UNIT – 1 LASERS AND OPTICAL FIBRES

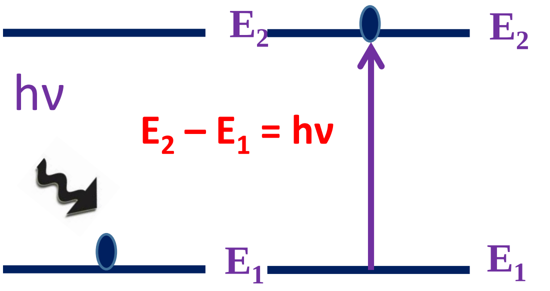
EXTERNAL ENERGY INTERACTION WITH MATTER

External energy interacts with the atomic energy states in three ways namely,

1. **Absorption**
2. **Spontaneous emission**
3. **Stimulated emission**

ABSORPTION

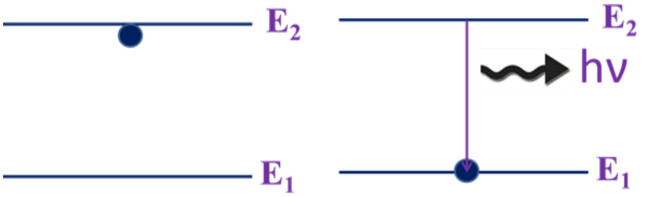
Let us consider a sample with two different energy states E_1 and E_2, E_1 is ground state (lower energy state) and E_2 is the excited state (higher energy state). As said earlier, the electrons stay in the lower energy level as shown in Figure. When a photon of energy hν is incident on it, the atom absorbs it and jumps to the excited state. This transition process is termed as absorption or induced or stimulated absorption.



EMISSION PROCESS

The process of an electron getting de-excited from its higher energy level to lower energy level leads to radiation emission is termed as emission process. In two ways emission occurs, they are

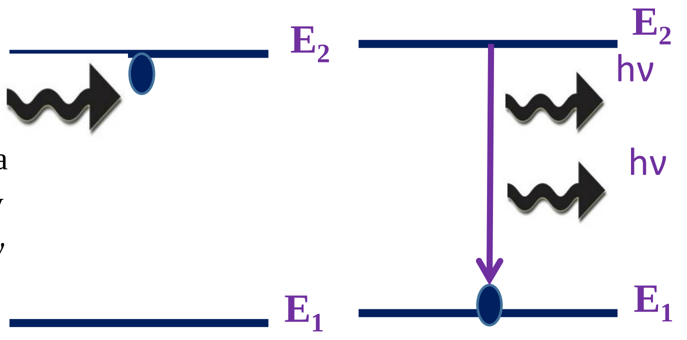
- **Spontaneous emission**
- **Stimulated emission**



SPONTANEOUS EMISSION

The excited atom in the higher energy state seems to be unstable. It stays there for a very short time unless any external stimuli act on it. After a short time, it automatically de-excites itself to the ground state. During this process the excess energy possessed by the atom is being emitted in the form of radiation. This automatic process of de-excitation shown in figure is termed as spontaneous emission.

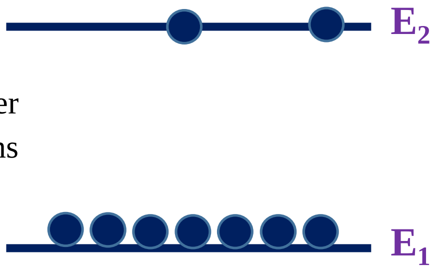
STIMULATED EMISSION



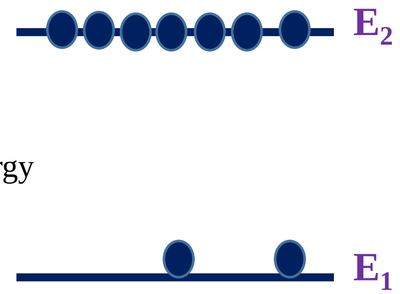
The excited atom in the higher energy level state need not wait for spontaneous emission, when a photon of suitable energy (E_2-E_1 =hν) is absorbed by the atom it gets de-excited. The photon of energy hν triggers the excited atom to move from excited state to ground state by emitting another photon as shown in figure.

POPULATION INVERSION

At thermal equilibrium, the number of electrons in lower energy level E_1 (ground state) is more than the number of electrons in the higher energy level E_2 (excited state) as shown in figure.



The condition for laser action is, More electrons should be in the excited state (E_2) than the ground state E_1 as shown in figure



The process by which more electrons are excited to the higher energy state from the ground state is termed as population inversion.

PARTS OF LASER

Three essential parts are required for laser action which is listed below,

- **Energy source (pump source)**
- **Gain medium (Laser medium)**
- **Optical resonator (Two or more mirrors)**

PROPERITES OF LASER

- Monochromatic
- High intensity
- Directional
- Coherent

TYPES OF LASERS

Lasers are classified based on their operational wavelength and applications, various types of lasers are

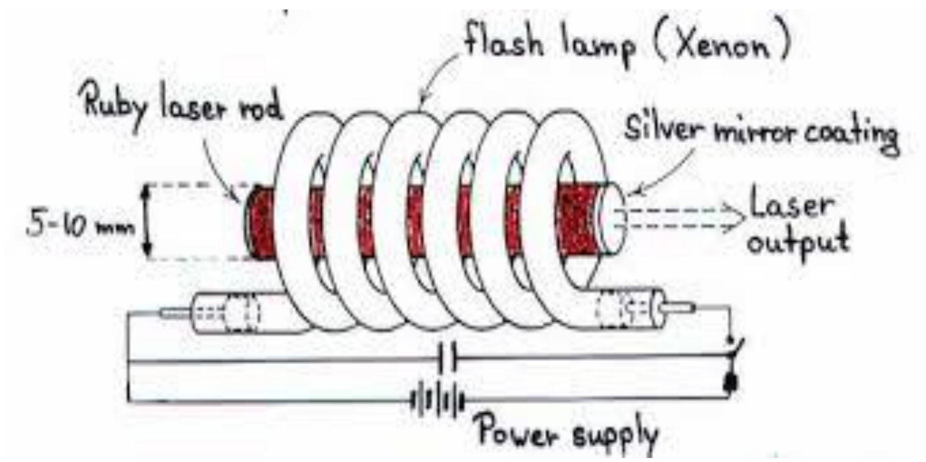
- **Gas lasers**
- **Chemical lasers**
- **Dye laser**
- **Solid state lasers**
- **Semiconductor lasers**
- **Metal-vapor lasers**

RUBY LASER

A ruby laser is a solid-state laser that uses the synthetic ruby crystal as its laser medium. Ruby laser is the first successful laser developed by Maiman in 1960. It emits deep red light of wavelength 694.3 nm and it is a three level laser.

