OPTICAL FIBER

In ancient time, light has been used for transmission of information between two points e.g torch, fire etc. As technology become advanced, light was used in diff-rent form for information transmission e.g LASER. In case of LASER, information was propagated through laser light in open atmosphere but it was realised that the factors like rain, fog, dust become barrier for information transmission i.e loss in information observed. So that it was concluded that, there should be guided medium (wires or cables) through which light can carry information withaught loss. This idea gave a birth to optical fiber. Indian born American Scientis N.S. Kapany worked on this new idea of optical fiber. He is also known as father of fiber optics.

An optical fiber is a thin, flexible and transperent fiber made by glass or plastic, In optical fiber cable information is carry by light from one end to other end. As compare to coaxial cables, fiber optic cabe has so many benefits. fiber optic transmission works on the principle of total internal reflection i.e TIR

Structure: It consist of central core surrounded by cladding. Generally glass or plastic is used to make core and cladding. A soft plastic coating is done on optical fiber to give strength and protection to it.

When light enters in the core, it travels on the principle of total internal reflection (TIR). This TIR is satisfied on two conditions

① Refractive index of core should be greater than refractive index of cladding

② Angle of incidence should be greater than critical angle.

CORE : Light transmits within the core only. The typical value of refractive index of core is 1.48

CLADDING : It keeps the light within the core because its refractive index (R.I) is less than core i.e it act as reflector for light. The value of R.I is 1.46. This cladding provides strength to core. When bunch of optical fibers placed in one cable, cladding layer avoids the interference of light in the adjecent fibers.

PLASTIC COVERING : It protect the fiber from moisture, heat etc. It gives mechanical strength to optical fiber.

Dimensions :

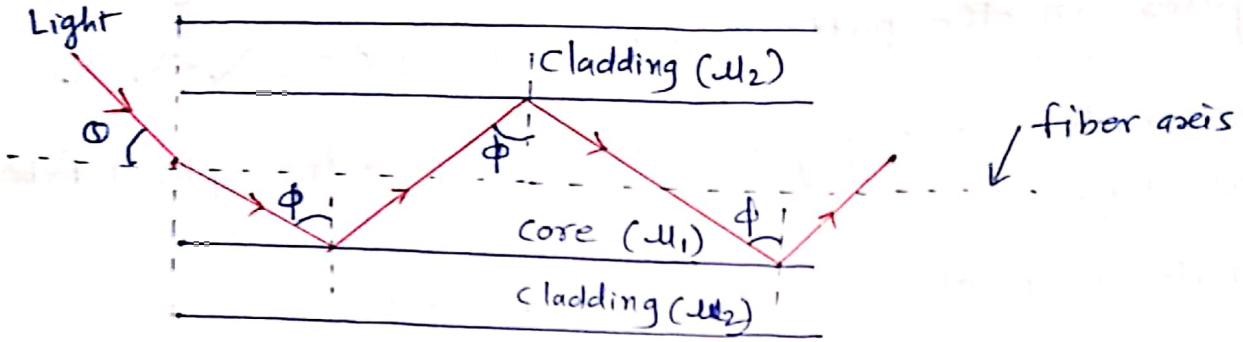
① Length of optical fiber is normally 1 Km. they joined with suitable connectors.

② Core has diameter nearly 40 to 50 μm

③ Cladding has diameter nearly 100 to 200 μm

④ Plastic covering has diameter 250 μm.

* Propation of light thraugh optical fiber :



Consider the light ray entering the optical fiber cable. Let μ_1 & μ_2 are R.I of core & Cladding. For TIR, R.I of core (μ_1) should be greater than R.I of Cladding (μ_2) i.e $\mu_1 > \mu_2$. When the angle ϕ at core cladding interface is greater than critical angle (ϕ_c), then ray will suffer TIR. Due to the symmetry in fiber structure ray will suffer multiple reflections up to end of fiber. According to snelis law, the critical angle (ϕ_c) is $\sin^{-1}\frac{\mu_2}{\mu_1}$ i.e $\boxed{\phi_c = \sin^{-1}\frac{\mu_2}{\mu_1}}$

* Types of optical fibers

Depending on the variation in R.I of core and modes of propagation, there are two types of optical fiber. In all types R.I of cladding is always uniform

1. Step index optical fiber
2. Graded index optical fiber

In step index optical fiber, R.I of core is uniform throughout the fiber. Due to sudden or step change in R.I of core at core cladding interface light propagates in the pattern like zig zag i.e 

