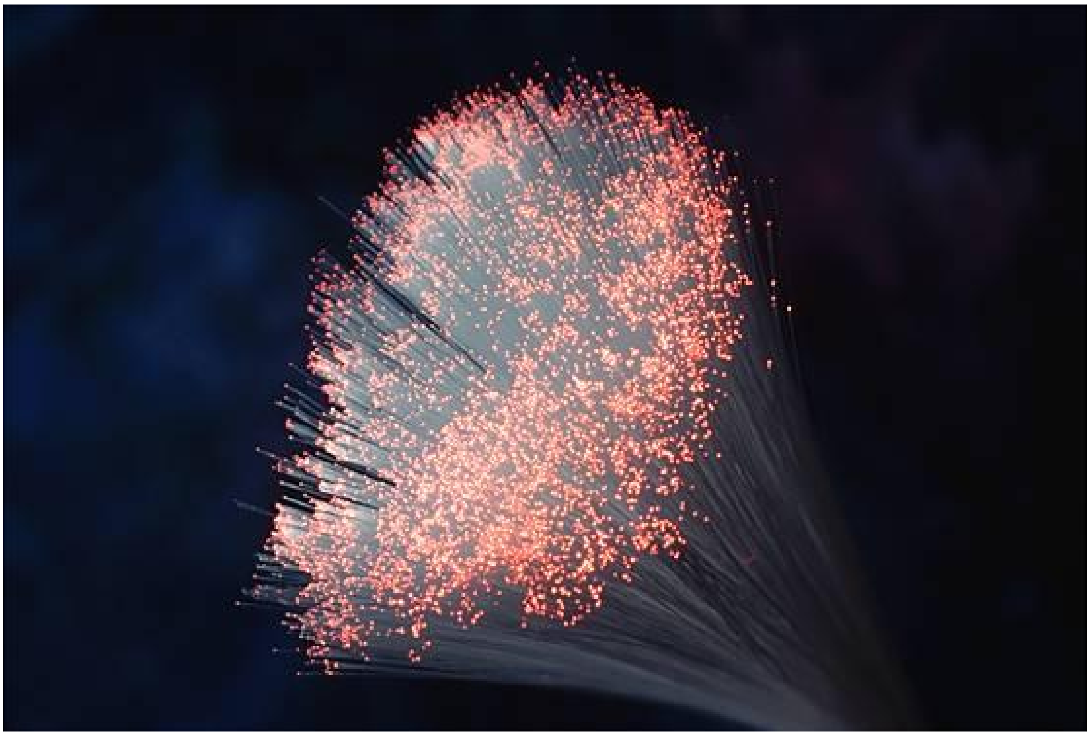
Application of
Fiber Optic Passive Components



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Abstract

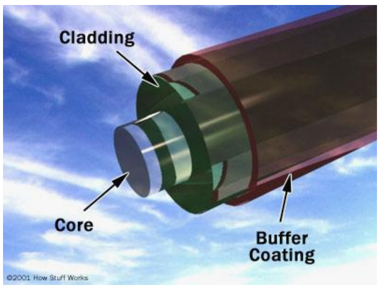
There are many different types of components used for communication via fiber optic cable. However, all these components fall under two categories, fiber optic active component and fiber optic passive component. The fiber passive components, those which require no input power to function, include but are not limited to such devices as fiber optic connectors and splices, two simple components that join two pieces of fiber. More complex devices include optical couplers, fiber optic multiplexers and demultiplexers, optical filters, and isolators. These devices are generally used to split and combine signals, or alter them in various other manners. All of these devices are vital to the communications industry, as they not only make possible fiber optic communication, but also allow for more complex signals, leading to higher traffic availability, thus allowing for higher levels of communication. This allows for more versatile applications of fiber optic as the preferred medium for communication.

Application of Fiber Optic Passive Components

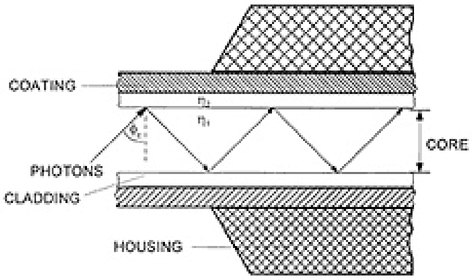
As man ventures into the Information Age, the need for high speed communication in many new fields will be the driving force behind technological expansion. At the heart of this expansion lies the communications industry, the provider of high-speed data transfer. The future of this industry depends on high bandwidth communication, which is limited by the medium of transfer. The question facing many leading edge companies is that of a reliable, high-speed, high-bandwidth medium, and the conclusion drawn by most is optical fiber. Little more than a highly refined piece of glass, this fiber holds the key to the future of the communications industry, and the expansion of technology.

