OPTICAL FIBER COMMUNICATION.

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Introduction

In recent years it has become apparent that fiber-optics are steadily replacing copper wire as an appropriate means of communication signal transmission. They span the long distances between local phone systems as well as providing the backbone for many network systems. Other system users include cable television services, university campuses, office buildings, industrial plants, and electric utility companies. This is an overview of fiber-optic technology, telecommunication applications, fiber-optic advantages and disadvantages, and fiber-optic economics.

Fiber Optic Technology

A fiber-optic system is similar to the copper wire system that fiber-optics is replacing. The difference is that fiber-optics use light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the components in a fiber-optic chain will give a better understanding of how the system works in conjunction with wire based systems.

At one end of the system is a transmitter. This is the place of origin for information coming on to fiber-optic lines. The transmitter accepts coded electronic pulse information coming from copper wire. It then processes and translates that information into equivalently coded light pulses. A light-emitting diode (LED) or an injection-laser diode (ILD) can be used for generating the light pulses. Using a lens, the light pulses are funneled into the fiber-optic medium where they transmit themselves down the line.

Light pulses move easily down the fiber-optic line because of a principle known as total internal reflection. "This principle of total internal reflection states that when the angle of incidence exceeds a critical value, light cannot get out of the glass; instead, the light bounces back in. When this principle is applied to the construction of the fiber-optic strand, it is possible to transmit information down fiber lines in the form of light pulses. There are generally five elements that make up the construction of a fiber-optic strand, or cable: the optic core, optic cladding, a buffer material, a strength material and the outer jacket (Fig. 1). The optic core is the light carrying element at the center of the optical fiber. It is commonly made from a combination of silica and Germania. Surrounding the core is the optic cladding made of pure silica. It is this combination that makes the principle of total internal reflection possible. The difference in materials used in the making of the core and the cladding creates an extremely reflective surface at the point in which they interface. Light pulses entering the fiber core reflect off the core/cladding interface and thus remain within the core as they move down the line.

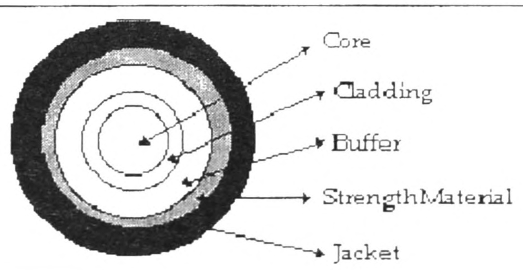


Fig. 1. Cut away of a fiber-optic cable.

Surrounding the cladding is a buffer material used to help shield the core and cladding from damage. A strength material surrounds the buffer, preventing stretch problems when the fiber cable is being pulled. The outer jacket is added to protect against abrasion, solvents, and other contaminants.

Once the light pulses reach their destination they are channeled into the optical receiver. "The basic purpose of an optical receiver is to detect the received light incident on it and to convert it to an electrical signal containing the information impressed on the light at the transmitting end. The electronic information is then ready for input into electronic based communication devices, such as a computer, telephone, or TV.

Fiber Optic Applications

The use of fiber-optics was generally not available until 1970 when Corning Glass Works was able to produce a fiber with a loss of 20 dB/km. It was recognized that optical fiber would be feasible for telecommunication transmission only if glass could be developed so pure that attenuation would be 20dB/km or less. That is, 1% of the light would remain after traveling 1 km. Today's optical fiber attenuation ranges from 0.5dB/km to 1000dB/km depending on the optical fiber used. Attenuation limits are based on intended application.

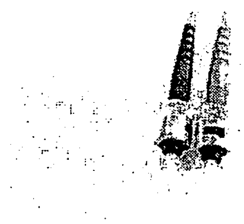
The applications of optical fiber communications have increased at a rapid rate, since the first commercial installation of a fiber-optic system in 1977. Telephone companies began early on, replacing their old copper wire systems with optical fiber lines. Today's telephone companies use optical fiber throughout their system as the backbone architecture and as the long-distance connection between city phone systems.

Cable television companies have also begun integrating fiber-optics into their cable systems. The trunk lines that connect central offices have generally been replaced with optical fiber. Some providers have begun experimenting with fiber to the curb using a fiber/coaxial hybrid. Such a hybrid allows for the integration of fiber and coaxial at a neighborhood location. This location, called a node, would provide the optical receiver that converts the light impulses back to electronic signals. The signals could then be fed to individual homes via coaxial cable.

Local Area Networks (LAN) is a collective group of computers, or computer systems, connected to each other allowing for shared program software or data bases. Colleges, universities, office buildings, and industrial plants, just to name a few, all make use of optical fiber within their LAN systems.

Power companies are an emerging group that has begun to utilize fiber-optics in their communication systems. Most power utilities already have fiber-optic communication systems in use for monitoring their power grid systems.

Termination and splicing of fiber optic cables



ST connectors on multi-mode fiber.

Optical fibers are connected to terminal equipment by optical fiber connectors. These connectors are usually of a standard type such as *FC*, *SC*, *ST*, *LC*, or *MTRJ*.

Optical fibers may be connected to each other by connectors or by *splicing*, that is, joining two fibers together to form a continuous optical waveguide. The generally accepted splicing method is arc fusion splicing, which melts the fiber ends together with an electric arc. For quicker fastening jobs, a "mechanical splice" is used.