A ruby laser consists of three important parts

- **Laser medium**
- **Pump source**
- **Optical resonator**



LASER MEDIUM

In a ruby laser, single crystal of ruby (Al_2O_3) doped with chromium (Cr^{3+}) in the form of cylinder as shown in figure is used as a laser medium.

PUMP SOURCE

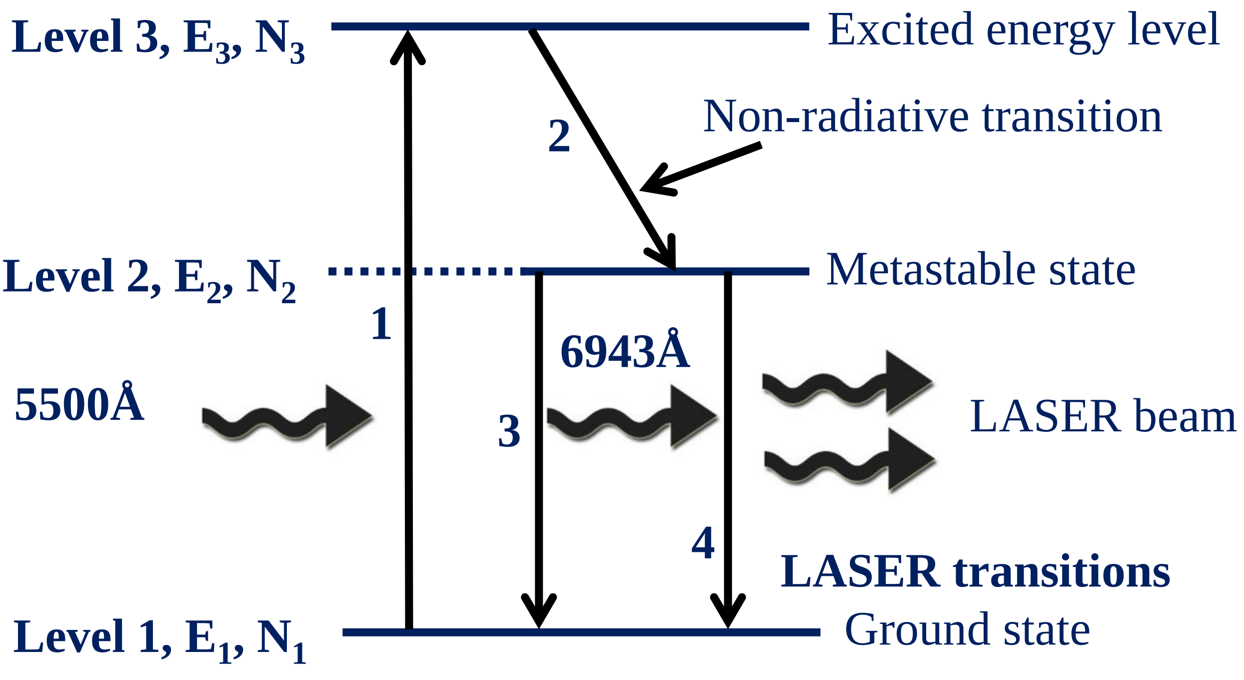
The pump source of a ruby laser provides energy to the laser medium. Population inversion is achieved in ruby laser by using flashtube as the energy source or pump source. The flash tube supplies energy to the laser medium (ruby). When lower energy state electrons in the laser medium gain sufficient energy from flashtube they jump into the higher energy state or excited state.

OPTICAL RESONATOR

The ends of cylindrical ruby rod is flat and parallel, two mirrors are placed at the ends of ruby rod. One mirror at one end is fully silvered and another mirror at another end is partially silvered, fully silvered mirror completely reflect the light whereas the partially silvered mirror reflect most of the light but allows a small portion of light as output laser light.

WORKING

The energy level diagram and different transitions is shown in the figure below. At thermal equilibrium most of the chromium ions stay in the ground state E_1. Light of wavelength 5500Å is produced by the xenon flash lamp, this is being illuminated on the ruby rod. The chromium ions present in the ruby rod absorbs this energy and gets excited to the higher energy level (E_3). The excited atom does not stays in the higher energy level (E_3) for a longer time, it decays to the metastable state E_2 without emitting any radiations. This is a nonradiative transition. The lifetime in metastable state is more which leads to the increase in the population of ions in E_2 state which leads to the achievement of population inversion between E_2 and E_1. After a period of time, excited atom from the energy state E_2 decays to the ground state (E_1) by emitting a photon of wavelength 6943Å. This emitted photon travels through the ruby rod back and forth due to the reflection between the two mirrors, these photons travel back and forth and stimulate other atoms in the energy state E_2 resulting in amplified laser light emission which comes out from the partially reflecting end.



ADVANTAGES OF RUBY LASER

- Ruby lasers are economical (cost effective)
- Since ruby is in solid form, there is no chance of wasting material of active medium.
- Construction and function of ruby laser is easy.

DISADVANTAGES

- Efficiency is low
- Optical cavity is short when compared with other lasers

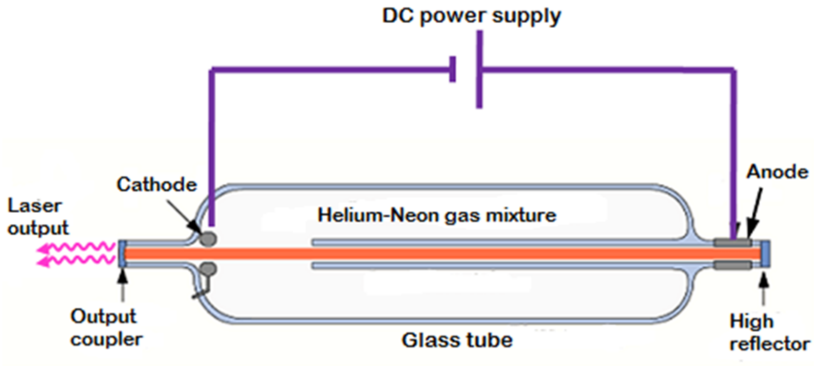
APPLICATIONS

- Medical laser systems for tattoo removal and cosmetic dermatology
- Drilling holes in hard materials

HELIUM-NEON LASER

- It is a four level laser.
- Population inversion in this laser is achieved by electric discharge.
- Mixture of about 7:1 of He and Ne at a pressure of about 1mm of mercury is used as active material.

