Optical Data Communication

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Optical Device

The general definition of an optical device is that it creates, manipulates or measures the electromagnetic radiation. There are hundreds of practical applications related to the field of optics but keeping in view the scope of our question, we will stick with the devices that deal with optical data transmission.

Optical Data Transmission

Optical data transmission is a method of transmission of information from one place to another place by the mean of pulses of light through an optical fiber. The light first forms an electromagnetic carrier wave that is then modulated to carry the information intended to transfer.

The first optical data transmission system was developed in the year 1970 and since its creation, it has revolutionized the way telecommunication industry works. This is because it has several advantages over the regular electrical transmission methods. Nowadays it has almost totally replaced the copper wire communication in the developed world. Optical fiber is used by most of the telecommunication companies to transmit telephone signals, internet communication and cable television signals due to its remarkable speed.

Basics of Optical Data Transmission

The process of communicating using fiber optic involves the creation of the optical signal using a transmitter, relaying the signal along the fiber, ensuring that the signal does not become distorted or weak, then receiving the optical signal and converting it into an electrical signal.

The transmitter and how a signal travels in the an optical fiber can be visualized as:-
Figure 1: Light travelling inside an optical fiber
Applications of Fiber-Optic Transmission

Nowadays the field of telecommunication is on a boom and applications of fiber-optic are numerous. The processes involving transmission of voice, data, or video over distances of few feet to thousands of kilometers can be done with the help of optical data transmission.

Furthermore, it is used in the field of Aerospace and Avionics in order to provide maximum performance and durability in the harsh and tough conditions. It is also used in the data storage equipment and semiconductor equipment in order to provide communication link between multiple devices on a network. It is also being used by the military world wide in order to ensure the reliability of military applications.

Physics behind Optical Data Communication
The field of Optical Data Communication depends upon the total internal reflection of light rays traveling through tiny optical fibers. The fibers inside the optical fiber are quite small and when the light is introduced into the fiber, it will continue to reflect almost losslessly off the walls of the fiber and in this way it can travel long distances in the fiber. This phenomenon can be seen as:

![Total internal reflection](image)

Figure 3: Total internal reflection

Another aspect according to the laws of physics in optical data communication is fiber-optic imaging. This technique uses the fact that the light when introduced inside the fiber optic will be transmitted to the other end of the fiber. Each single fiber acts as a light pipe. If the arrangement of the fiber in the bundle is kept constant, the transmitted light from one end of the fiber results in a mosaic image on the other side. The total internal reflection can be calculated as $q_c = \cos^{-1}\left(\frac{n_2}{n_1}\right)$ where $n_1$ is the refractive index of the core and $n_2$ is the refractive index of the cladding.

This phenomenon can be seen as:
The fiber-optic cable is made up of two concentric layers called the core and the cladding which can be seen as:

Both, the core and the cladding have distinct refractive indices. The core have the refractive index of $n_1$ and the cladding with $n_2$. As we know that the light fastest in the vacuum, the index of refraction is the way we can calculate the speed of light in a material. The refractive index of the core is always greater than the index of the cladding. Light is usually guided through the core and then the fiber inside the cable acts as an optical waveguide.

Advantages of using optical data communication over electrical communication
Some of the advantages of using optical data communication methods over the conventional electrical methods are:

- A typical optical fibre cable can carry about 9000 telephone channels, or over 1000 music channels, or 8 television channels, which is over five times the capacity of the best copper cable.
- Optical fibres can carry information over greater distances without significant attenuation. Copper cables require boosters to be spaced much closer together.
- An optical fibre cable is lighter, smaller and easier to handle than a copper cable.
- Optical signals are free from ‘noise’ due to electrical interference.
- Distortion between adjacent channels is negligible.
- Also, because light waves do not create an external magnetic field (unlike an electric current flowing down a wire), they are far less susceptible to external surveillance.
- Apart from communication, optical fibres can be used as endoscopes in medicine and engineering to visualize inaccessible places. This helps surgeons to investigate the problems without cutting through the skin.

References