On the modes of propagation, the step index optical fiber has two types

① Single mode step index optical fiber:

In this type, core has very small diameter i.e 10 μm. Light travels along single path only so that it is called single mode step index optical fiber. It has only one zig zag path

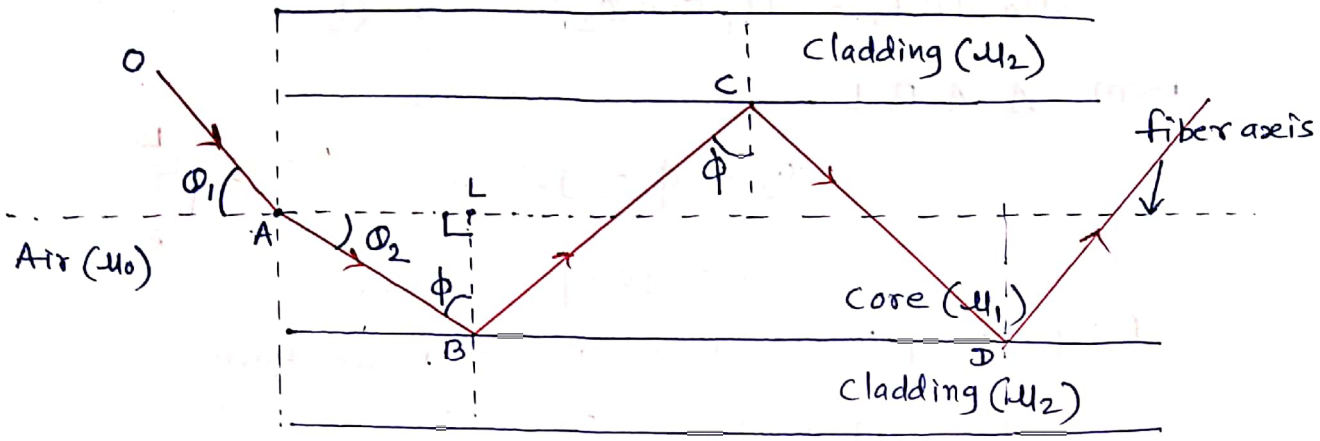
② Multimode step index optical fiber:→

In this type, core has diamer about 50 μm to 200 μm. Because of larger diameter light travels in many paths i.e why it is called multimode. It has many zig zag paths

* Graded index optical fiber:

In this type, R.I of core is not uniform throughout the fiber. R.I of core is maximum at core axis i.e at centre and it is minimum at core-cladding interface. Because of difference in R.I of core, light travels in different speed in different parts of core. So the path of light is curved or curled, coiled or helical.

* Acceptance angle and Numerical aperture



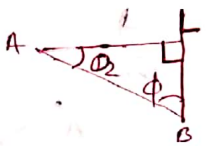
Consider an optical fiber which consist of inner core having R.I (μ_1), cladding having R.I (μ_2). for light propagation inside fiber, $\mu_1 > \mu_2$. Let μ_0 be the R.I of air, where the light rays entering the fiber. Let us consider OA is the ray of light incident on fiber axeis. It makes an angle Φ_i i.e angle of incidence. This ray refracts in to the core at an angle Φ_2 and strikes core-cladding interface at point B. Now consider ϕ is angle of incidence at B. If this angle of incidence (ϕ) is greater than critical angle (ϕ_c), ray will suffer total internal reflection and reach at point C. At C it again suffer total internal reflections, thus this ray will stay inside the fiber. It travels in zig zag like path.

Now we shall evaluate the angle of incidence Φ_i

Now applying Snell's law at entry of optical fibe i.e air-core interface.

$$\mu_0 \sin\theta_1 = \mu_1 \sin\theta_2 \longrightarrow (1)$$

from Δ A B L,



$$\theta_2 + \phi = 90^\circ$$

$$\therefore \theta_2 = 90 - \phi \longrightarrow (2)$$

By putting value of θ_2 in eqn (1) we have,

$$\mu_0 \sin\theta_1 = \mu_1 \sin(90-\phi)$$

$$\mu_0 \sin\theta_1 = \mu_1 \cos\phi \longrightarrow (3) \quad (\because \sin(90-\phi) = \cos\phi)$$

$$\mu_0 \sin\theta_1 = \mu_1 \sqrt{1-\sin^2\phi} \longrightarrow (4) \quad \left(\begin{array}{l}\sin^2\phi + \cos^2\phi = 1 \\ \therefore \cos\phi = \sqrt{1-\sin^2\phi}\end{array}\right)$$