The schematic setup of He-Ne laser is shown in Figure, Mixture of helium neon gas in suitable ratio is filled in a glass tube at a pressure of 1mm of mercury. Two mirrors are placed at both ends of the tube, one mirror is fully silvered and other mirror is partially silvered.



He-Ne laser construction

The helium-neon laser consists of three essential components

- Pump source (high voltage power supply)
- Gain medium (laser glass tube or discharge glass tube)
- Resonating cavity.

PUMP SOURCE

Population inversion is achieved by supplying energy to gain medium, in helium-neon laser a high voltage DC power supply is used as the pump source. A high voltage DC supplies electric current through the gas mixture of helium and neon.

GAS MEDIUM

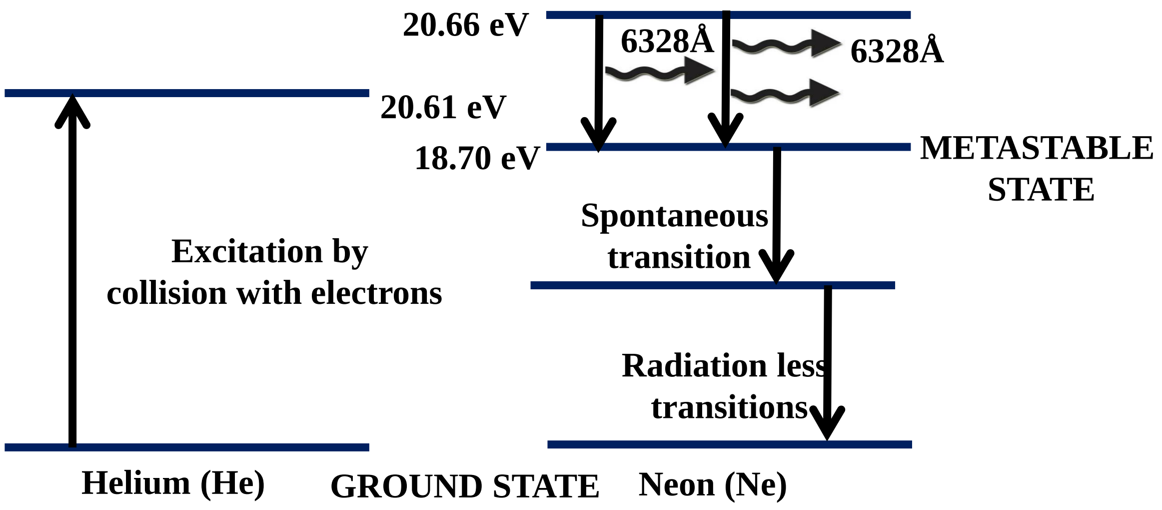
The gas medium in helium-neon laser is made up of mixture of helium and neon gas in 7:1 ratio contained in a glass tube at low pressure. The gas mixture is mostly comprised of helium gas. In order to achieve population inversion, we need to excite the lower energy state electrons of the helium atoms. In He-Ne laser, neon atoms are active centres and have energy levels suitable for laser transitions while helium atoms help in exciting neon atoms. Electrodes (cathode and anode) in the glass tube send electric current through the gas mixture. These electrodes are connected to a DC power supply.

RESONATING CAVITY

The glass tube (mixture of helium and neon gas) is placed between two parallel mirrors. Each mirror is silvered differently, left side mirror is partially silvered whereas the right side is fully silvered and it acts as a high reflector. The fully silvered mirror will completely reflect the light whereas the partially silvered mirror will reflect most part of the light but allows some part of the light to produce the laser beam.

WORKING

When the power is switched on, a high voltage is applied through the gas mixture. This power is enough to excite the electrons in the gas mixture. Electrons are produced in the process of discharge and it is being accelerated between the cathode and anode via the gas mixture. The energetic electrons while flowing through the gas transfer some of their energy to the helium atoms in the gas. As a result of collision with electrons, the lower energy state electrons of helium atoms gain enough energy and jumps into the excited state at 20.61eV. To excite the lower energy state electron of neon atom, helium atom requires 20.66eV of energy, but helium atoms possess only 20.61eV. There is a difference of 0.05eV of energy which is being provided to the He atoms by the kinetic energy of the He atoms. Now helium atoms have got the required energy to excite lower energy state electron of neon atom to their metastable state. The use of He atom in Helium-Neon laser is to achieve population inversion in Ne atoms. Various transitions states of helium and neon atoms is shown in Fig. 21. The excited neon atom passes spontaneously from 20.66eV to 18.70eV which emit a photon of 6328Å. This stimulates another excited atom which leads to laser transition. From 18.70eV level Ne atom drops down spontaneously to a lower metastable state by emitting incoherent light and goes to ground state with radiationless transition.



Advantages of helium-neon laser

- Helium-neon laser emits laser light in the visible portion of the spectrum.
- High stability
- Low cost
- Operates without damage at higher temperatures

Disadvantages of helium-neon laser

- Low efficiency
- Low gain
- Helium-Neon lasers are limited to low power tasks

Applications of helium-neon lasers

- Helium-Neon lasers are used in industries.
- Helium-Neon lasers are used in scientific instruments.
- Helium-Neon lasers are used in the college laboratories.

SEMICONDUCTOR LASER

Earlier we have seen different kinds of laser (Ruby laser, He-Ne laser etc.), but all theses lasers are heavy, quite hot and capable of producing a very high intense beam of light. But the size of laser are quite big which does not allow it to use in small stuffs like portable CD players, handheld barcode scanners etc.. In these cases we would be using semiconductor laser or diode laser or injection lasers. These lasers were developed in 1960s by Robert N. Hall and they are so compact and inexpensive. These lasers are now the most widespread lasers in the world.

Working of semiconductor laser

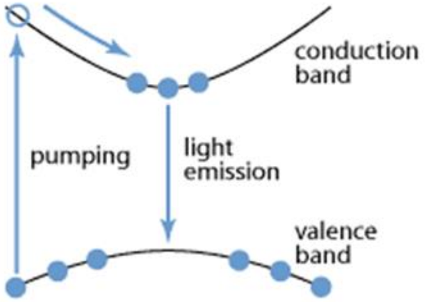
The schematic setup diagram of a semiconductor laser is shown in the figure.

