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Fiber Optic Network Applications

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Abstract: Technological changes based on the art of optical signal processing technologies and devices their limitations and thus there is increased focus on technologies that use photons. There are vast opportunities to carrying information in the field of fiber optics for communication purpose. Basically there are two types of fiber optics cables are used i.e. step graded and graded index. Fiber-optic networks have been used for decades to transmit large volumes of traffic across the country. The economics of fiber networks have only recently allowed for connecting the fiber directly to the home, creating a fiber-to-the-home (FTTH) network. FOSAPP objectives to develop a high-speed fiber optic data link, future prospects such as FTT/FISL and HFC are the challenging opportunities in the status of fiber optics in the counter's. *Fiber-optic* networks have been used for decades to transmit large volumes of traffic across the country. The economics of fiber networks have only recently allowed for connecting the fiber directly to the home, creating a fiber-to-the-home (*FTTH*) network.

Fiber optic cables:-

A fiber-optic cable is made up of incredibly thin strands of glass or plastic known as optical fibers; one cable can have as few as two strands or as many as several hundred. Each strand is less than a tenth as thick as a human hair and can carry something like 25,000 telephone calls, so an entire fiber-optic cable can easily carry several million calls.

Fiber-optic cables carry information between two places using entirely optical (light-based) technology. Suppose you wanted to send information from your computer to a friend's house down the street using fiber optics. You could hook your computer up to a laser, which would convert electrical information from the computer into a series of light pulses. Then you'd fire the laser down the fiber-optic cable. After traveling down the cable, the light beams would emerge at the other end. Your friend would need a photoelectric cell (light-detecting component) to turn the pulses of light back into electrical information his or her computer could understand. So the whole apparatus would be like a really neat, hi-tech version of the kind of telephone you can make out of two baked-bean cans and a length of string.

Key Words: Fiber Optic, Optical Fiber, Wave-Guide, Telecom Communication, FOSAPP, FTTC and HFC.

Prologue: Optical communication systems date back two centuries, to the "optical telegraph" that French engineer Claude Chappe invented in the 1790s. His system was a series of semaphores mounted on towers, Doctors Roth and Reuss, of Vienna, used bent glass rods to illuminate body cavities in 1888. French engineer Henry Saint-Rene designed a system of bent glass rods for guiding light images seven years later in an early attempt at television. In 1898, American David Smith applied for a patent on a dental illuminator using a curved glass rod. Where human operators relayed messages from one tower to the next, it beat hand-carried messages hands down, but by the mid-19th century was replaced by the electric telegraph, leaving a scattering of "Telegraph Hills" as its most visible legacy. The first non-experimental fiber-optic link was installed by the Dorset (UK) police in 1975. Two years later, the first live telephone traffic through fiber optics occurs in Long Beach, California.

Fibre will dominate enterprise networks, just as it does in today's public networks. This is since fibre will serve most access points and radio based stations in the near future, whether an enterprise user connects to the network via mobile or fixed line device. Fibre optics will carry the majority of the traffic.

To support the changing and fast-growing bandwidth needs of the Data Centre, the IEEE ratified standards for supporting 40 Gigabit and 100 Gigabit. Both single mode Fibre and OM3 and OM4 multimode fibre (OM3, OM4) were approved in the standard. Today 40Gbs Multimode uses parallel optics with MPO interconnects and requires additional cable infrastructure depending on the system deployed, while single mode fibre will use LC or SC connectors. However, Cisco has announced a new technology for deploying 40G Ethernet that has, so far, received little attention. Cisco calls that technology BiDi. Photonics is declared as on of the twelve emerging technologies, which are being tracked closely between USA and Japan, while Department of Commerce, USA, recognize prominently in the list of ten technologies Today, a variety of industries including the medical, military, telecommunication, industrial, data storage, networking, and broadcast industries are able to apply and use fiber optic technology in a variety of applications.

Fiber Optics:

As a system point of view an optical system that uses one or more glass or Perspex fibers as a light guide or for transmitting optical images. The fiber has polished surfaces coated with a material of suitable refractive index. Light entering one end within a certain solid angle undergoes total refraction at the surface and is transmitted through fiber. The technical point of view there are main two types of optical fiber wave-guide is used at the present time. There are two basic types of fiber used today and many different types of Fiber Optic Cable. The two types of fiber are called SingleMode (SM) and MultiMode (MM), and SM fiber is more expensive but more efficient than MM fiber. SingleMode fiber is generally used where the distances to be covered are greater. Cables come in a variety of configurations determined by a variety of factors. With the major research and development work being done in the field of fiber optics and its diversified applications in telecom industry and submarine communications.