Fiber optic communication deals with the generation of a light beam that modulates a sound wave. Thousands of these beams can be combined into one wave for transmission, and thousands of these can be transmitted in one fiber, and then split into separate voices on the receiving end. This requires several components to function properly and quickly, ranging from multiplexers and demultiplexers that combine signals to couplers that join fibers, and various other devices route signals. Other components include amplifiers to add power to a signal for long-haul communication, and lasers to generate light. All components can be classified into two categories, passive and active. Passive components are those that require no input power to function, and include the actual fiber itself, coupler, connectors, isolators, multiplexers and demultiplexers, and various others. Active components are those that require power to function, such as amplifiers and lasers. Passive components handle a large amount of the work in fiber optic communication, as they not only perform such jobs as combining, dropping, adding, filtering, or routing signals, but also carry the signal itself. (Hecht, 1999)

The most obvious example of a passive component used in optical communication is the fiber itself. An optical fiber is a very high-grade glass strand, smaller in diameter than a human hair. There are two types of these fibers, single-mode, which transmits only one signal, and multi-mode, which transmits 100's of signals simultaneously. Composed of several parts, both fibers are constructed the same, having a glass or plastic fiber at the center called the core, which is surrounded by cladding, and both are encapsulated by a plastic shield. A single mode fiber is much smaller than a multi-mode fiber, having a core diameter of merely 9 microns, or 3.5×10^{-4} inches, as compared to a multi-mode fiber, whose core is 2.5×10^{-3} inches in diameter. Thousands of these fibers are bundled together around a reinforced



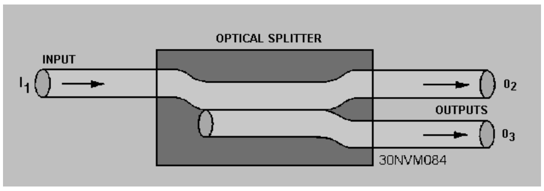
center to form a cable, and then protected by a jacket. (Freudenrich)



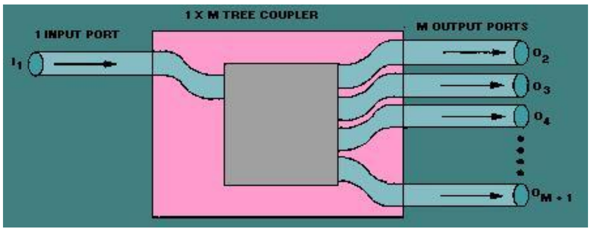
The principle upon which an optical fiber works is simple, relying on total internal reflection of the light signal inside the core. A light beam generated by a laser strikes the wall of a fiber and is reflected inwards, only to bounce again, trapped inside the cabling. (Fiber Optics)

Inevitably, a single fiber cannot stretch endlessly to its destination. To this end, fiber optics must often be joined to form one cable, seamlessly connecting end to end to make one cable. This can be achieved through a variety of means, generally utilizing a connector or splice. A splice is a permanent fusion of the two fibers together, melting them to form one. A connector is an easily removable device that holds the two ends perfectly aligned, allowing communication and simple removal.

However, multiple fibers often require joining together at a junction, either to drop or add signals, or simply to reduce traffic in one fiber. Passive components that perform this task are referred to as couplers, and there are several types of this device. The simplest form of a coupler is a three-port T or Y coupler (see left), also called a tap



because it is most commonly used to drop a line from the carrier to make a new loop. This device splits a signal into two, and can be configured to drop one wavelength in a certain direction, while all others travel together in another direction. A second type of coupler, called a tree coupler (see below), takes a single input and splits it among several output fibers, or receives several inputs and combines them into one output. Yet another type of coupler is the star coupler, named so for its geometry. Often containing multiple inputs and outputs, these devices can operate in a variety of manners. Some devices are directional, sending an input to a certain output at all times. Other devices receive several inputs and distribute them all evenly among outputs.



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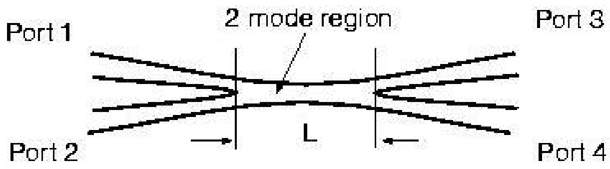
A basic four-port fused coupler (see below) has many applications in communication, including use as a three-port coupler. One of the input or output leads can be removed to form such a device. Also, it can be applied to amplification to add a short lead crossing the main fiber in order to form a channel for the pump signal, as it does not actually remain in the carrier fiber. (Hecht, 1999)