A semiconductor material is used as a gain medium in semiconductor laser. They are electrically pumped laser diodes, where electron-hole pairs are generated by an electrical current in a region where n-doped and p-doped semiconductor materials meet.

Common semiconductor materials used as gain medium are

- **Gallium arsenide (GaAs)**
- **Aluminium gallium arsenide (AlGaAs)**
- **Gallium phosphide (GaP)**
- **Indium Gallium phospide (InGaP) etc..**

These are all direct bandgap materials.



PRINCIPLE

Light emission in semiconductors is associated with the electronic transitions from the conduction band to valence band. Initially most of the electrons are at the valence band, a pump beam with a photon energy slightly above the bandgap energy excite the electrons to a higher state in the conduction band from there it quickly decay to the energy state near to bottom of conduction band. At the same time holes generated in the bottom of valence band move to the top. Electrons in the conduction band recombine with these holes by emitting a photon of energy equivalent to the bandgap energy. This process is being stimulated by the incoming photons with suitable energy.

CONSTRUCTION

Active medium is a p-n junction diode made from a single crystal. It is cut in the form of platelet with a thickness of 0.5mm. The platelet consists of n-type (electron conductivity) and p-type (hole conductivity).

WORKING

As shown in the above figure, electric voltage is applied to the crystal through the electrode. The end faces of the junction diode are well polished and they act as optical resonator.

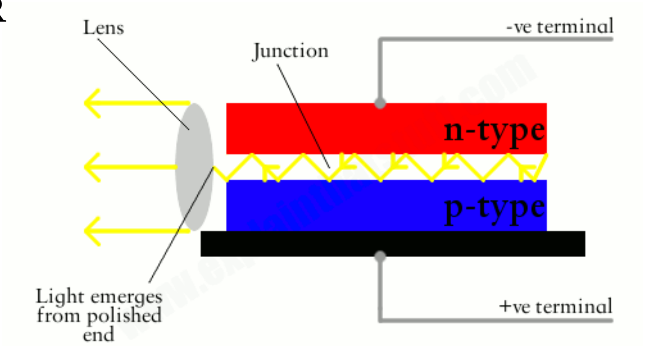
When the p-n junction is forward biased, the electron and holes are injected into the junction region. The region around the junction contains a large number of electrons in conduction band and large amount of holes in valence band. If the population density is high, population inversion is achieved. The electrons and holes recombine with each other and produce radiation in the form of light.

When the forward biased voltage is increased, more photons are emitted which leads to stimulated recombination. The photons moving back and forth by reflection between the two polished sides and promote stimulated recombination. After enough strength is gained laser beam comes out at one end.

TYPES OF SEMICONDUCTOR LASER

The two types of semiconductor lasers are

- **Homo junction laser**
- **Hetero junction laser**

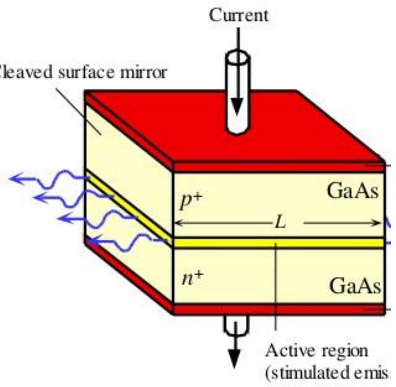


HOMO JUNCTION LASER

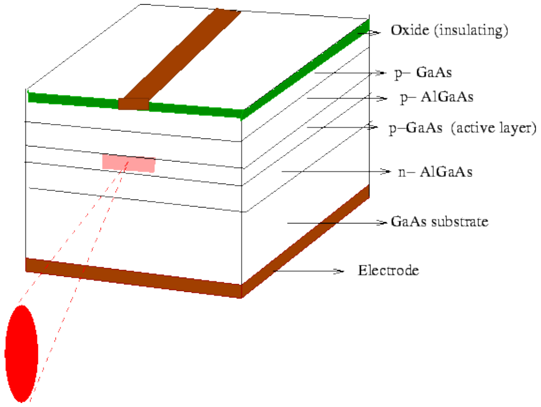
It is made of a single material, both the p-n junction diodes are made of a same material.

HETERO JUNCTION LASER

The active medium is made using different materials.



HOMO JUNCTION LASER



HETERO JUNCTION LASER

Advantages

- It is compact in size
- Exhibit high efficiency
- Laser output could be modulated by controlling the junction current

Disadvantages

- Poor coherence and stability when compared with other types of laser.
- Only pulsed mode output is obtained.

Application

- Used in fibre optic communication
- Used in barcode scanners, printers, CD drivers etc.

APPLICATIONS OF LASER

The most unique property like coherence, monochroamcity, high directionality and high intensity makes laser different from an ordinary light.

Lasers are used in various fields such as,

- **Medicine**
- **Industries**
- **Communications**
- **Military**
- **Science and technology**

Lasers in Medicine

- Lasers are used for bloodless surgery.
- Lasers are used to destroy kidney stones.
- Lasers are used in cancer diagnosis and therapy.
- Lasers are used for eye lens curvature corrections.
- Lasers are used in fiber-optic endoscope to detect ulcers in the intestines.
- The liver and lung diseases could be treated by using lasers.
- Lasers are used to study the internal structure of microorganisms and cells.
- Lasers are used to remove the caries or decayed portion of the teeth.
- Lasers are used in cosmetic treatments such as acne treatment, cellulite and hair removal.

Lasers in Industries

- Lasers are used to cut glass and quartz.
- Lasers are used in electronic industries for trimming the components of Integrated Circuits (ICs).
- Lasers are used for heat treatment in the automotive industry.
- Laser light is used to collect the information about the prefixed prices of various products in shops and business establishments from the bar code printed on the product.
- Ultraviolet lasers are used in the semiconductor industries for photolithography. Photolithography is the method used for manufacturing printed circuit board (PCB) and microprocessor by using ultraviolet light.
- Lasers are used to drill aerosol nozzles and control orifices within the required precision.

Lasers in Communications

- Laser light is used in optical fiber communications to send information over large distances with low loss.
- Laser light is used in underwater communication networks.
- Lasers are used in space communication, radars and satellites.

