Introduction to Fibre Optics

White paper

Introduction

In today's networks, it is almost impossible to find a network professional who has never been in touch with fibre-based links between switches, routers, or other network devices. The widespread use of fibres makes a lot of sense, since a single strand of fibre can provide very high capacity.

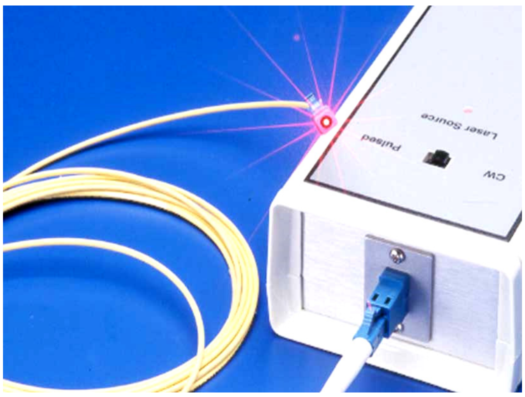
Some of the first commercial fibre links were deployed in the mid-1970's and operated at 45 Mbit/sec. Since then, research and development has allowed a single strand of fibre to carry in excess of 100 Terabits/sec. Although these kinds of speeds may not be commercially available today, it proves that fibre-based communication is the best bet we have in terms of providing the ever-rising need of more bandwidth in the future.

Fibre optic technology uses glass (or plastic) threads (fibres) to transmit data. Fibre optics is the contained transmission of light through long fibre rods of either glass or plastics. The light travels by process of internal reflection. The core medium of the rod or cable is more reflective than the material surrounding the core. That causes the light to keep being reflected back into the core where it can continue to travel down the fibre. Fibre optic cables are used for transmitting voice, images, and other data at close to the speed of light.

This white paper gives a brief introduction about fibre optics and its applications.

What is Fibre Optic?

Optical fibres, with the exception of some types of communication fibre, are all composed of two distinct and different types of optically conducting material. For simplicity, the term glass will be used for all types of fibre. Fibre Optic Communication is basically transmitting communications signals over hair thin strands of glass (or plastic). It is not a "new" technology and its concept is a century old. This technology is being used commercially for last 25 years.



Optical fibres are long, thin strands of very pure glass about the diameter of a human hair. They are arranged in bundles called fibre optic cables and used to transmit light signals over long distances.

Fibre Capacity & it's Use

Fibre Channel is fast becoming the gigabit-per-second interconnect technology of choice for high-speed system designers. It performs extremely well for storage, networks, video, data acquisition and many other applications. Below are some of the advantages and parameters to understand it's capacity:

- Economical - Several miles of optical cable can be made cheaper than equivalent lengths of copper wire. This saves your provider (cable TV, Internet) and you money.
- Speed - Fibre optic networks operate at high speeds - up into the gigabits.
- Distance - Signals can be transmitted further without needing to be "refreshed" or strengthened.
- Weight/size - Fibre optic cables are much thinner and lighter than metal wires. They take up less space in the ground.
- Bigger data capacity - Because optical fibres are thinner than copper wires, more fibres can be bundled into a given-diameter cable than copper wires. This allows more phone lines to go over the same cable or more channels to come through the cable into your cable TV box.

- Freedom from interference - Less signal degradation – The loss of signal in optical fibre is less than in copper wire.

- Electrical isolation / No electrical hazard - With fibre optics, you reap immunity to radio frequency interference, crosstalk, and additional electrometric-related interferences. Plus, fibre optic cables are not affected so much by outlying temperatures and is actually submersible.

- Security - Fibre optic cabling in any setting means a greater security for your entire network. Because of the tendency for light to leak when a fibre optic cable is tapped, any hidden tapping would create a signal loss that would be easy to detect as it would likely compromise the entire network. Furthermore, fibre optic cables do not radiate an exterior signal like many copper cabling systems do, and, therefore, wireless threats become less of a concern.

