



# edu Guide

Making sense out of complex Pro A/V and Broadcast technologies.

## Fiber Optic Cables and Connectors

Learn how easy it is to terminate and fabricate your own fiber optic cables and what types of fiber and fiber jackets are available.



**CSI** Communications  
Specialties, Inc.

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## Introduction

In the design of a fiber optic transmission system, the first step is to determine which transmitters and receivers are best suited to the signal type. The best way to find the right system is to compare data sheets and consult with sales engineers to find which products best meet the system specifications. Once this is done, the next consideration is the choice of the fiber optic cable itself, the optical connectors to be used and the method of attaching these connectors. This portion of the system design is not so straightforward and is shrouded in a great deal of misunderstandings and fear of complex “glass grinding” techniques by the inexperienced. This booklet should clarify several misconceptions about fiber cable and termination.

## Cable Construction

Like copper wire, fiber optic cable is available in many physical variations. There are single and multiple conductor constructions, aerial and direct burial styles, plenum and riser cables and even ultra-rugged military type tactical cables that will withstand severe mechanical abuse. Which cable one chooses is, of course, dependent upon the application.

Regardless of the final outer construction however, all fiber optic cable contains one or more optical fibers. These fibers are protected by an internal construction that is unique to the type of fiber optic cable. The two most common protection schemes in use today are to enclose the tiny fiber in a loose fitting tube or to coat the fiber with a tight fitting buffer coating.

In the loose tube method the fiber is enclosed in a plastic buffer-tube that is larger in inner diameter than the outer diameter of the fiber itself. This tube is sometimes filled with a silicone gel to prevent the buildup of moisture as well. Since the fiber is basically free to “float” within the tube, mechanical forces acting on the outside of the cable do not usually reach the fiber.

Cable containing a loose buffer-tube fiber is generally very tolerant of axial forces of the type encountered when pulling through conduits or where constant mechanical stress is present such as cables employed for aerial use. Since the fiber is not under any significant strain, loose buffer-tube cables exhibit low optical attenuation losses.

In the tight buffer construction, a thick coating of a plastic-type materials applied directly to the outside of the fiber itself. This results in a smaller overall diameter of the entire cable and one that is more resistant to crushing or overall impact-type forces. Because the fiber is not free to “float” however, tensile strength is not as great. Tight buffer cable is normally lighter in weight and more flexible than loose-tube cable and is usually employed for less

severe applications such as within a building or to interconnect individual pieces of equipment.

Figure 1 - Basic Fiber Optic Cable Construction - loose tube and tight buffer fiber optic cable.

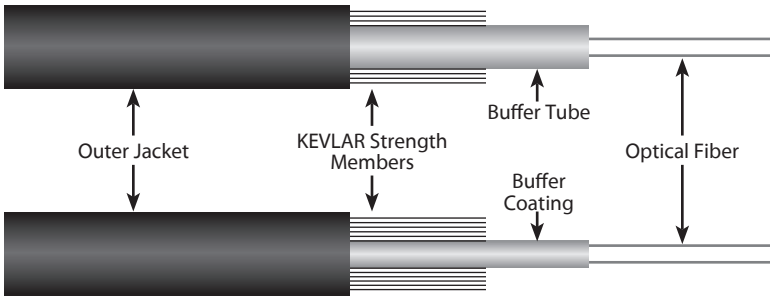
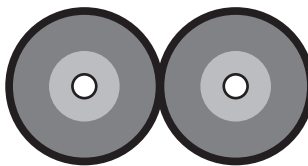


Figure 2 - Types of Fiber Optic Cable - single and two conductor fiber optic cables, as well as a more complex multi-fiber cable. Note that the two conductor cable is similar to the common AC powerline electrical cable.