Lasers in Military

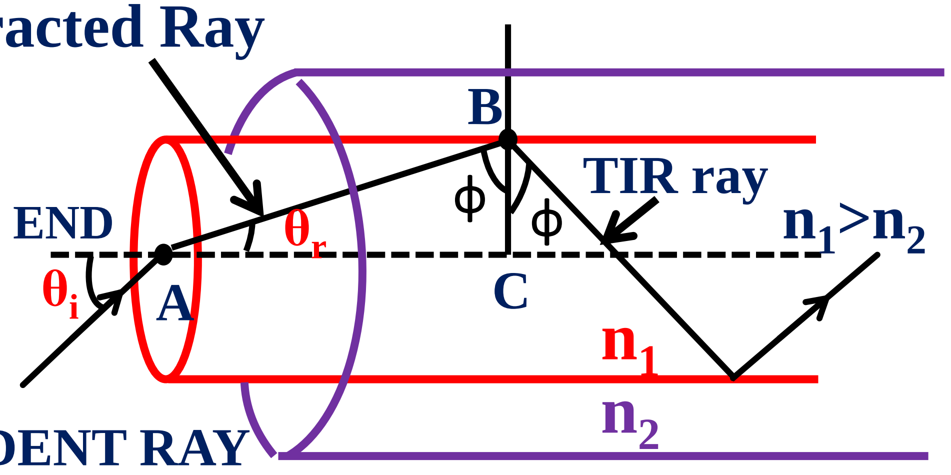
- Laser range finders are used to determine the distance to an object.
- Lasers are used to dispose the energy of a warhead by damaging the missile.
- Laser light is used in LIDAR’s to accurately measure the distance to an object.

Lasers in Science and Technology

- Lasers are used in computers to retrieve stored information from a Compact Disc (CD).
- Lasers are used to store large amount of information or data in CD-ROM.
- Lasers are used to measure the pollutant gases and other contaminants of the atmosphere.
- Lasers are used in computer printers.
- Lasers are used for producing three-dimensional pictures in space without the use of lens.
- Lasers are used for detecting earthquakes and underwater nuclear blasts.
- A gallium arsenide diode laser can be used to setup an invisible fence to protect an area.

OPTICAL FIBRES

ACCEPTANCE ANGLE AND NUMERICAL APERTURE DERIVATION



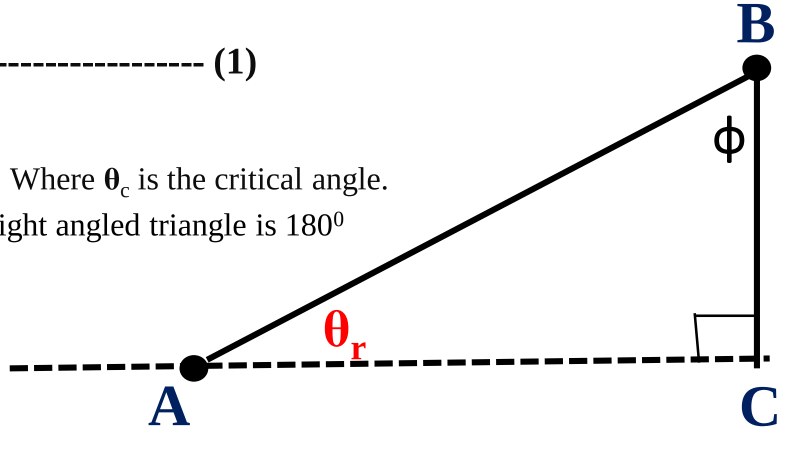
In the optical fibre, core and cladding arrangement is in such a way that the core acts like a parallel mirrors. The message which has to be sent via optical fibre is first being encoded into light wave and fed into the fibre as shown in the figure. Multiple internal reflections within the core results in propagation of light within the core.

- Launching end – where the light enters
- Core refractive index is n_1
- Cladding refractive index is n_2
- For total internal refection $n_2 < n_1$
- Refractive index from where light launched – n_0
- Let $\boldsymbol{\theta}_i$ be the incident angle
- Let $\boldsymbol{\theta}_r$ be angle of refraction
- The refracted ray strikes core-cladding interface at an angle φ

- If φ > critical angle θ_c the ray undergoes total internal reflection at interface
- Light remains inside the fibre till angle φ> Θ_c

When we apply Snell's law at the launching face of fibre (light travels from air medium to the core),

$$\frac{\sin\theta_i}{\sin\theta_r} = \frac{n_1}{n_0} \qquad \text{------------------------- (1)}$$



The largest value for $\boldsymbol{\theta}_i$ will be at φ = $\boldsymbol{\theta}_c$ Where $\boldsymbol{\theta}_c$ is the critical angle.

As we know, sum of all the angles in a right angled triangle is 180^0

Similarly, for triangle ABC

$$\theta_r + \varphi + 90 = 180$$

$$\theta_r = 90 - \varphi$$

$$\sin\theta_r = \sin(90^0 - \varphi) = \cos\varphi$$

$$\sin\theta_i = \frac{n_1}{n_0}\sin\theta_r$$

Substituting, $\sin\theta_r = \cos\varphi$ in equation (1) we get,

$$\sin\theta_i = \frac{n_1}{n_0}\cos\varphi \qquad \text{------------------------- (2)}$$

When $\varphi=\theta_c$, $\theta_i = \theta_{max}$ equation (2) becomes

$$\sin\theta_{max} = \frac{n_1}{n_0}\cos\theta_c \quad \text{------------------------ (3)}$$

Now on applying Snell's law at point B (Core-cladding boundary),

$$n_1 \sin\theta_c = n_2 \sin 90^0 \quad \text{------------------------ (4)}$$

For total internal reflection, refraction angle will be 90°

sin 90° = 1, equation (4) becomes,

$$n_1 \sin\theta_c = n_2 \sin 90^0$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