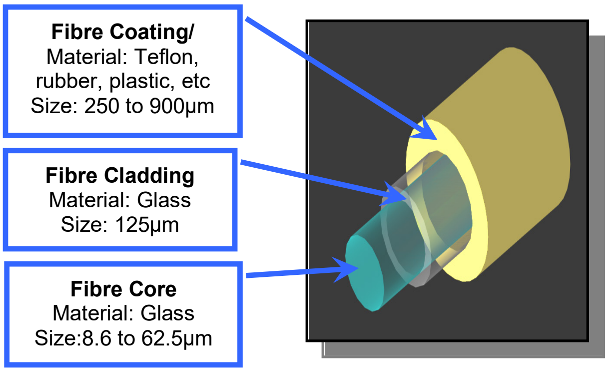
The main disadvantage of fibre optics is that the cables are expensive to install. In addition, they are more fragile than wire and are difficult to splice

Fibre has become the communications medium of choice for telephones, cell phones, CATV, LAN backbones, security cameras, industrial networks, just about everything. Fibre Channel is ideal for reliable, high-speed transfer of digital audio/video signals. Currently, aerospace design engineers are using Fibre Channel for highly reliable, real-time networking, as well as for low-latency, high-throughput signal processing applications. Below are some more fibre applications in communication:

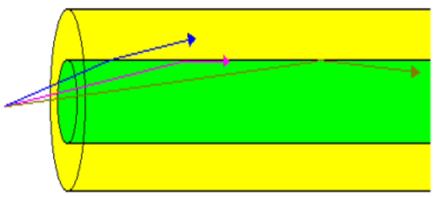
- Telephones and Mobile Operators
- Enterprise LAN
- Internet
- FTTH
- CATV - for video, voice and Internet
- Enterprise LAN
- Security Systems
- Utility Networks
- Military
- Video Links

General Structure & Transmission

Optical fibres are made up of two concentric cylindrical glasses. The light is "guided" down the centre of the fibre called the "core". The inner core is surrounded by a concentric core made up of glass and of lower refractive index known as cladding. Glass fibre is coated with a protective plastic covering called the "primary buffer coating" that protects it from moisture and other damage. More protection is provided by the "cable" which has the fibres and strength members inside an outer protective covering called a "jacket".



The core is designed to have a higher index of refraction, an optical parameter that is a measure of the speed of light in the material, than the cladding, which causes "Total Internal Reflection" to trap light in the core up to a certain angle, which defines the "numerical aperture" of the fibre.



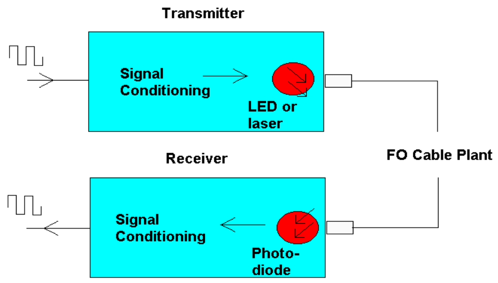
Optical Transmission in Fibre
(Total Internal Reflection)

The total internal reflection takes place at the cladding – core interface. The core diameter ranges in a few microns and is not much larger than the wavelength of light used. When high data transmission rates are not required, core with comparatively large diameters are used which may be of a few hundred microns.

How are Fibre Optic Transmissions Sent?

To understand the benefits of fibre for telecommunications purposes, let's explain how transmissions are sent:

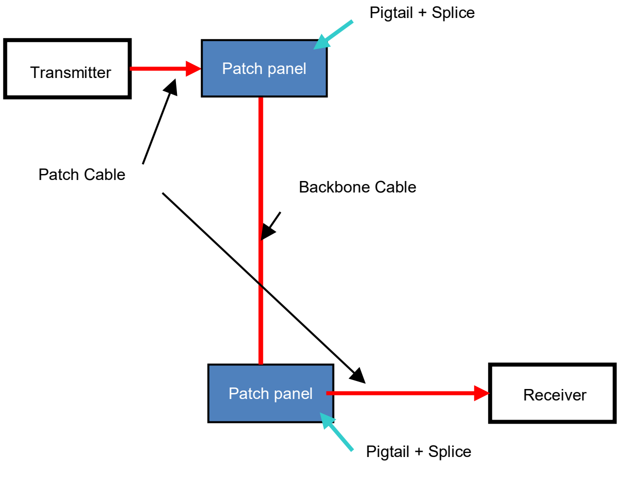
- An optical signal is created using a transmitter.
- The signal is relayed via the fibre, ensuring the signal is not distorted or diminished.
- The signal is received and converted into an electrical signal.



Fibre optic links work by sending optical signals over fibre. Fibre optic transmission systems all use data links that work similar to the diagram shown above. Each fibre link consists of a transmitter on one end of a fibre and a receiver on the other end. Most systems operate by transmitting in one direction on one fibre and in the reverse direction on another fibre for full duplex operation. Transmitters are semiconductor LEDs or lasers and receivers are semiconductor photodetectors.