Fusion splicing is done with a specialized instrument that typically operates as follows: The two cable ends are fastened inside a splice enclosure that will protect the splices, and the fiber ends are stripped of their protective polymer coating (as well as the more sturdy outer jacket, if present). The ends are *cleaved* (cut) with a precision cleaver to make them perpendicular, and are placed into special holders in the splicer. The splice is usually inspected via a magnified viewing screen to check the cleaves before and after the splice. The splicer uses small motors to align the end faces together, and emits a small spark between electrodes at the gap to burn off dust and moisture. Then the splicer generates a larger spark that raises the temperature above the melting point of the glass, fusing the ends together permanently. The location and energy of the spark is carefully controlled so that the molten core and cladding don't mix, and this minimizes optical loss. A splice loss estimate is measured by the splicer, by directing light through the cladding on one side and measuring the light leaking from the cladding on the other side. A splice loss under 0.1 dB is typical. The complexity of this process makes fiber splicing much more difficult than splicing copper wire.

Mechanical fiber splices are designed to be quicker and easier to install, but there is still the need for stripping, careful cleaning and precision cleaving. The fiber ends are aligned and held together by a precision-made sleeve, often using a clear index-matching gel that enhances the transmission of light across the joint. Such joints typically have higher optical loss and are less robust than fusion splices, especially if the gel is used. All splicing techniques involve the use of an enclosure into which the splice is placed for protection afterward.

Advantages and disadvantages of Fiber-optic technology

There are several advantages that have been established with the development and implementation of fiber-optic cable systems. Compared to copper, optical fiber is relatively small in size and light in weight. This characteristic has made it desirable as intra-floor conduits and wiring duct space has become increasing plugged with expanded copper cable installation.

Optical fiber is also desirable because of its electromagnetic immunity. Since fiber-optics use light to transmit a signal, it is not subject to electromagnetic interference, radio frequency interference, or voltage surges. This may be an important consideration when laying cables near electronic hardware such as computers or industrial equipment. As well, since it does not use electrical impulses, it does not produce electric sparks which can be an obvious fire hazard.

Advances in optical fiber technology have lead to decreases in signal loss, or attenuation. As an electric pulse or a light pulse travels down its respective cable line, it will eventually lose signal energy due to imperfections in the transmission medium. To keep the signal going, it must be boosted every so often along the medium line. A signal regenerator is used to boost the electronic pulse in a copper cable. An optical repeater is used to boost the light pulse in a fiber-optic cable. The advantage of optical fiber is that it performs better with respect to attenuation. Fiber-optic cable needs fewer boosting devices, along the same length of line, than copper cable.

A characteristic feature of optical fiber that has yet to be fully realized is it's potentially wide bandwidth. Bandwidth refers to the amount of information that a fiber can carry. The greater the bandwidth, the greater the carrying capacity of the optical fiber. It is said that currently, the fastest fiber circuits used in trunk connections between cities and countries carry information at up to 2.5 gigabits per second, enough to carry 40,000 telephone conversations or 250 television channels. Experts predict larger bandwidths than this as light frequency separation becomes available. Private communication systems are already using much higher bandwidths.

A disadvantage of the fiber-optic system is it's incompatibility with the electronic hardware systems that make up today's world. This inability to interconnect easily requires that current communication hardware systems be somewhat retrofitted to the fiber-optic networks. Much of the speed that is gained through optical fiber transmission can be inhibited at the conversion points of a fiber-optic chain. When a portion of the chain experiences heavy use, information becomes jammed in a bottleneck at the points where conversion to, or from, electronic signals is taking place. Bottlenecks like this should become less frequent as microprocessors become more efficient and fiber-optics reach closer to a direct electronic hardware interface.

Fiber-optic economics

One of the initial economic factors to consider when converting to fiber-optics is the cost of replacing wire systems with fiber. Increased demand for optical fiber has brought the prices down within competitive range of copper. Cable sales are expected to increase. However, since transmitters, converters, optical repeaters, and a variety of connecting hardware will be needed, the initial cost of changing over to fiber can be expensive. Increased demand, advances in the technology, and competition has brought the prices down somewhat.

Short term and long term gains should be considered when updating a communications system. In the short term it is often less expensive to continue using copper cabling for covering expanded communication needs. By simply adding more wire to an existing system, expanded needs can be covered. This avoids the expense of adding the transmitters and receivers needed for integrating optical fiber. Long term needs, however, may require more expansion in the future.

In the long term it may be more cost effective to invest in conversion to fiber-optics. This cost effectiveness is due to the relative ease of upgrading fiber optics to higher speeds and performance. It has already been seen in the industry as communication providers are wiring customers with optical fiber bandwidth that exceed consumer bandwidth needs. This is in anticipation of future bandwidth needs. It is generally accepted that customers will need increased bandwidth as the information highway grows. Replacing copper with fiber today would avoid continued investment in a soon to be outdated copper system.

Recent changes in the laws regulating the telecommunications industry have helped to promote and spur the use of fiber optics. The passage of the Telecommunications Act of 1996 has helped this effort by allowing television and telephone companies to enter each other's markets. Fiber optics will play a pivotal role in this race since the bandwidth needed for providing an all-in-one service with television, telephone, interactive multimedia, and internet access is not available in much of the wiring of America.

Summary

Based on industry activity, it is evident that fiber-optics have become the industry standard for terrestrial transmission of telecommunication information. The choice is not whether to convert to optical fiber, but rather when to convert to optical fiber. The bandwidth needs of the Information Superhighway require a medium, like optical fiber, that can deliver large amounts of information at a fast speed. It will be difficult for copper cable to provide for future bandwidth needs. Satellite and other broadcast media will undoubtedly play a role alongside fiber optics in the new world telecommunications order.

Considering all the services that the telecommunications industries are announcing to be just around the corner, and a modern society that seems to be expecting them, it is evident that fiber optics will continue to be a major player in the delivery of these services.

References

1). Telecommunication Engineering(.N.N.Deb)
2). Wikipedia.com