From trigonometry, we know

$\sin^2\theta + \cos^2\theta = 1$, thus

$$\sin\theta_c^2 = \frac{n_2^2}{n_1^2} \quad \text{So,} \quad \cos\theta_c^2 = 1 - \frac{n_2^2}{n_1^2} \Rightarrow \cos\theta_c^2 = \frac{n_1^2 - n_2^2}{n_1^2}$$

$$\cos\theta_c = \frac{\sqrt{n_1^2 - n_2^2}}{n_1}$$

Substitute the value of $\cos\theta_c$ in equation (3),

$$\sin\theta_{max} = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}$$

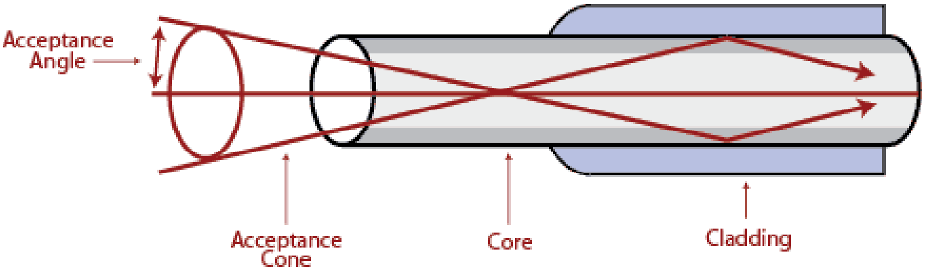
For total internal reflection to occur at all angle of incidence, $\sqrt{n_1^2 - n_2^2} \leq n_0$

For $n_0 = 1$, maximum angle of incidence θ_m

$$\sin\theta_m = \sqrt{n_1^2 - n_2^2}$$

$$\theta_m = \sin^{-1}\left[\sqrt{n_1^2 - n_2^2}\right]$$

θ_m- acceptance angle



Acceptance angle (θ_m) is the maximum angle the incident light makes with fibre axis for propagation through the fibre.

NUMERIAL APERTURE

It is a number which define the acceptance of light or capacity of light propagating of a fibre. Numerical aperture is termed as the **sine of acceptance angle of the fibre**.

$$NA = \sin\theta_m = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}$$

OPTICAL FIBRE TYPES

Optical fibres are classified based on three categories,

- **Material**
- **Propagation modes**
- **Refractive index profile**

MATERIAL CLASSIFICATION

Based on the material made, optical fibres are classified into two types

- **Glass fibre**
- **Plastic fibre**

Glass fibre

Optical fibre made of silica glasses and various metal oxides are called as glass fibre. Various example of glass fibre are made with any one of the following combination of core and cladding.

- Core-GeO_2 (Germanium oxide)-SiO_2 (silicon oxide), Cladding – SiO_2
- Core – SiO_2, Cladding – P_2O_3- SiO_2

Plastic fibre

Plastic fibres are made of plastic materials, various core and cladding combination are given below,

Core- Polystyrene
Cladding – Methyl methacrylate
Core – Polymethyl methacrylate
Cladding – co polymer

Generally plastic fibre is very cheap and flexible. It can be handled without any special care due to its toughness and durability.

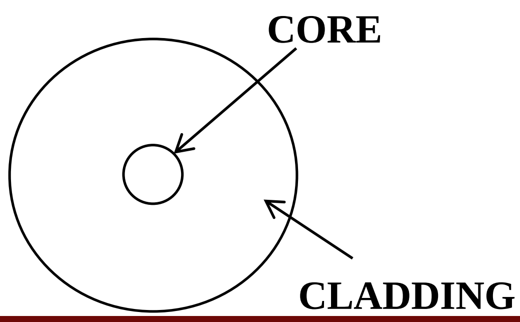
BASED ON PROPAGATION MODES

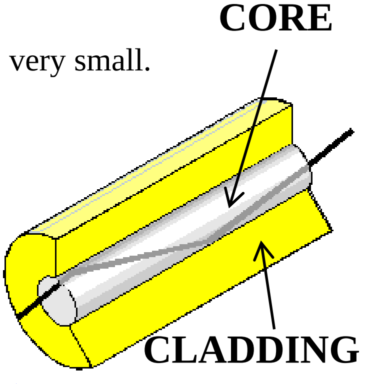
Based on the propagation modes, optical fibres are classified as

- **Single-mode**
- **Multi-mode**

Single-mode fibre

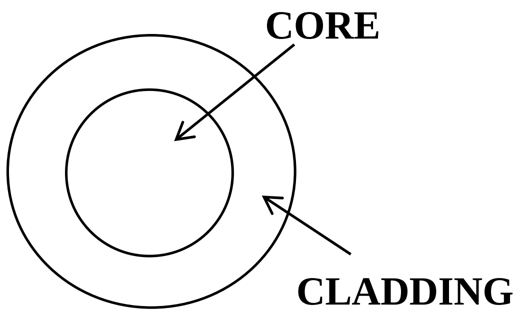
- If only one mode is transmitted through the fibre, it is called as single-mode fibre.
- In this mode light travels in one discrete path through the core thus it supports only one mode of propagation.
- The core diameter will be very small.
- The refractive index difference between the core and cladding will be very small.

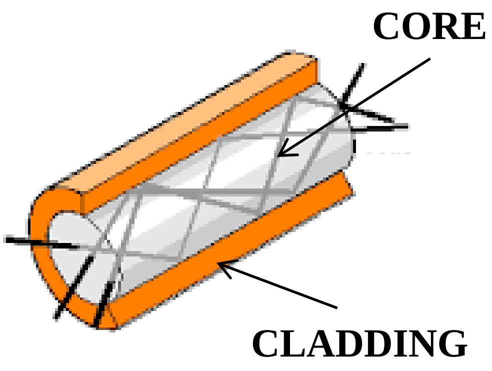




Multi - mode fibre

• In multi-mode fibre more than one mode is transmitted through the optical fibre as shown in the figure below,





• In multimode fibre light can travel in many different paths inside the fibre.
• The core diameter will be larger for the multi mode fibre.
• This larger diameter allows us to easily launch light easily into the fibre.

CLASSIFICATION OF OPTICAL FIBRES BASED ON REFRACTIVE INDEX PROFILE

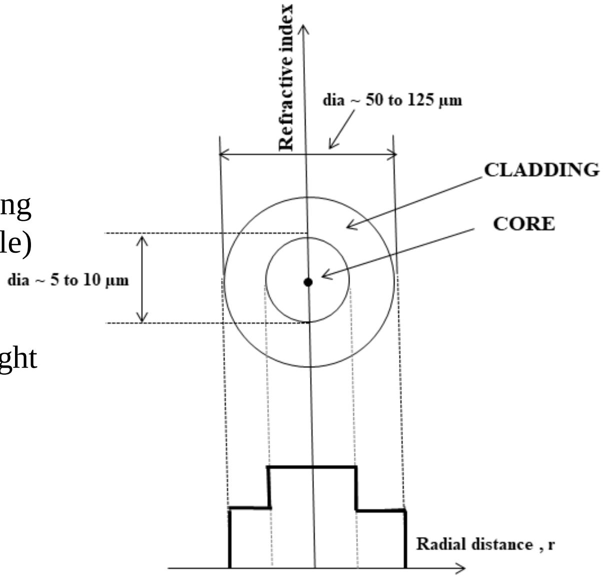
On the basis of refractive index of the core and cladding, optical fibres are classified into two different types,

• **Step index fibre**
• **Graded index fibre**

STEP INDEX FIBRE

• The core and cladding refractive index varies step by step for this type of fibre as shown the refractive index profile below,

• The core has a diameter (~ 5 to 10μm) lesser than the cladding diameter (~50 to 125μm).
• The refractive index of the core will be higher than the refractive index of the cladding.
• The refractive index abruptly changes at the core-cladding boundary (which can be seen in the refractive index profile)
• A step shape is observed which is clearly seen from the refractive index profile.
• Due to the small core diameter, only a single mode of light ray transmission is possible as shown in the above figure.



