UNIT - IV

OPTICAL FIBRES

1

1) What is an optical fiber? What are the main parts? Explain the function of each parts.

Explain TIR and hence establish the condition for propagation of light

2) Explain the working principle of an optical fiber.

3) Explain the following terms
   i) TIR ii) Acceptance angle iii) Numerical aperture
   iv) V - Number (v) Cone of acceptance (vi) Modes of propagation

4) Define N.A. Derive the expression for the numerical aperture. Mention the condition for propagation of light in an optical fiber.

OR

Define N.A and θa, Derive a relation between the two

OR

What is meant by acceptance angle for an optical fiber? What is meant by numerical aperture. Show how it is related

5) Define N.A and Fractional R.I change (Δ). Derive the relation between them. OR P.T $NA = n_1\sqrt{2\Delta}$ where Δ is the relative refractive index difference.

6) With neat figure explain the different types of an optical fiber.

7) What is an attenuation? Explain the factors contributing to the fiber losses

8) Define attenuation of an optical fiber? Derive an expression for attenuation coefficient?

9) Distinguish between a single mode and a multimode fiber

10) Distinguish between step index singlemode fiber and graded index multimode fiber

11) Distinguish the different types of optical fibers based on core diameter, refractive index profile and modes of propagation.

12) With neat diagram explain the application of optical fibers in point-to-point communication.

13) Distinguish between the three types of optical fibers

14) Give an account of point to point communication system using optical fibers.

15) Discuss point to point optical fiber communication System and Mention its advantages over the conventional Communication Systems.

16) Bring out the advantages of optical fiber over copper Cable.

17) State any four advantages of an optical fibers when used for communication

(OR)

What are the advantages of optical fiber in communication?

Optical Fiber – Introduction

Optical fiber is a medium for communication system. it carries information from one point to another point in the form of light. Use of light waves in place of radio and micro waves has improved the speed of communication.

Propagation of light through the fiber is known as optical fiber, it is used in optical communication

Optical communication → The transmission of information by light waves through fiber

Electrical communication → The transmission of information by electrical signal through copper wire.

Optical Cable → Carrying large amount of information — 10^{14} Hz to 10^{15} Hz light waves

Copper Cable → Carrying Small amount of information 10^5 Hz to 10^8 Hz Radio waves

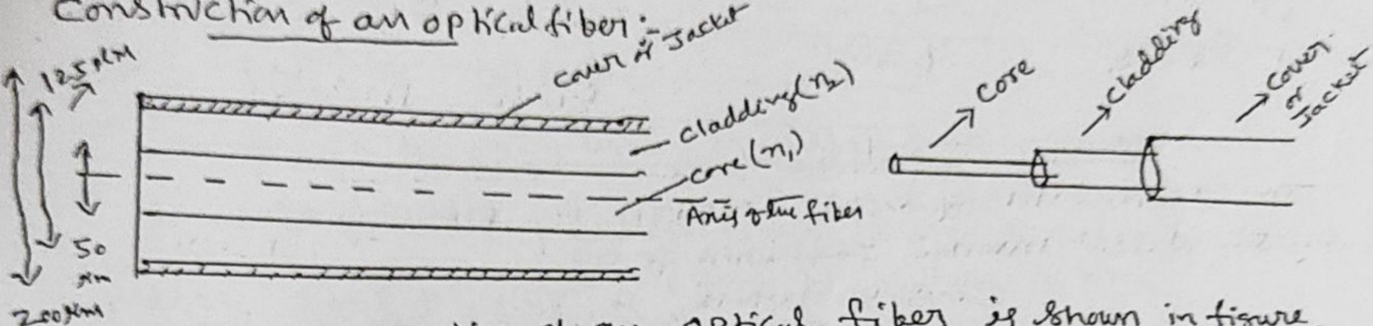
10^{11} Hz — Micro waves

Optical fibers are now a days used to carry Telephone Signals Television Signals and computer Signals from one place to the other

The light wave can not transmit information for long distance in air. Therefore optical fiber is used to transmit the data from one place to another place using light.