As θ_1 increases ϕ also increases. for $\phi = \phi_c$, θ_1 becomes maximum i.e $\theta_1 = \theta_{max}$

$\therefore$ eqn (4) becomes

$$\mu_0 \sin\theta_{max} = \mu_1 \sqrt{1-\sin^2\phi_c} \longrightarrow (5)$$

we know that, $\sin\phi_c = \frac{\mu_2}{\mu_1}$ i.e condition for TIR

$\therefore$ above eqn becomes

$$\mu_0 \sin\theta_{max} = \mu_1 \sqrt{1-\left(\frac{\mu_2}{\mu_1}\right)^2}$$

$$= \mu_1 \sqrt{1 - \frac{\mu_2^2}{\mu_1^2}}$$

$$= \mu_1 \sqrt{\frac{\mu_1^2 - \mu_2^2}{\mu_1^2}}$$

$$= \frac{\mu_1}{\mu_1}\sqrt{\mu_1^2-\mu_2^2}$$

$$\mu_0 \sin\Phi_{max} = \sqrt{\mu_1^2-\mu_2^2} \rightarrow (6)$$

for air $\mu_0 = 1$

$$\therefore \sin\Phi_{max} = \sqrt{\mu_1^2-\mu_2^2} \rightarrow (7)$$

$$\therefore \boxed{\Phi_{max} = \sin^{-1}\sqrt{\mu_1^2-\mu_2^2}} \rightarrow (8)$$

This angle Φ_{max}. is called acceptance angle.

It is the maximum ~~angle~~ value of angle of incidence for which light propagates through fibe on the principle of TIR.

* If the angle of incidence at entry of fiber is greater than acceptance angle light will not propagates in core it may pass through cladding and loss of information will occur.

Numerical aperture:

It is defined as light gathering capacity of optical fibor. Numerical aperture (NA) is sine of acceptance angle

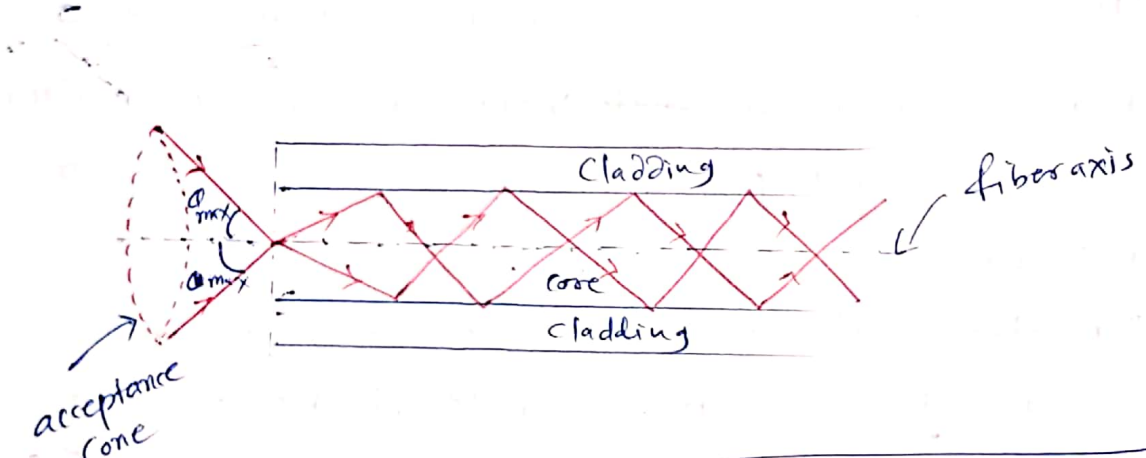
i.e $NA = \sin\Phi_{max}$

$$\therefore \boxed{NA = \sqrt{\mu_1^2-\mu_2^2}} \quad \left(\because \sin\Phi_{max} = \sqrt{\mu_1^2-\mu_2^2}\right)$$

NA is dimensionless quantity. It is depends on R.I of core & cladding only. Larger the value of NA, more & more light accepted by fiber. The range of NA is 0.13 to 0.50