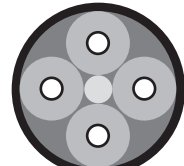
- Outer Jacket
- Kevlar Strength Member
- Buffer Tube
- Optical Fiber
- Ridged Fiberglass Central Strength Member



Single Cable



Dual Core Cable



Quad Core Cable

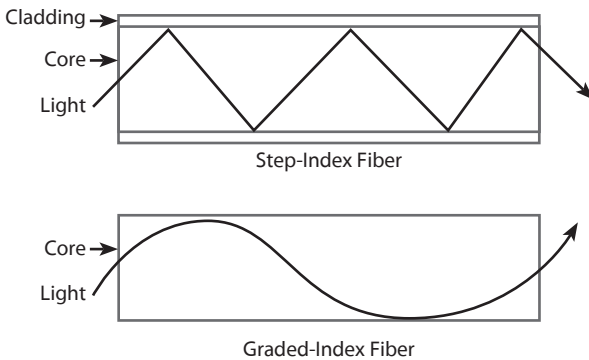
As can be seen from the diagram, in all cases the fiber/buffer tube is first enclosed in a layer of synthetic yarn such as Kevlar for strength. An outer jacket of PVC or similar material is then extruded over everything to protect the inside of the cable from the rigors of the operating environment. In multifiber cables, an additional strength member is also often added.

While most fiber optic cables are manufactured of totally non-conductive materials, there are some cable that employ steel tape-wound outer jackets for rodent resistance (direct burial types) or metallic strength members such as steel wire for aerial (telephone pole) use. There are even fiber optic cables with imbedded copper electrical conductors for transferring power to remote electronic packages.

## Optical Fiber

Whether loose-buffer or tight-buffer, the actual glass fiber used in any fiber optic cable only comes in one of two basic types, multimode fiber for use over short to moderate transmission distances (up to about 2 Km) and single mode fiber for use over distances that are generally greater than 2 Km. Communications grade multimode fiber normally comes in two sizes, 50 micron core and 62.5 micron core, the latter being the size most commonly available. The outer diameter of both is 125 microns and both use the same connector size. Single mode fiber comes in only one size, 8-10 microns for the core diameter and 125 microns for the outer diameter. Connectors for single mode fiber are not the same as those designed for multimode fiber but can look the same as we will soon discuss.

Figure 3 - Two types of optical fiber: step-index and graded-index fibers

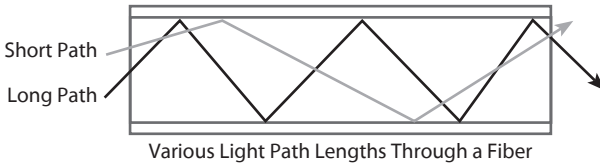


Step index fiber has a core of ultra-pure glass surrounded by a cladding layer of standard glass with a higher refractive index. This causes light traveling within the fiber to continually “bounce” between the walls of the core much like a ball bouncing through a pipe. Graded index fiber on the other hand operates by refracting (or bending) light continually toward the center of the fiber like a long lens. In a graded index fiber the entire fiber is made of ultra-pure glass. In both types of fiber however, the light is effectively trapped and does not normally exit except at the far end.

Losses in an optical fiber are the result of absorption and impurities within the glass as well as mechanical strains that bend the fiber at an angle that is so sharp that light is actually able to “leak out” through the cladding region. Losses are also dependent on the wavelength of the light employed in a system since the degree of light absorption by glass varies for different wavelengths. At 850 nanometers, the wavelength most commonly used in short-range transmission systems, typical fiber has a loss of 3 to 4 dB per kilometer of length. At 1310 nanometers this loss drops to under 2 dB per kilometer and at 1550 nanometers, the loss is a dB or so.

The last two wavelengths are therefore obviously used for longer transmission distances. The losses described above are independent of the frequency or data rate of the signals being transmitted. There is another loss factor however that is frequency (and wavelength) related and is due to the fact that light can have many paths through the fiber. This is commonly referred to as dispersion.

