Lecture-05

FIBRE OPTICS

Unit-03

FIBRE OPTICS

- INTRODUCTION
- FUNDAMENTAL IDEAS ABOUT OPTICAL FIBRE
- Multimode Fibres
- Multimode Step Index Fibres
- Multimode Graded Index Fibres

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INTRODUCTION

- In communication systems, there has been a frequent use of either the radio waves or the microwaves in the form of carrier waves for sending the information.
- However, the advent of the laser in 1960 revolutionized the telecommunication and networking areas with an immediate appreciation of the potential benefits of sending information from one place to the other using light, as the laser is a coherent source of light waves.
- It is worth mentioning that at higher optical frequencies (~ 1015 Hz), one hundred thousand times more information can be carried compared with microwaves.

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- However, the energy of light waves gets dissipated in open atmosphere. So it cannot travel long distances and hence a guiding channel is required to guide them just like a metal wire is required to guide electrical currents.
- This purpose is solved with the use of optical Fibre. Optical Fibre is a very thin glass or plastic conduit designed to guide light waves along the length of the Fibre.
- As long as the refractive index of this Fibre is greater than that of its surrounding medium, the light shall suffer a large number of total internal reflections and hence much of the light launched into one end will emerge from the other end due to small losses.

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- Fibre optics is a technology that uses glass, plastic, threads or fibres to transmit data.
- A fibre optic cable consists of a bundle of glass threads . which are protected by the cable's outer covering of treated paper, PVC or metal, called a jacket.
- Optical fibre has a number of advantages over the copper wire used to make connections electrically.
- For example, optical fibre, being made of glass or sometimes plastic, is protected from electromagnetic interference such as is caused by thunderstorms.
- A single optical fibre has its parts as core, cladding and sheath (protecting layer), as shown in fig. Core is thin glass centre of the fibre where the light travels.
- Cladding is outer optical material surrounding the core that reflects the light back into the core because cladding has lower refractive index. Sheath is plastic coating that protects the fibre from damage and moisture.

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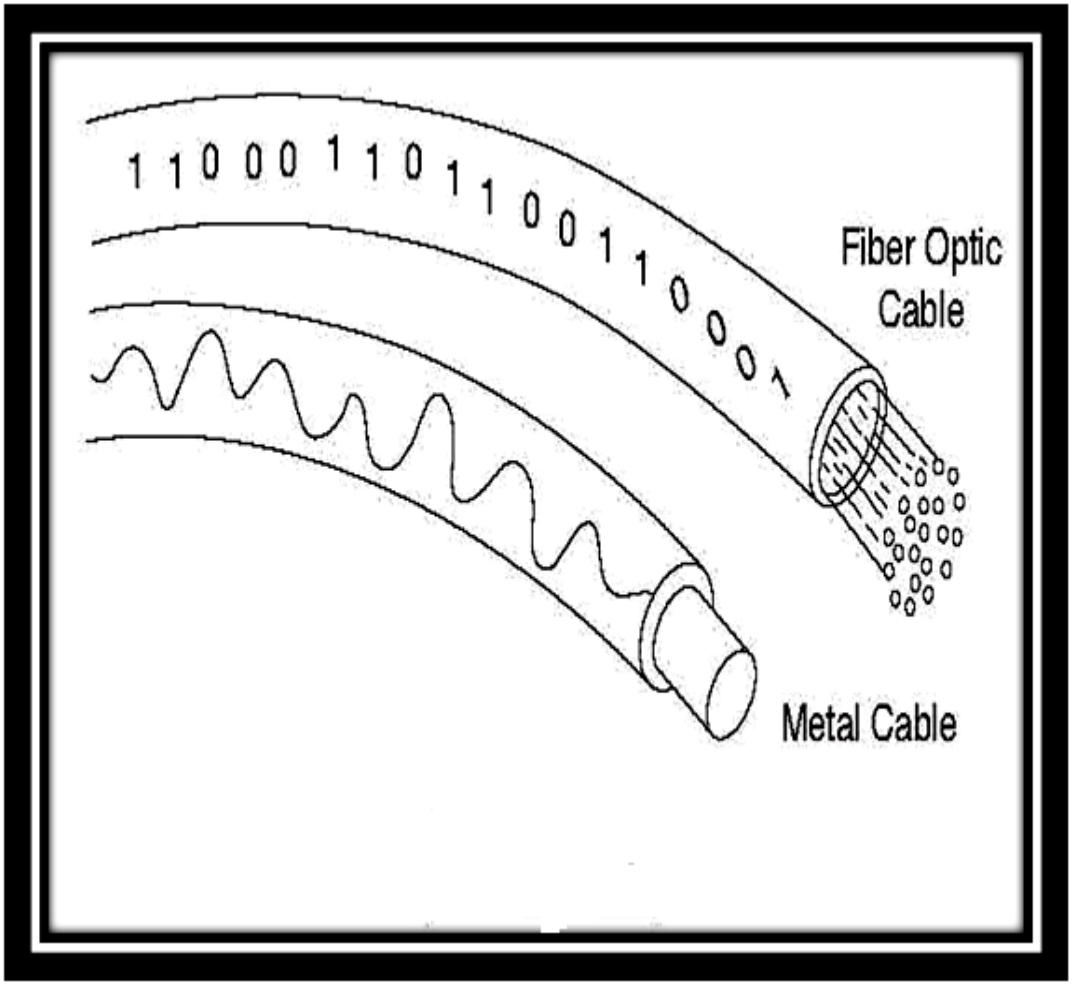