* **Acceptance Cone**: If ray OA is rotated around the fiber axis keeping Φ_{max} same, it describes a ~~conifo~~ conical surface. Now only those rays will be funneled by fiber within this cone having full angle $2\Phi_{max}$ will be totally internally reflected inside the fiber.

i.e only these rays within the cone are accepted so that this cone is called acceptance cone.



$$\text{Acceptance cone} = 2\Phi_{max} = 2\sin^{-1}\sqrt{\mu_1^2 - \mu_2^2}$$

Wireless Communication

The term wireless communication was introduced in the 19th century and wireless communication technology has developed over the subsequent years. It is one of the most important mediums of transmission of information from one device to other devices. In this technology, the information can be transmitted through the air without requiring any cable or wires or other electronic conductors, by using electromagnetic waves like IR, RF, satellite, etc. In the present days, the wireless communication technology refers to a variety of wireless communication devices and technologies ranging from smart phones to computers, tabs, laptops, Bluetooth Technology, printers. This article gives an overview of wireless communication and types of wireless communications.

Introduction To Wireless Communication

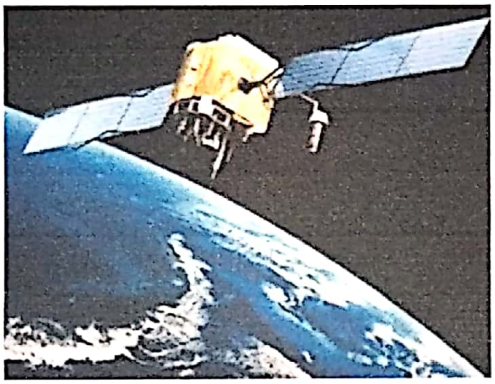
In the present days, wireless communication system has become an essential part of various types of wireless communication devices, that permits user to communicate even from remote operated areas. There are many devices used for wireless communication like mobiles. Cordless telephones, Zigbee wirelss technology, GPS, Wi-Fi, satellite television and wireless computer parts. Current wireless phones include 3 and 4G networks, Bluetooth and Wi-Fi technologies.

Types of Wireless Communication

The different types of wireless communication mainly include, IR wireless communication, satellite communication, broadcast radio, Microwave radio, Bluetooth, Zigbee etc.

Satellite Communication

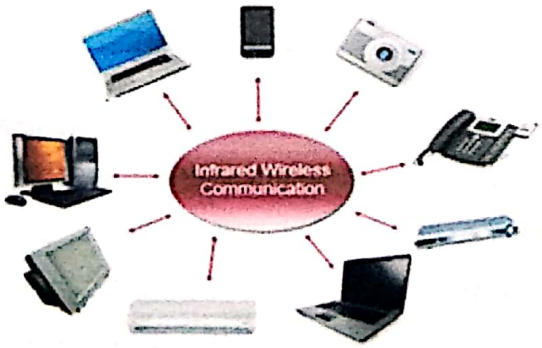
Satellite communication is one type of self contained wireless communication technology, it is widely spread all over the world to allow users to stay connected almost anywhere on the earth. When the signal (a beam of modulated microwave) is sent near the satellite then, satellite amplifies the signal and sent it back to the antenna receiver which is located on the surface of the earth. Satellite communication contains two main components like the space segment and the ground segment.The ground segment consists of fixed or mobile transmission, reception and ancillary equipment and the space segment, which mainly is the satellite itself.



Satellite Communciaiton

Infrared Communication

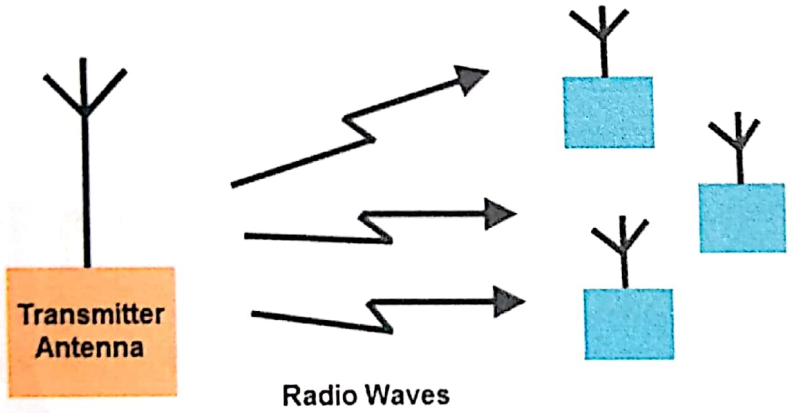
Infrared wireless communication communicates information in a device or systems through IR radiation . IR is electromagnetic energy at a wavelength that is longer than that of red light. It is used for security control, TV remote control and short range communications. In the electromagnetic spectrum, IR radiation lies between microwaves and visible light. So, they can be used as a source of communication