How does Fibre Optic work?

Fibre optics transmit data in the form of light particles - or photons -- that pulse through a fibre optic cable. The glass fibre core and the cladding each have a different refractive index that bends incoming light at a certain angle. When light signals are sent through the fibre optic cable, they reflect off the core and cladding in a series of zig-zag bounces, adhering to a process called total internal reflection. The light signals do not travel at the speed of light because of the denser glass layers, instead traveling about 30% slower than the speed of light. To renew, or boost, the signal throughout its journey, fibre optics transmission sometimes requires repeaters at distant intervals to regenerate the optical signal by converting it to an electrical signal, processing that electrical signal and retransmitting the optical signal.

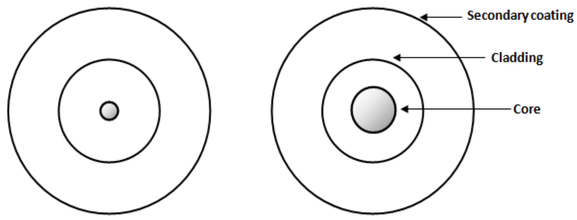


Simple Optical Network

The above diagram shows how a simple optical network looks like. It primarily consists of transmitter, receiver, fibre optic cables, patch panels, pigtails and patch cables.

Types of Fibre Optic Cables

Singlemode and multimode fibres are the two primary types of fibre optic cables.



Singlemode fibre is used for longer distances due to the smaller diameter of the glass fibre core, which lessens the possibility for attenuation - the reduction in signal strength. The smaller opening isolates the light into a single beam, which offers a more direct route and allows the signal to travel a longer distance. Singlemode fibre also has a considerably higher bandwidth than multimode fibre. The light source used for singlemode fibre is typically a laser. Singlemode fibre is usually more expensive because it requires precise calculations to produce the laser light in a smaller opening.

Multimode fibre is used for shorter distances because the larger core opening allows light signals to bounce and reflect more along the way. The larger diameter permits multiple light pulses to be sent through the cable at one time, which results in more data transmission. This also means that there is more possibility for signal loss, reduction or interference, however. Multimode fibre optics typically use an LED to create the light pulse.

Both singlemode and multimode fibre is categorised as following:

OM1: Multi mode with a 62.5μm core diameter. Supports slightly higher bandwidths compared to FDDI-grade cables, allowing slightly longer reach

OM2: Multi mode with a 50μm core diameter. The core of the fibre cable was shrunk to 50 microns as opposed to the 62.5 microns. This allows better control over light propagation inside the cables allowing longer reach.

OM3: Multi mode with a 50μm core diameter. This (and OM4) types of cables are optimised for lasers (called VCSEL's) and provides even higher bandwidth.

OM4: Multi mode with a 50μm core diameter. Adds even more bandwidth, allowing longer reaches compared to OM3 fibres.

OS1 & OS2: Single mode with an 8-9μm core diameter. The difference lies in the attenuation profile of the cable, where OS2 cables have considerably lower attenuation than OS1 cables. The applications supported by the two types are identical – it is a matter of the distance over which they can do it. Typically, OS1 cables are used for internal cabling, while OS2 cables have found their primary use in outdoor applications, such as fibres in the ground. However, OS2 can also be used for internal cabling if desired.

Conclusion

Fibre optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fibre. The light forms an electromagnetic carrier wave that is modulated to carry information. Due to optical fibre's ability to transmit data and provide high bandwidth, fibre optics is commonly used in computer networking, Similarly, fibre optics is frequently used in broadcasting and electronics to provide better connections and performance.

Many people believe that fibre optics are the future of communication. And for good reason, fibre optic cables are currently being used to send voice messages, images, videos, and more at the speed of light. The fibre rods are made of glass or plastic and have the capability of sending data quicker and more effectively than the old metal wires that have been used to do the same thing for many years now.

Today, optical fibres specifically, and lasers more generally, are used in countless applications including communications, medicine, energy, manufacturing, sensing, transportation, entertainment, and as tools for scientific inquiry. Fibre optics is a particularly popular technology for local area networks. In addition, telephone companies are steadily replacing traditional telephone lines with fibre optic cables. In the future, almost all communications will employ fibre optics.

www.datatronix.com - sales@datatronix.com

This white paper has been produced by Khushbu Solanki, on behalf of Datatronix