Advantages of Fiber Optic Systems:

For many years it has been appreciated that the use of optical (light) waves as a carrier wave provides an enormous potential bandwidth. Optical carriers have three to six orders of magnitude higher than microwave frequencies. However, the atmosphere is a poor transmission medium for light waves. Optical communication only became a widespread option with the development of low-loss dielectric waveguide. In addition to the potential bandwidth, optical fibre communication offers a number of benefits:

a) Size, weight, flexibility. Optical fibres have very small diameters. A very large number of fibres can be carried in a cable the thickness of a coaxial cable.

b) Electrical isolation. Optical fibres are almost completely immune from external fields. They do not suffer from cross-talk, radio interference, etc.

c) Security. It is difficult to tap into an optical line. It is extremely difficult to tap into an optical line unnoticed.

d) Low transmission loss. Modern optical fibre now has better loss characteristics than coaxial cable. Fibres have been fabricated with losses as low as.

e) Bandwidth - Fibre optic cables have a much greater bandwidth than metal cables. The amount of information that can be transmitted per unit time of fibre over other transmission media is its most significant advantage.

f) With the high performance single mode cable used by telephone industries for long distance telecommunication, the bandwidth surpasses the needs of today's applications and gives room for growth tomorrow.

g) Low Power Loss - An optical fibre offers low power loss. This allows for longer transmission distances. In comparison to copper; in a network, the longest recommended copper distance is 100m while with fibre, it is 2000m.

h) Interference - Fibre optic cables are immune to electromagnetic interference. It can also be run in electrically noisy environments without concern as electrical noise will not affect fibre.

i) Size - In comparison to copper, a fibre optic cable has nearly 4.5 times as much capacity as the wire cable has and a cross sectional area that is 30 times less.

j) Weight - Fibre optic cables are much thinner and lighter than metal wires. They also occupy less space with cables of the same information capacity. Lighter weight makes fibre easier to install.

k) Safety - Since the fibre is a dielectric, it does not present a spark hazard.

l) Security - Optical fibres are difficult to tap. As they do not radiate electromagnetic energy, emissions cannot be intercepted. As physically tapping the fibre takes great skill to do undetected, fibre is the most secure medium available for carrying sensitive data.

m) Flexibility - An optical fibre has greater tensile strength than copper or steel fibres of the same diameter. It is flexible, bends easily and resists most corrosive elements that attack copper cable.

n) Cost - The raw materials for glass are plentiful, unlike copper. This means glass can be made more cheaply than copper.

Fiber optic transmission systems – a fiber optic transmitter and receiver, connected by fiber optic cable – offer a wide range of benefits not offered by traditional copper wire or coaxial cable. These include:

1. The ability to carry much more information and deliver it with greater fidelity than either copper wire or coaxial cable.

2. Fiber optic cable can support much higher data rates, and at greater distances, than coaxial cable, making it ideal for transmission of serial digital data.

3. The fiber is totally immune to virtually all kinds of interference, including lightning, and will not conduct electricity. It can therefore come in direct contact with high voltage electrical equipment and power lines. It will also not create ground loops of any kind.

4. As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil or exposed to most corrosive atmospheres in chemical plants without significant concern.

5. Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber. Even in the most explosive of atmospheres, there is no fire hazard, and no danger of electrical shock to personnel repairing broken fibers.

6. Fiber optic cables are virtually unaffected by outdoor atmospheric conditions, allowing them to be lashed directly to telephone poles or existing electrical cables without concern for extraneous signal pickup.

7. A fiber optic cable, even one that contains many fibers, is usually much smaller and lighter in weight than a wire or coaxial cable with similar information carrying capacity. It is easier to handle and install, and uses less duct space. (It can frequently be installed without ducts.)

8. Fiber optic cable is ideal for secure communications systems because it is very difficult to tap but very easy to monitor. In addition, there is absolutely no electrical radiation from a fiber.

An appreciation of the underlying technology will provide a useful framework for understanding the reasons behind its many benefits.

The primary disadvantage of optical fibre is the technical difficulties associated with reliable and cheap connections, and the development of an optical circuit technology that can match the potential data-rates of the cables. The speed of these circuits, which are electronically controlled, is usually the limiting factor on the bit-rate. The difficulty of connection and high-cost of associated circuitry result in optical fibres being used only in very high bit-rate communication. There is considerable current debate as to whether optics will ever completely replace electronic technology. In addition, good phase control of an optical signal is extremely difficult. Optical communications are forced to use the comparatively crude method of ASK modulation.

Fiber Properties

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Numerical aperture (NA) of the fiber defines which light will be propagated and which will not. NA defines the light-gathering ability of the fiber. Imagine a cone coming from the core. Light entering the core from within this cone will be propagated by total internal reflection. Light entering from outside the cone will not be propagated.

A high NA gathers more light, but lowers the bandwidth. A lower NA increases bandwidth.

NA has an important consequence. A large NA makes it easier to inject more light into a fiber, while a small NA tends to give the fiber a higher bandwidth. A large NA allows greater modal dispersion by allowing more modes in which light can travel. A smaller NA reduces dispersion by limiting the number of modes

Bandwidth: Fiber bandwidth is given in MHz-km. A product of frequency and distance, bandwidth scales with distance: if you half the distance, you double the frequency. If you double the distance, you half the frequency. What does this mean in premises cabling? For a 100-meter run (as allowed for twisted pair cable), the bandwidth for 62.5/125-micrometer fiber is 1600 MHz at 850 nm and 5000 MHz at 1300 nm. For the 2-km spans allowed for most fiber networks, bandwidth is 80 MHz at 850 nm and 250 MHz at 1300 nm. With singlemode fibers, the bandwidth for a 100-meter run is about 888 GHz.