For a successful infrared communication, a photo LED transmitter and a photo diode receptor are required. The LED transmitter transmits the IR signal in the form of non visible light, that is captured and saved by the photoreceptor. So the information between the source and the target is transferred in this way. The source and destination can be mobile phones, TVs, security systems, laptops etc supports wireless communication.

Broadcast Radio

The first wireless communication technology is the open radio communication to seek out widespread use, and it still serves a purpose nowadays. Handy multichannel radios permit a user to speak over short distances, whereas citizen's band and maritime radios offer communication services for sailors. Ham radio enthusiasts share data and function emergency communication aids throughout disasters with their powerful broadcasting gear, and can even communicate digital information over the radio frequency spectrum.



Broadcast Radio

Mostly an audio broadcasting service, radio broadcasts sound through the air as radio waves. Radio uses a transmitter which is used to transmit the data in the form of radio waves to a receiving antenna(Different Types of Antennas). To broadcast common programming, stations are associated with the radio N/W's. The broadcast happens either in simulcast or syndication or both. Radio broadcasting may be done via cable FM, the net and satellites. A broadcast sends information over long distances at up to two megabits/Sec (AM/FM Radio).

Radio waves are electromagnetic signals, that are transmitted by an antenna.These waves have completely different frequency segments, and you will be ready to obtain an audio signal by changing into a frequency segment.

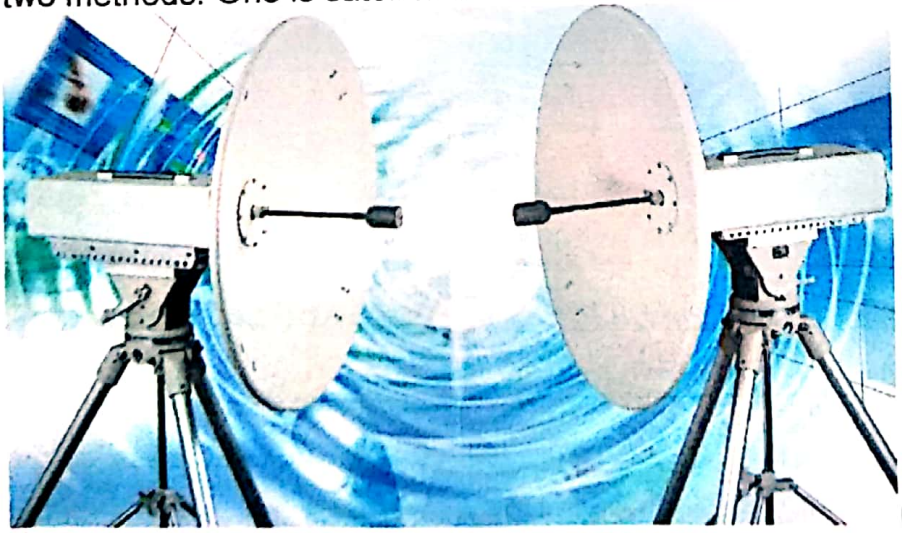
Radio

For example, you can take a radio station. When the RJ says you are listening to 92.7 BIG FM, what he really means is that signals are being broadcasted at a frequency of 92.7megahertz, that successively means the transmitter at the station is periodic at a frequency of 92.700,000 Cycles/second.

When you would like to listen to 92.7 BIG FM, all you have to do is tune the radio to just accept that specific frequency and you will receive perfect audio reception.

Microwave Communication

Microwave wireless communication is an effective type of communication, mainly this transmission uses radio waves, and the wavelengths of radio waves are measured in centimeters. In this communication, the data or information can be transfers using two methods. One is satellite method and another one is terrestrial method.



Microwave Communication

Wherein satellite method, the data can be transmitted though a satellite, that orbit 22,300 miles above the earth. Stations on the earth send and receive data signals from the satellite with a frequency ranging from 11GHz-14GHz and with a transmission speed of 1Mbps to 10Mbps. In terrestrial method, in which two microwave towers with a clear line of sight between them are used, ensuring no obstacles to disrupt the line of sight. So it is used often for the purpose of privacy. The frequency range of the terrestrial system is typically 4GHz-6GHz and with a transmission speed is usually 1Mbps to 10Mbps.