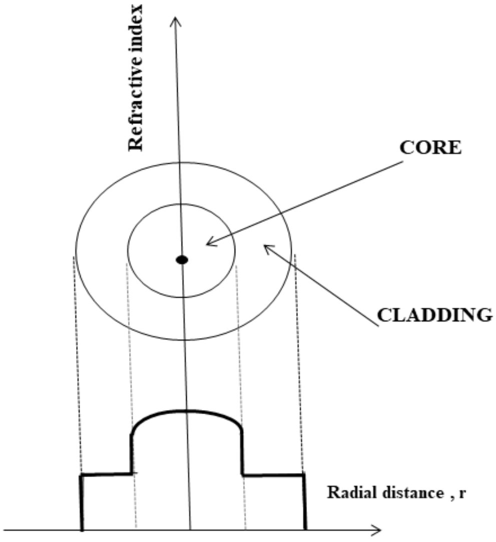
Advantages:
• It has high bandwidth, high capacity
• About 80% of optical fibre manufactured is of this type

Disadvantages
• The manufacturing and handling of this type of fibre is very expensive.

Applications
• Used as under-sea cable, long distance telephone communication, submarine cable system.

Graded indexed

- In graded indexed optical fibre, the refractive index in the core decreases continuously in parabolic manner from a maximum value at the core and a minimum value at the core-cladding interface as shown in the refractive index profile.



- Core diameter is around 50 to 200μm.
- External diameter of cladding is 100 to 250 μm.
- Refractive index of core at the centre is maximum.
- Refractive index gradually decreases from the core centre to the core-cladding interface.
- It works on the basic ray theory, rays travelling in the core axis (centre) will have shorter path when compared with the other rays travelling in the outer regions apart from the centre.
- The rays travelling in the axis will travel slowly, since the refractive index is higher at the centre.
- Due to the gradual decrease in the refractive index of the core, the intermodal dispersion loss is minimized.

ADVANTAGES
- It is a high quality fibre
- Intermodal dispersion can be reduced.
- Low attenuation and has intermediate bandwidth

DISDVANTAGES
- Most expensive fibre
- Fusing of the fibre is difficult.

APPLICATIONS
- Used in intra city links between central telephone offices.
- Used in medium distance applications.

ATTENUATION/ LOSSES IN OPTICAL FIBRE

When light propagates through an optical fibre, a small percentage of light is lost by various mechanisms. The output power of the light at the other end is always lesser than the power of light launched at input end. The loss depends on various factors like fibre material, wavelength of light and length of the fibre.
The loss in optical power is termed as attenuation and it is generally measured in decibel (dB).

Attenuation is defined as the logramathic value of ratio of the output power of light wave (P_{out}) from the fibre to the input power (P_{in}).
The loss in decibel is measured as,

$$\text{dB Loss} = -10 \log_{10} \frac{P_{out}}{P_{in}}$$

P_{out} – power of the output signal
P_{in} – power of the input signal

TYPES OF LOSES

Various mechanisms leads to the power losses in an optical fibre, they are

- **Absorption loss**
- **Scattering loss**
- **Bending loss**
- **Dispersion loss**

Absorption loss

Material absorption loss mechanism relates to the fibre material composition. It depends on the wavelength of the light used. The absorption of light by the fibre material is caused by three different mechanisms.

- ❖ **Extrinsic absorption**
- ❖ **Intrinsic absorption**
- ❖ **Absorption by atomic defect**

Extrinsic Absorption

The presence of impurities in the fibre material leads to the absorption loss, the photons of light energy are being absorbed by these impurities. During light signal propagation, the light photons interact with these impurities. The electrons in the impurity absorb these photons and get excited to higher energy level which leads to the loss of light.

Intrinsic Absorption

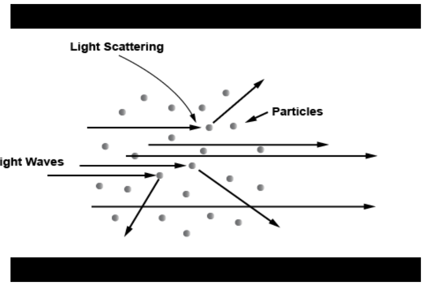
This loss is connected with the fibre material itself, even when the fibre is free from impurities there is a tendency to absorb small amount of light energy. This is known as intrinsic absorption. This loss of light is a small quantity.

Absorption by atomic defects

Atomic defects such as vacancies, imperfections in atomic structure of the fibre material and cluster of atoms produce a minimal absorption loss. The losses arising from these defects are negligible when compared with intrinsic and extrinsic absorption losses.

SCATTERING LOSS

When light is scattered by any obstacle it results in power loss. The microscopic density variations in the fibre cause variations in the refractive index. These variations occur due to the manufacturing defects and cannot be eliminated. They act as an obstacle and scatter the light in all directions. This is also called as **Rayleigh scattering,** it is shown below in the figure.