Figure 4 - shows the mechanism of this loss through step-index fiber



A straight light path through a fiber is shorter than one that travels with maximum “bouncing”. This means that for a fast rise-time pulse of light, some paths will result in light reaching the end of the fiber sooner than through other paths. This causes a smearing or spreading effect on the output rise-time of the light pulse which limits the maximum speed of light changes that the fiber will allow. Since data is usually transmitted by pulses of light, this in essence, limits the maximum data rate of the fiber.

The spreading effect for a fiber is expressed in terms of MHz per kilometer. Standard 62.5 micron core multimode fiber usually has a bandwidth limitation of 160 MHz per kilometer at 850 nanometers and 500 MHz per kilometer at 1310 nanometers due to its large core size compared to the wavelength of the propagated light. Single mode fiber, because of its very small 8 micron core diameter has a bandwidth of thousands of MHz per kilometer at 1310 nanometers. For most low frequency applications however, the loss of light due to absorption will limit the transmission distance rather than the pulse spreading effect.

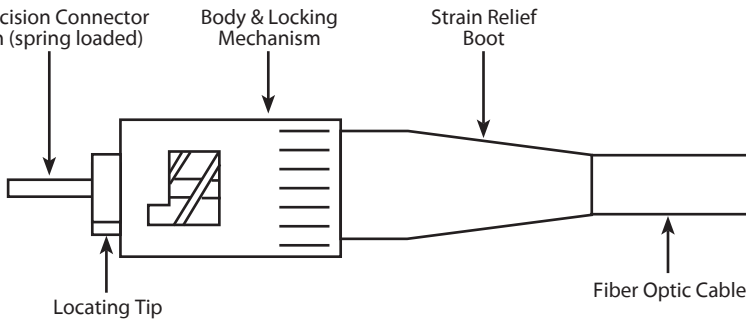
## Optical Connectors

Since the tiny core of an optical fiber is what transmits the actual light, it is imperative that the fiber be properly aligned with emitters in transmitters, photo-detectors in receivers and adjacent fibers in splices. This is the function of the optical connector. Because of the small sizes of fibers, the optical connector is usually a high precision device with tolerances on the order of fractions of a thousandth of an inch.

*Although there are many different styles available the most common optical cable connector in current use is the ST type shown in figure 5.*

The connector consists of a precision pin that houses the actual fiber, a spring-loaded mechanism that presses the pin against a similar pin in a mating connector (or electro-optic device) and a method of securing and strain-relieving the outer jacket of the fiber optic cable. ST connectors are available for both multimode and single mode fibers. The main difference between the two is the precision of the central pin. Since this difference is not readily noticeable, care must be taken to use the correct connector. This is especially true with pre-terminated connectors, such as the Corning Unicam Connector System.

*Figure 5 - The ST-style Optical Connector*



The traditional method for attaching optical connectors consists of first stripping the jacket from the fiber cable with tools that are almost exact equivalents of those used for electrical cable. Once this is done the strength members are trimmed and inserted into various restraining grommets or sleeves. For loose-tube fibers, the buffer tube is then removed, exposing the actual fiber. For tight-buffer fibers, the buffer coating is removed with a precision stripping tool that looks like a small wire stripper. The process, up to this point is still similar to preparing copper wire. It is when the bare

fiber is exposed that the differences (compared to copper wire) occur. The stripped fiber is now coated with a quick drying epoxy resin and inserted into a precision hole or groove in the connector pin.

Then the strain relieving components are assembled and the basic connector is ready for finishing. At this point the end of the bare fiber is protruding from the front of the connector pin. The pin is placed in a special tool that is then used to cleave or cut the tiny glass fiber flush with the end of the pin. This takes a second or two. Next the connector is placed into a small jig and run over two or three grades of fine lapping film, the equivalent of ultra-fine sandpaper. This completes the polishing of the fiber and the optical connector is ready for use. The complete task, not including the 5 minutes of epoxy drying time, takes anywhere from 5 to 10 minutes per connector depending on the skill level of the person. Figure 6 shows the various steps involved in installing conventional ST connectors.