The main disadvantage of microwave signals is, they can be affected by bad weather, especially rain.

Mobile Communication Systems

The advancement of mobile networks is enumerated by generations. Many users communicate across a single frequency band through mobile phones. Cellular and cordless phones are two examples of devices which make use of wireless signals. Typically, cell phones have a larger range of networks to provide a coverage.But, Cordless phones have a limited range. Similar to GPS devices, some phones make use of signals from satellites to communicate.

Mobile Communication Systems

Bluetooth Technology

The main function of the Bluetooth technology is that permits you to connect a various electronic devices wirelessly to a system for the transferring of data.Cell phones are connected to hands free earphones, mouse, wireless keyboard. By using

Bluetooth device the information from one device to another device. This technology has various functions and it is used commonly in the wireless communication market.

Bluetooth Technology

Advantages of Wireless Communication

- Any data or information can be transmitted faster and with a high speed
- Maintenance and installation is less cost for these networks.
- The internet can be accessed from anywhere wirelessly
- It is very helpful for workers, doctors working in remote areas as they can be in touch with medical centers.

Disadvantages of Wireless Communication

- An unauthorized person can easily capture the wireless signals which spread through the air.
- It is very important to secure the wireless network so that the information cannot be misused by unauthorized users

Fiber optical communication System:

The fibre optic communication system block diagram is shown in Fig. 5.7. The electrical circuit converts non-electrical signal into the electrical signal (measurable signal) first. This signal is then converted into the light signal by the light emitting diode (*LED*). In a communication system light waves are the carrier waves. Now this light signal is launched into optical fibre cable. The output of fibre cable is converted into electrical signal by a device known as photodetector. The optical signal traveling through the fibre will progressively attenuate and distorted because of various losses and dispersion occurring in the fibre. Therefore, repeaters or amplifiers are used in the transmission line to reshape the signal. The signal is then fed into a suitable transducer to convert into an audio or video form.

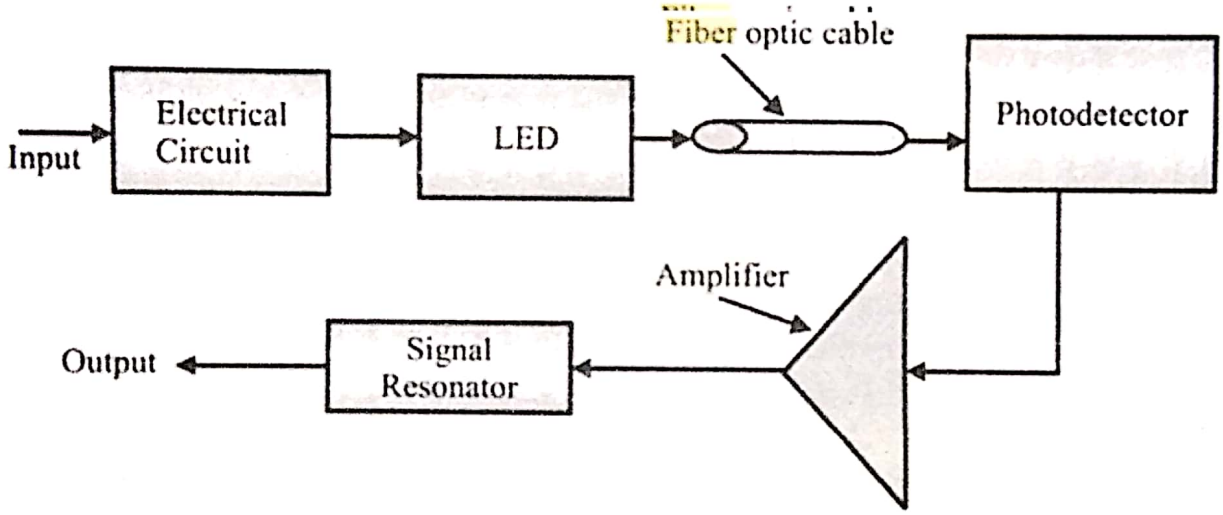


Fig. 5.7 *Block diagram of a typical fibre optic communication system*