 15 times its original size. This larger beam provides improved tolerance of dirt or imperfections on the face of the fiber ferrule.

In addition, these connectors are typically hermaphroditic (i.e., sexless connectors) designs allowing easy and fast field deployment. Hybrid designs with both electrical and optical interfaces in the same connector shell are also available. Originally designed for the military, these tactical-style connectors have found fiber optic applications in the broadcast

and pro A/V markets. Many of these expanded beam connectors cannot be repaired in the field. They must be taken off site in special jigs for repair and termination thus limiting their usefulness in some applications.



Figure 5
Expanded Beam, Hermaphroditic Connector

Industry-specific connectors will continue to evolve. One example is the High Definition TV connector developed by LEMO for broadcast-quality video applications both in studios and for special events where cables link production vans to remote cameras. The connector is a hybrid connector sending HD video and audio signals over two singlemode fibers, but also includes metallic conductors in the same push-pull connector. Variations of this connector provide a number of different optical and electrical interconnect options.

This article just touched on the very basics of optical connectors. Other connector types and a number of other connector-related topics such as testing, connector end face types, terminating, cleaning, inspection, etc. can be found in any number of publications from connector and connector supply manufacturers.

References:

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