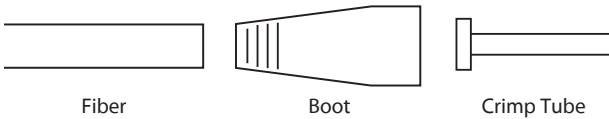
Many people have reservations about “connectorizing” fiber optic cable due to problems they have heard about concerning the “grinding and polishing of glass”. When one realizes that the “grinding and polishing” takes less than a minute, and is done within a simple fool-proof fixture, the mystery quickly evaporates. In fact, assembling an ST style optical connector is, in reality no more demanding a task than assembling an older style electrical BNC. Once one is completely familiar with the process, (which takes from 30 minutes to an hour to learn) the longest time interval involved in the finishing process is waiting for the epoxy to cure.

Never-the-less the reservations continue. As a result, several connector manufacturers manufacture so-called “quick-crimp” optical connectors. These devices are installed with various mechanical clamp arrangements and hot melt or instant bond adhesives (or, in some cases no chemical adhesive at all). Some of these connectors, such as the Corning Unicam Connector System, are even provided with a pre-polished length of optical fiber in the tip there by eliminating the finishing step altogether. The performance and reliability of this system is on par with the traditional “grind and polish” system and is now in common use.

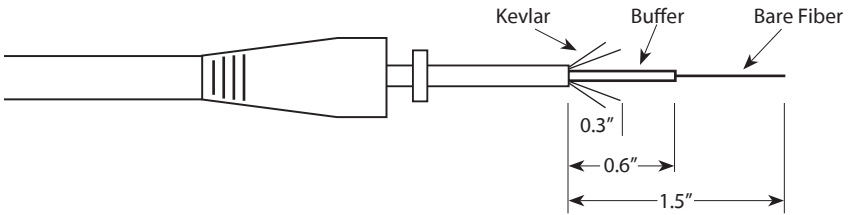
Other optical connectors that are available include the LC, SC and FCPC. All are similar in that they position the fiber within a close tolerance tip which then mates with an equally precise device on the other end. They really only differ from each other in the mechanical way that the connectors mate to each other. In any event all optical connector manufacturers provide detailed, easy to follow step-by-step installation procedures for their respective connectors.

Figure 6 - Traditional steps involved in installing conventional ST connectors

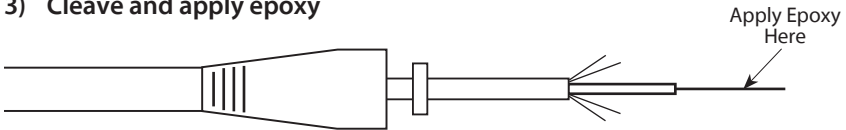
1) Slide boot and crimp tube over end of fiber



2) Strip fiber optic cable to dimensions shown



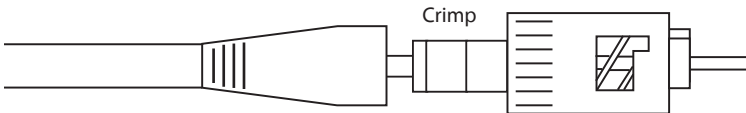
3) Cleave and apply epoxy



Note that with the Corning Unicam Connector System or the Fiberlink® 6202 Field Termination Kit you do not need to perform any grinding or polishing and there is no need for any epoxies or glues.

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4) Assemble and crimp



5) Complete the cable assembly



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Detailed analysis of how Pure Digital Fiberlink® has become the solution of choice for mission critical government, intelligence and military applications. If you are involved in this market segment, this document will prove to be valuable during your next project specification.







## About Communications Specialties, Inc.

Communications Specialties, Inc. (CSI) is an award-winning, Long Island based company that manufactures and sells a variety of products for the distribution, conversion or transmission of television and computer video signals, including fiber optic transmission systems, scan converters and video scalers.