BENDING LOSSES

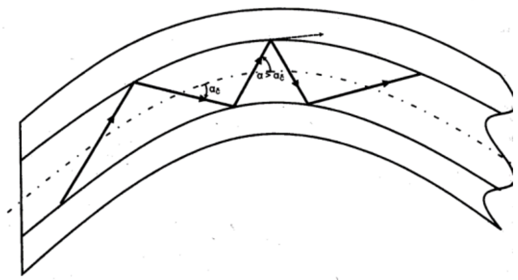
Whenever the optical fibres bend, they have radiative losses. Two types of bending losses occur,

- **Macroscopic bending loss**
- **Microscopic bending loss**

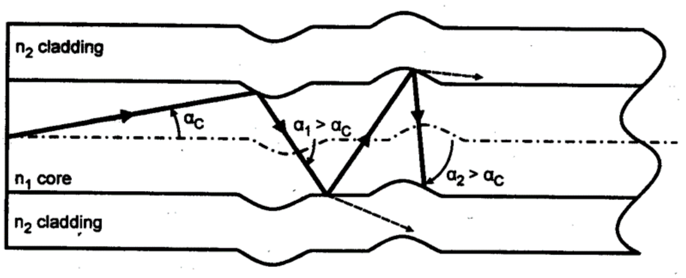
MACROSCOPIC BENDING LOSS

These losses occur when the radius of curvature of bend is greater than the fibre diameter. When a fibre cable turns in a corner macroscopic bending loss occurs.
At the corner, the light radiation does not satisfy the condition for total internal reflection and hence the light escapes out from the fibre, this is called as macroscopic bending loss.

MACROSCOPIC BENDING LOSS



MICROSCOPIC BENDING LOSS

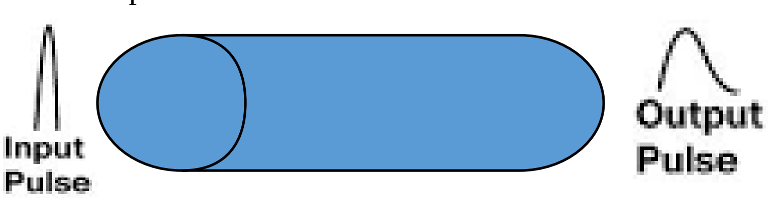


MICROSCOPIC BENDING LOSS

These losses occur due to the presence of micro-bends inside the fibre. These micro bends are formed due to the non-uniform pressures created during the cabling of fibre or during the manufacturing process itself. This leads to the loss of light by leakage through the fibre as shown in the figure below,

DISPERSION LOSS

The degradation of the optical signal or signal distortion is termed as dispersion loss. In fibre optic communication, signal to be transmitted is launched in the form of light pulses with a given width, amplitude and spacing between the pulses. When an optical signal (or) pulse is sent into the fibre, the pulse spreads or broaden as it propagates through the fibre. This phenomenon is called as dispersion.



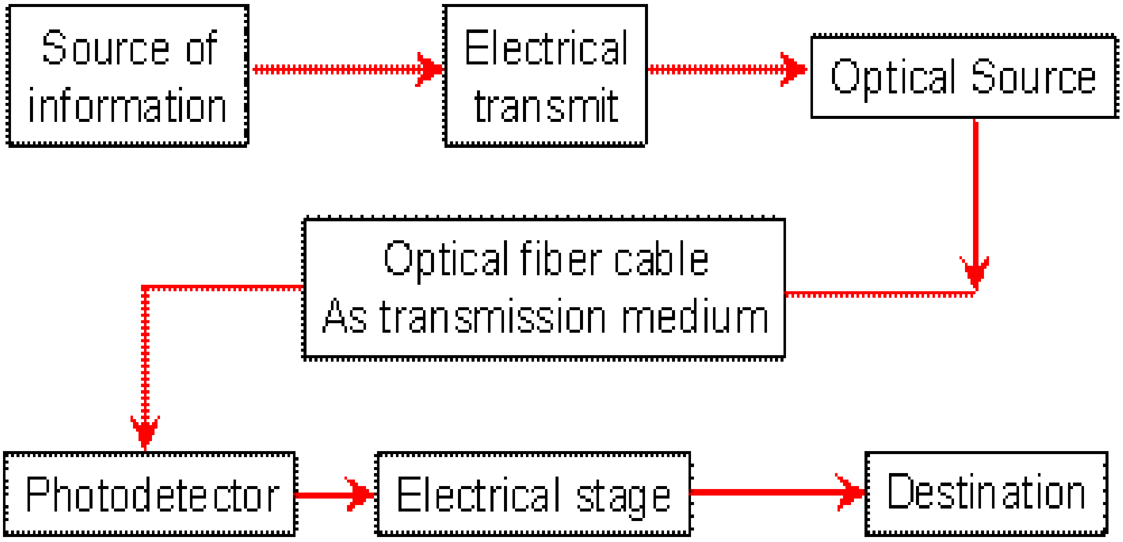
OPTICAL FIBRE COMMUNICATION SYSTEM

A fibre optical communication system is very much similar to the traditional communication system. The purpose is to transfer an information from a source to a distant user.

Principle

Information carried by optical signals is sent to a required distance through optical fibre. The block diagram of a fibre optic communication system is shown in the figure below, the main parts are,

- **Information signal source**
- **Transmitter**
- **Light source**
- **Propagation medium (optical fibre)**
- **Receiver**



INFORMATION SIGNAL SOURCE

The information signal source may be voice, music or video signals (it is analog signal)

TRANSMITTER and OPTICAL SOURCE

It consists of a drive circuit and a light source, the light source generates optical light pulses which acts as a the information carrier. Laser or LED is used as light source.

PROPAGATION MEDIUM

Optical fibre is used as propagation medium. It acts as a waveguide and transmits optical pulses to receiver by the principle of total internal reflection.

RECEIVER

It consists of a photo detector, an amplifier and a signal restoring circuit. The photo detector converts light pulses back into an electrical pulses.

WORKING

An analog information such as the voice of a telephone produces electrical signals in analog form. The drive circuit transfers the analog electrical input signals into digital electrical pulses. The electrical pulses modulate the light emitted by an optical source (such as LED or laser diode). Thus the light source converts digital electrical pulses into optical light pulses.

Now, these light pulses are fed into one end of the fibre. The optical pulses propagate through the fibre and emerge out of other end of the fibre. At the receiving end, the optical pulses coming out of the fibre is fed into a photo detector. The photo detector detects optical signal and converts it into electrical pulses.

Further the signals are amplified using an amplifier. These electrical pulses are decoded i.e., converted from digital signal to analog electrical signal. This analog signal contains the same information as transferred from the transmitting end. By this way, the information is transmitted from one end to another end.

ADVANTAGES OF FIBRE OPTIC COMMUNICATION

- Extremely wide band width
- No cross talk between parallel fibres
- Absence of inductive interference.
- Smaller-diameter, lighter-weight cables.
- Signal security
- Optical fibres are cheaper
- Have low loss per unit length.
- Easy maintenance.
- System reliability.