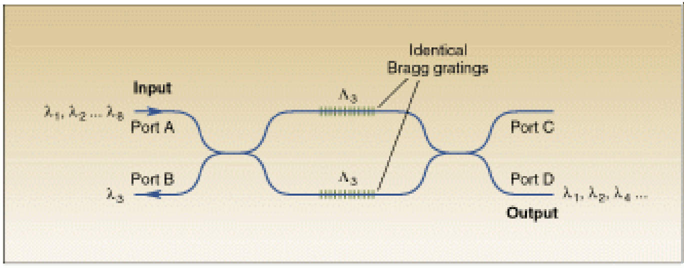


A separate family of couplers, the wavelength-selective group can be any of the above coupler types, but configured to send a specific input wavelength to a certain output. This type of component is used for a variety of means within optical communication, most often multiplexing. Multiplexing, as defined by the Free Online Dictionary of Computing, is the act of combining several signals for transmission on a shared medium (in this case optical fiber). The signals are combined by a multiplexer, transmitted in bulk through the fiber, and then separated on the receiving end. (Multiplexing, 1995)

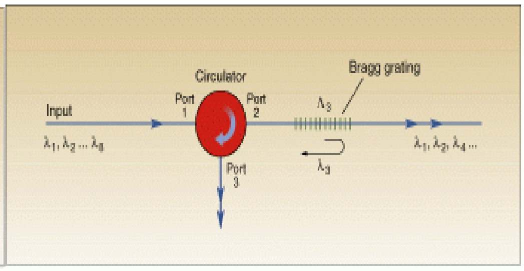
A multiplexer is a very important device in optics, as it allows for high traffic to be used in one fiber, therefore faster and more versatile communication can be achieved. To utilize the full potential of multi-mode fiber, to transmit large quantities of data efficiently, many signals of different wavelengths must be combined into one beam of many wavelengths, and transmitted through the fiber, then demultiplexed on the receiving end, to be routed to their appropriate locations. Tree couplers can be applied to both of these applications. (Hecht, 1999)

Another often-used component in optical transmission is Bragg grating, a component built into the fiber itself. A Bragg grating is a piece of fiber in which the index of refraction alternates between high and low in one part of the fiber. Based on the Bragg effect, they act like light selective mirrors, reflecting one wavelength and letting the rest through with virtually no attenuation. Used to filter out a wavelength or a group of wavelengths, this special type of fiber has several applications, such as multiplexing, dropping signals, and dispersion compensation.

To be applied to multiplexing, one must place a piece of grated fiber on one port of a circulator (see right), a device that sends a signal in a certain direction depending on the direction of entry. The grated fiber can reflect one wavelength, and let all others pass. The reflected wavelength will then pass out through a third port, effectively dropping a signal from the carrier. Another such device can be placed on the same node of a loop, to add a signal. Paired, two sets of circulators with Bragg gratings can drop and add signals, effectively forming a multiplexer. However, this setup uses a circulator, and can be simplified into another form, using two fibers. If two fibers with grated regions are coupled together on each end of the grating (see left), it can be used to separate one wavelength from the group and exit through one port, while the others will continue through the grated region and exit through a separate port. This device can be slightly altered to form a drop, or used as it is and used for multiplexing, adding another signal just after the gratings.

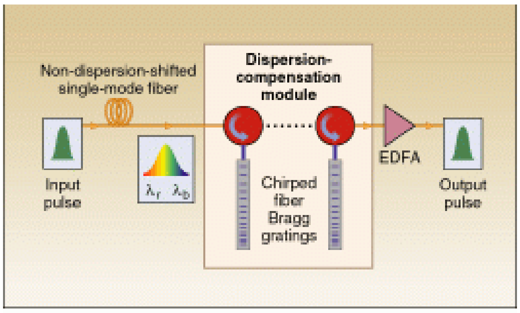


11-FOH-1 Fig. 3



11-FOH-1 Fig. 2

Another application of grated fiber is to reduce the effects of chromatic dispersion, a problem caused by the natural phenomenon of lights of different wavelengths traveling at different speeds. If a signal travels far enough, the different wavelengths will become separated and undistinguishable at the receiving end. To correct this problem, a special type of grating referred to as chirped fiber grating is used (see right), in which different wavelengths are reflected at different places along the grating, forcing certain wavelengths to travel farther before being reflected. In a practical application, light enters a circulator, and the dispersed wavelengths are all sent into a short piece of this chirped grating. The slower traveling wavelengths are reflected before the faster traveling wavelengths, and all are in sequence when they exit through the third port of a circulator. (Juma, 1996)



11-FOH-1 Fig. 4

The future of communications technology is uncertain. However, one can rest assured that fiber optics will pave the way for newer and unimagined applications of data transfer and ease of life. As this field is more highly refined, newer applications of these passive devices will be discovered, and the speed scope of communication will grow exponentially.