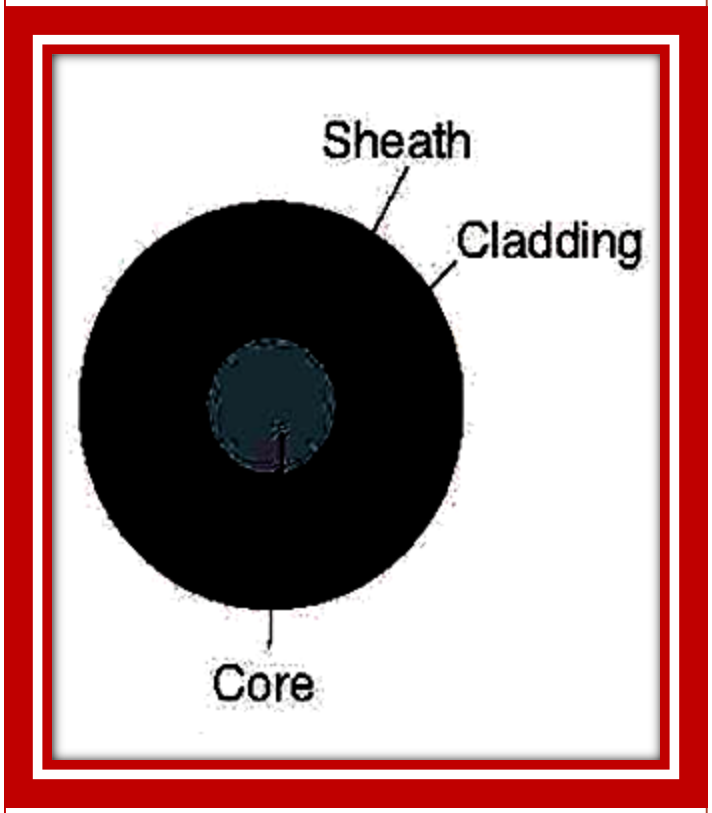

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- Bandwidth is the difference between the upper and lower cutoff frequencies of a filter, a communication channel, or a signal spectrum.
- It is typically measured in Hertz. In the case of a lowpass filter or baseband signal, the bandwidth is equal to its upper cutoff frequency.
- In radio communications, bandwidth is the range of frequencies occupied by a modulated carrier wave.
- For example, an FM radio receiver's tuner spans a limited range of frequencies.
- In optics, it is the width of an individual spectral line or the entire spectral range.

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- Fibre optics has many advantages compared with traditional metal communications lines, which are listed below.
- Fibre optic cables can carry more data as their bandwidth is greater than metal cables.
- Fibre optic cables are less susceptible than metal cables to interference.
- Fibre optic cables are much thinner and lighter than metal wires.
- Through fibre optic cables the data can be transmitted digitally rather than analogically.
- Attenuation through fibre optic cables is very low in transmitting the data over a long distance, so there is no need of repeaters.

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- Optical fibres are categorised based on their transmission properties and the structure. These can be classified into two types, one of which is single mode fibre and the second one is multimode fibre.
- The core size is the basic structural difference in the optical fibres.

Single Mode Step Index Fibre

- A single mode fibre is called single (mono) mode step index fibre because the refractive index of the fibre “steps” up as we move from the cladding to the core and this fibre allows single mode to propagate at a time due to very small diameter of its core .
- In this fibre, the refractive indices of the cladding and the core remain constant. The size of its core (diameter) is typically around 10 μm.
- Single mode fibres have a lower signal loss and a higher information capacity or bandwidth than multimode fibres (introduced later) as the signal loss depends on the operational wavelength.

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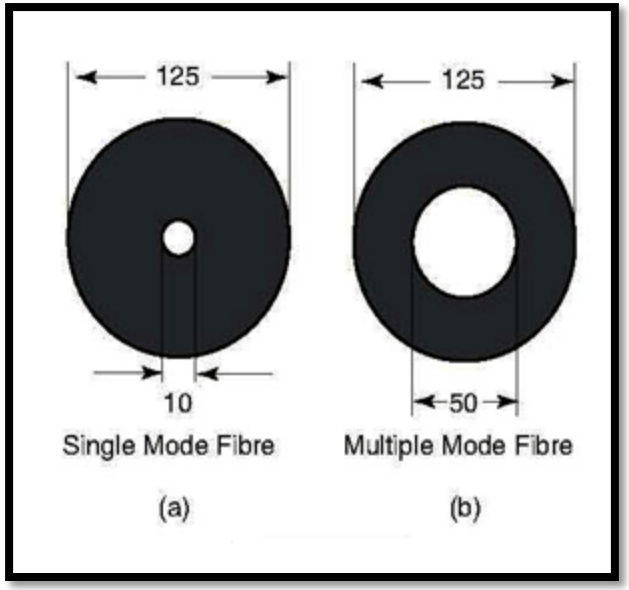
- These fibres are capable of transferring higher amount of data due to low fibre dispersion. In these fibres, the wavelength can increase or decrease the losses caused by fibre bending.
- In general, single mode fibres are considered to be low loss fibres, which increase system bandwidth and length. So these fibres are most useful for large bandwidth applications.
- Since these fibres are more resistant to attenuation, they can also be used in significantly longer cable runs.



