History and Application Of Fiber Optics

History of Fiber Optics

A technology that uses glass (or plastic) threads (fibers) to transmit data. A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves. History of optical fiber began with the invention of “optical telegraph” by French Chappe brothers. Optical telegraph is the system comprised of series of light mounted on towers where operators would relay a message from one tower to another.

Then in 1840, Physicists Daniel collodon and Jacques Babinet showed that light could be directed along jet of water for fountain.

http://en.wikipedia.org/wiki/Optical_fiber

Fig. Daniel Colladon first described this “light fountain” or “light pipe” in an 1842 article entitled On the reflections of a ray of light inside a parabolic liquid stream.
John Tyndall also demonstrated it in public lectures in 1854. He also wrote about the property of total internal reflection.

Fig. John Tyndall British physicist

“When the light passes from air into water, the refracted ray are bent towards the perpendicular. When the ray passes from water to air it is bent from the perpendicular. If the angle which the ray in water encloses with the perpendicular to the surface be greater than 48 degrees, the ray will not quit the water at all: it will be totally reflected at the surface.” The angle which marks the limit where total reflection begins is called the limiting angle of the medium.

In 1880, Alexander Graham Bell invented his 'Photophone', which transmitted a voice signal on a beam of light. Bell focused sunlight with a mirror and then talked into a mechanism that vibrated the mirror. At the receiving end, a detector picked up the vibrating beam and decoded it back into a voice the same way a phone did with electrical signals.

Doctors Roth and Reuss, of Vienna, used bent glass rods to illuminate body cavities in 1888.

In 1930, German medical student, Heinrich Lamm was the first person to assemble a bundle of optical fibers to carry an image. Lamm's goal was to look inside inaccessible parts of the body. During his experiments, he reported transmitting the image of a light bulb.

In 1973, Bell Laboratories developed a modified chemical vapor deposition process that heats chemical vapors and oxygen to form ultra-transparent glass that can be mass-produced into low-loss optical fiber. This process still remains the standard for fiber-optic cable manufacturing.

In the late 1970s and early 1980s, telephone companies began to use fibers extensively to rebuild their communications infrastructure.
After this, series of the discoveries are made in the progression of optical fiber till now. Today more than 80 percent of the world's long-distance traffic is carried over optical fiber cables, 25 million kilometers of the cable Maurer, Keck and Schultz designed has been installed worldwide.

The History of Fiber Optics in Telecommunications

In 1870, John Tyndall demonstrated that light follows the curve of a stream of water pouring from a container. It was this simple principle that led to the study and development of applications for this phenomenon. In 1926, John Logie Baird patented an early type of colour TV using glass rods to carry the light, but the optical losses inherent in the materials at the time made it impractical to use. In the 1950’s more research and development into the transmission of visible images through optical fibres led to some success in the medical world, for example early fibroscopes. In 1966 Charles Kao and George Hockham proposed the transmission of information over glass fibre, concluding that to make it a practical proposition, much lower losses in the cables were essential. In 1968, fibre had losses of typically 100db/km, and it was thought that if this could be reduced to at least 20db/km, fibre could be used for telecommunications. This was the driving force behind the developments to improve the optical losses in fibre manufacturing, and in 1970, Corning Glass were credited for manufacturing the first fibre with a loss of 20db/km.

Telecommunications engineers and scientists continued to undertake research and development into optical fibres, and groundbreaking work at British Telecom’s laboratories at Martlesham in the late 1970s finally created glass fibre that was pure enough for the technology's potential to be fully developed.

Key developments that followed include:-

1978

- The first optical cable system in Europe to form part of the public telephone network was installed between the Post Office Research Centre at Martlesham and Ipswich telephone exchange.
- The world's first purpose-designed optical fibre submarine cable, a five nautical mile test loop, was laid in Loch Fyne, Scotland
- The first operational optical fibre link in Great Britain went into service between Brownhills and Walsall in the West Midlands, a distance of 9 km.

1982

The world's longest optical fibre telephone cable was brought into service between London and Birmingham.