Attenuation: Attenuation is loss of power. During transit, light pulses lose some of their energy. Attenuation for a fiber is specified in decibels per kilometer (dB/km). For commercially available fibers, attenuation ranges from approximately 0.5 dB/km for singlemode fibers to 1000 dB/km for large-core plastic fibers.

Attenuation varies with the wavelength of light. There are three low-loss "windows" of interest: 850 nm, 1300 nm, and 1550 nm. The 850-nm window is perhaps the most widely used because 850-nm devices are inexpensive. The 1300-nm window offers lower loss, but at a modest increase in cost for LEDs. The 1550-nm window today is mainly of interest to long-distance telecommunications applications.

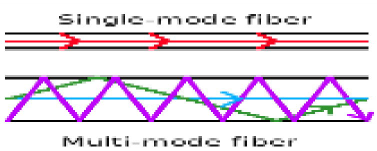
A cross-section of a typical fiber optic cable showing the core, cladding, Kevlar reinforcement, and outer jacket.

The simplest type of optical fiber is called single-mode. It has a very thin core about 5-10 microns (millionths of a meter) in diameter. In a single-mode fiber, all signals travel straight down the middle without bouncing off the edges (red line in diagram). Cable TV, Internet, and telephone signals are generally carried by single-mode fibers, wrapped together into a huge bundle. Cables like this can send information over 100 km (60 miles).

Another type of fiber-optic cable is called multi-mode. Each optical fiber in a multi-mode cable is about 10 times bigger than one in a single-mode cable. This means light beams can travel through the core by following a variety of different paths (purple, green, and blue lines)—in other words, in multiple different modes. Multi-mode cables can send information only over relatively short distances and are used (among other things) to link computer networks together.

Even thicker fibers are used in a medical tool called a gastroscope (a type of endoscope), which doctors poke down someone's throat for detecting illnesses inside their stomach. A gastroscope is a thick fiber-optic cable consisting of many optical fibers. At the top end of a gastroscope, there is an eyepiece and a lamp. The lamp shines its light down one part of the cable into the patient's stomach. When the light reaches the stomach, it reflects off the stomach walls into a lens at the bottom of the cable. Then it travels back up another part of the cable into the doctor's eyepiece. Other types of endoscopes work the same way and can be used to inspect different parts of the body. There is also an industrial version of the tool, called a fiberscope, which can be used to examine things like inaccessible pieces of machinery in airplane engines.

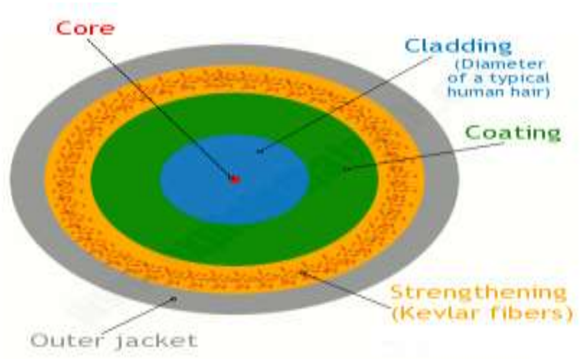
Types of fiber-optic cables



Optical fibers carry light signals down them in what are called modes. That sounds technical but it just means different ways of traveling: a mode is simply the path that a light beam follows down the fiber. One mode is to go straight down the middle of the fiber. Another is to bounce down the fiber at a shallow angle.

Other modes involve bouncing down the fiber at other angles, more or less steep.

Artworks: Above: Light travels in different ways in single-mode and multi-mode fibers. Below: Inside a typical single-mode fiber cable (not drawn to scale). The thin core is surrounded by cladding roughly ten times bigger in diameter, a plastic outer coating (about twice the diameter of the cladding), some strengthening fibers made of a tough material such as Kevlar, with a protective outer jacket on the outside.



Epilogue:

An optical fiber (or fibre in British English) is a transparent thin fiber for transmitting light . Fiber optics is the branch of science and engineering concerned with optical fibers. The optical fiber can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables. Although fibers can be made out of either plastic or glass, the fibers used in long-distance telecommunications applications are always glass, because of the lower optical absorption of glass. The light transmitted through the fiber is confined due to total internal reflection within the material. This is an important property that eliminates signal crosstalk between fibers within the cable and allows the routing of the cable with twists and turns. In telecommunications applications, the light used is typically infrared light, at wavelengths nea r to the minimum absorption wavelength of the fiber in use.

Fiber optic is emerging field in the Indian context and there are vast opportunities to information carrying capacity in the fiber optics panorama. The biggest challenge remaining for fiber optics is economic. Today telephone and cable television companies can cost-justify installing fiber links to remote sites serving tens to a few hundreds of customers. However, terminal equipment remains too expensive to justify installing fibers all the way to homes, at least for present services. Instead, cable and phone companies run twisted wire pairs or coaxial cables from optical network units to individual homes. Time will see how long that lasts.

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