The company was founded in 1983 by veterans of the broadcast industry. Since then, CSI has managed to consistently design innovative products that are used worldwide by Fortune 500 Companies and Government Agencies in a variety of markets such as Broadcast, Professional A/V, Videoconferencing, Education, Home Theater, Security, ITS, Industrial Monitoring, Digital Signage, Government/Military and more!

The **Pure Digital Fiberlink**<sup>®</sup> line offers an extensive and affordable family of fiber optic transmission systems for the Professional A/V marketplace and includes several ground-breaking products for the transmission of high-resolution RGB signals. Systems for point-to-point and point-to-multipoint signal distribution make these products highly desirable for any Pro A/V applications.

Our premier product line, the **Scan Do**<sup>®</sup> family of computer to video scan converters, has redefined industry standards in computer video to NTSC/PAL technology with unsurpassed performance in its price range. All models support high resolutions and refresh rates and are VGA and Mac<sup>®</sup> compatible. The feature-rich and versatile Scan Do family offers the widest range of scan converters on the market.

The award-winning, **Deuce**<sup>®</sup> video scalers convert NTSC and PAL to high-resolution, non-interlaced video and offer a far superior and affordable alternative to line doubling and quadrupling. The new generation of Deuce products offer a wide range of non-interlaced resolutions and refresh rates for every application, from professional A/V installations to home theater, including a model designed especially for use with HDTV displays.

In addition, CSI manufactures a comprehensive selection of distribution amplifiers, VGA monitor, keyboard and mouse extenders and accessories for our entire product line.

Communications Specialties and its products have been the recipient of numerous industry awards. In 2005, the Pure Digital Fiberlink® 7220 Series for high-resolution RGB and Stereo Audio was honored as one of the AV industry's best technological innovations of the year by receiving a "rAVE Radical Product of the Year" award as "Best New Analog Signal Processing Product". The rAVE email newsletter is published by professional audiovisual industry veterans and is read industry-wide.

Among CSI's many other awards are AV Video Magazine's Platinum Award (given to Scan Do® Ultra and Deuce®) and the Video Systems' Vanguard Award (given to Deuce).

The company is headquartered in the United States on Long Island, New York, with Sales Offices in Florida, Indiana and Virginia. Research, development, design, engineering, manufacturing and customer support operations are performed at the New York headquarters. Other locations include Communications Specialties Pte Ltd (CSPL) - a wholly owned subsidiary office in Singapore that provides support to distributors in the Far East and Pacific Rim.

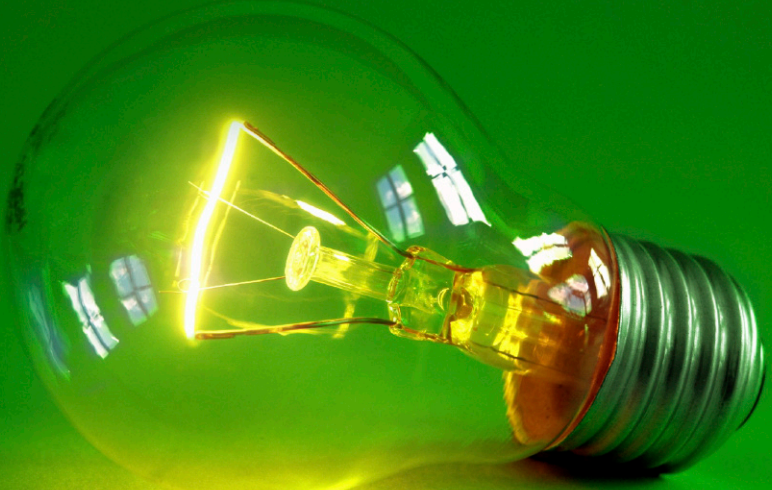
Our in-house sales department handles complete product-line sales directly to end-users as well as to an international network of representatives and resellers. All of our products are backed by an exceptional warranty.

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