1984

The world's first 140 Mbit/s single-mode optical fibre system was opened between Milton Keynes and Luton.

1985

The first UK operational undersea optical fibre cable was laid, linking the Isle of Wight to the mainland across the Solent.
1986
The first international optical fibre undersea link between the United Kingdom and Belgium was opened.

1988
The City Fibre Network, the UK's first fibre optic network, was opened in the City of London on 27 January by Iain Vallance, British Telecom's Chairman. An optical fibre undersea link to the Isle of Man - the longest un-regenerated system in Europe - was inaugurated on 28 March. The following year, the equivalent of 25,000 simultaneous telephone conversations was carried over a single optical fibre link in the optical submarine cable. TAT 8, the world's first transoceanic optical fibre cable, came into service. It was laid between Tuckerton, New Jersey, USA and Widemouth Bay, Britain via Penmarch, France and with a capacity of 280 Mbits/s capable of carrying 40,000 telephone channels simultaneously.

1992
A new transatlantic fibre optic cable (TAT 9) came into service linking the United States, Canada, the United Kingdom, France and Spain. The cable measured 9,000 kilometres in length and with a capacity of 560 Mbits/s capable of carrying 80,000 telephone channels. The TAT 10 transatlantic telephone cable was laid, linking the USA, Germany and Holland with a capacity of 560 Mbit/s (3 x 565 links).

1999
BT announced that it had pushed commercial optical fibre transmission to 80Gbit/s.

2012
Fast forward twenty years from TAT 10 to present day, 2012 and we have major undersea cabling projects being constructed for example; Emerald Express - a new trans-Atlantic undersea cable system along the "Great Circle" route connecting North America with Europe via Iceland, with six optic fibre pairs and a cable length of 5,200 km. Emerald Express is designed to support 100 x 100 Gbps on each of its six fibre pairs. The Emerald Express trans-Atlantic submarine cable system is expected to be ready for service in the end of 2012, aims to be the first 100 Gbps, long-haul, undersea fibre cable. Project Express a cable system which will provide connectivity between New York and London, initially using 40G technology with future upgrades to 100G possible.

It is claimed that Project Express will offer the lowest latency route from New York to London with less than a 60 millisecond round trip, making it the fastest and most direct route connecting both major continents.

Project Express will become an essential route on Hibernia Atlantic's GFN. Built specifically for the financial community, the GFN meets demanding performance and reliability requirements. Huawei Marine Networks, a strategic alliance between Huawei and Global Marine Systems is presently undertaking the installation work due for completion late 2012.

Application of fiber optics
Fiber optic cables are tubes of glass that find a host of uses in a variety of fields. Fiber optics have become increasingly more integrated into networks where they facilitate telecommunication applications. Since these cables are flexible and inert, they are often used in medicine during surgeries as light guides and imaging tools. Fiber optic cables are also used in industrial settings for imaging locations that are difficult to reach through conventional means.

Telecommunication uses

![Fiber optic cable](image)

Fiber optical cables have made excellent mediums for telecommunication networks due to their flexibility and durability. Optics fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Fiber is laid and used for transmitting and receiving purposes. Unlike electrical cables, signals transmitted using fiber optics experience relatively little loss of intensity, allowing them to transport information far distances with few repeaters. Fiber optic cables can carry a large number of different signals simultaneously through a technique called wavelength division multiplexing. This increases their efficiency and makes them ideal for transporting large quantities of independent signals. Their effectiveness is further helped by their immunity to electrical interference.

Optical fibers are ideally suited for carrying digital information, which is especially useful in computer and cellular networks. Higher carrying capacity, less signal degradation, low power, lightweight and flexible make the fiber optics ideal media for telecommunications.