Multimode Fibres

- As the name implies multimode fibres allow more than one mode to propagate. Over 100 modes can propagate through multimode fibres at a time.
- Multimode fibre is sometimes abbreviated as MMF. The size of its core is typically around 50 μm .
- The multimode fibre is of two types, namely step index and graded index fibres.

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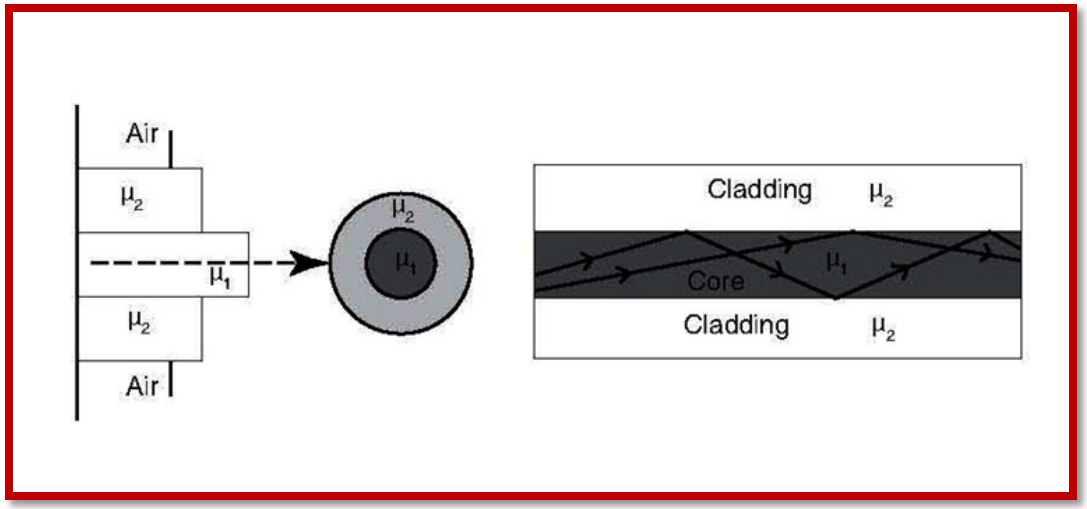
Multimode Step Index Fibres

- Multimode step index fibre is along with the refractive indices of its core and cladding.
- In this type of optical fibre, the number of propagating modes depends on the ratio of core diameter and the wavelength.
- This ratio is inversely proportional to the numerical aperture (abbreviated as NA and defined later).
- Typically the core diameter is 50 μm to 100 μm and NA varies from 0.20 to 0.29, respectively.



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- Multimode fibre is used in short lengths, such as those used in Local Area Networks (LANs) and Storage Area Networks (SANs).
- Because the multimode optical fibre has higher NA and the larger core size, fibre connections and launching of light has become very easy. Multimode fibres permit the use of light emitting diodes (LEDs).
- In such fibres, core-to-core alignment is less critical during fibre splicing. However, due to several modes the effect of dispersion gets increased, i.e. the modes arrive at the fibre end at slightly different times and so spreading of pulses takes place

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- This dispersion of the modes affects the system bandwidth. Therefore, the core diameter, NA, and index profile properties of multimode fibres are optimised to maximise the system bandwidth.

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Multimode Graded Index Fibres

- In a multimode graded index optical fibre, the refractive index of the core decreases with increasing radial distance from the fibre axis, which is the imaginary central axis running along the length of the fibre .
- The value of the refractive index is highest at the centre of the core and decreases to a value at the edge of the core that equals the refractive index of the cladding.
- Therefore, the light waves in the outer zones of the core travel faster than those in the centre of the core.
- Thus the dispersion of the modes is compensated by this type of fibre design.

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- Under this situation, the light waves follow sinusoidal paths along the fibre. In such fibres, the most common profile of the refractive index is very nearly parabolic that results in continual refocusing of the rays in the core, and minimizing modal dispersion.
- Standard graded index fibres typically have a core diameter of 50 μm or 62.5 μm and a cladding diameter of 125 μm.
- It is typically used for transmitting the information to the distances of a couple of kilometers.
- The advantage of the graded index fibre in comparison with multimode step index fibre is the considerable decrease in modal dispersion.

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