Biomedical Applications
In medicine, optical fibers enable physicians to look and work inside the body through tiny incisions without having to perform surgery. They are used for endoscopes— instruments for viewing the interior of hollow organs in the body. Most endoscopes have two sets of fibers: an outer ring of incoherent fibers that supplies the light, and an inner coherent bundle that transmits the image. Endoscopes may be designed to look into specific areas. For example, physicians use an arthroscope to examine knees, shoulders, and other joints. In some models, a third set of fibers transmits a laser beam that is used to stop bleeding or to burn away diseased tissue. Body temperatures can be measured using optical fiber. They can also be used for insertion into blood vessels to give a quick, accurate analysis of blood chemistry.

Fiber optic cables are found in hospitals and doctor's offices around the world. They form the backbone of advanced imaging techniques used in digital diagnostics since they can efficiently transport large quantities of sensitive data. Since fiber optical cables are inert, they introduce no risk of infection. Their flexibility make fiber optic cables the natural choice for endoscopes used in minimally invasive surgical procedures. The rise of endoscopy has replaced invasive exploratory surgery in diagnosing difficult medical conditions.

**Fiber Optic Cable Sensors**

Fiber optic cables sensors are used to measure a variety of physical properties such as mechanical strain, temperature, and pressure. Their small size allows them to be used in locations that are difficult to reach. Some fiber optic sensors measure these properties directly by using modulated light. Other sensors employ fiber optics as carriers to bring light from hostile environments to sensitive sensors located in more secure positions. One example is the fiber optic gyroscope, which can detect mechanical rotation without any moving parts.
Extrinsic fiber optic sensors use an optical fiber cable, normally a multimode one, to transmit modulated light from either a non-fiber optical sensor, or an electronic sensor connected to an optical transmitter. A major benefit of extrinsic sensors is their ability to reach places which are otherwise inaccessible. An example is the measurement of temperature inside aircraft jet engines by using a fiber to transmit radiation into a radiation pyrometer located outside the engine. Extrinsic sensors can also be used in the same way to measure the internal temperature of electrical transformers, where the extreme electromagnetic fields present make other measurement techniques impossible.

A fiber-optic sensor system consists of a fiber-optic cable connected to a remote sensor, or amplifier.

![Diagram of a fiber-optic sensor system](image)

The sensor emits, receives, and converts the light energy into an electrical signal. The cable is the mechanical component that transports the light into and out of areas that are either too space constrained or too hostile back to the sensor.

**Fiber Optic Lasers**

Fiber optic cables make convenient lasers since they are small and flexible. Cables used in lasing require the addition of rare earth elements like erbium. The fiber must be optically pumped using a separate laser, which is coupled into the optical cable. The fiber optic laser has many advantages that outweigh these limitations. The high intensity light can be transmitted substantial distances without much loss of power. The flexibility and durability of the fiber optic cable allow the laser to be brought into hazardous environments where conventional lasers would be unable to operate.
The invention of the laser made it possible to build optical communication systems with significant advantages:

1. Very high concentration of optical power and very little spread of that power with distance (low beam divergence).
2. Ability to carry huge amounts of information (high information bandwidth).
3. Small antennas required (compared to radio-frequency communication systems).
4. Narrow spectral linewidth, allowing the rejection of light except at the laser wavelength.
5. Coherence, allowing use of techniques such as frequency modulation and superheterodyne detection, which have been extremely useful in electronic communication.

Other uses of optical fibers

Fiber optics are used to connect users and servers in a variety of network settings and help increase the speed and accuracy of data transmission. They are also used in military as hydrophones for seismic and SONAR uses, as wiring in aircraft, submarines and other vehicles and also for field networking. Broadcast/cable companies are using fiber optic cables for wiring CATV, HDTV, internet, video on-demand and other applications. In industries and companies, it is used for imaging in hard to reach areas, as wiring where EMI is an issue, as sensory devices to make temperature, pressure and other measurements, and as wiring in automobiles and in industrial settings.

Optical fibers are also widely used in illumination applications. They are used as light guides in medical and other applications where bright light needs to be shone on a target without a clear line-of-sight path. In some buildings, optical fibers route sunlight from the roof to other parts of the building. Optical fiber illumination is also used for decorative applications, including art, toys and artificial Christmas trees.

Youtube Video

http://www.youtube.com/watch?v=0MwMkBET_5I

References