Explain the construction and working of an optical fiber

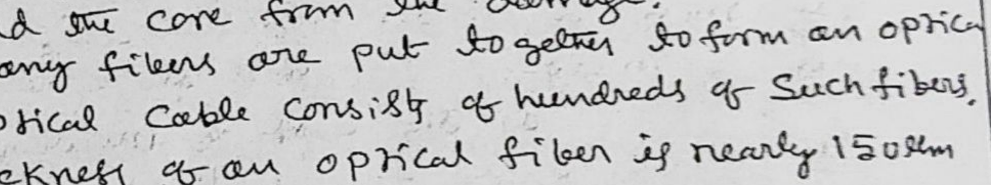
Construction of an optical fiber:-



The construction of an optical fiber is shown in figure. it consists of a central layer called core made up a glass or plastic of high refractive index. The core carries light. The core is surrounded by a another layer is called cladding of same but lower refractive index. The cladding helps to keep the light with in the core. The cladding is enclosed in a plastic or polymer called cover or Jacket. it protects the cladding and the core from the damage.

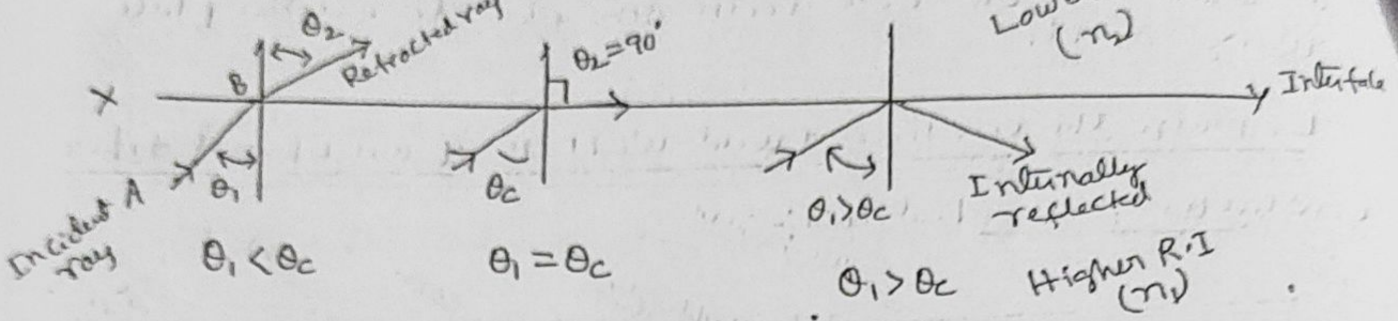
Many fibers are put together to form an optical cable. An optical cable consists of hundreds of such fibers. The over all thickness of an optical fiber is nearly 150 μm to 200 μm.

Working of optical fiber:-



The working of optical fiber is shown in figure, when a light is incident at an angle greater than the critical angle of the core with respect to its cladding, then it undergoes Total internal reflections along the fiber and emerges out from the other end of the fiber as shown in the figure.

Propagation Mechanism in optical fiber:-
(OR)
Basic principle involved in optical fiber:-



Refraction and Reflection of light-ray at the interface

The Propagation of light through the fiber is explained by the total internal reflection of light

Consider when a ray of light passes from a medium of higher R.I n_1 in to a medium of lower R.I n_2, it is bent away from the normal as shown in figure

When the angle of incidence θ_1 is increased the angle θ_2 increases and the refracted ray bend more and more away from the normal.

At particular angle of incidence, the refracted ray moves along the interface so that $\theta_2 = 90°$. This angle of incidence is called the critical angle.

If the angle of incidence is more than the critical angle, there will be no refraction. All the light will be reflected back in to the same medium. This type of reflection of light with in the same medium is known as total internal reflection.

The minimum angle of incidence required to produce the Total internal reflection is known as critical angle. it is represented by θ_c

The critical angle can be obtained using Snell's law.

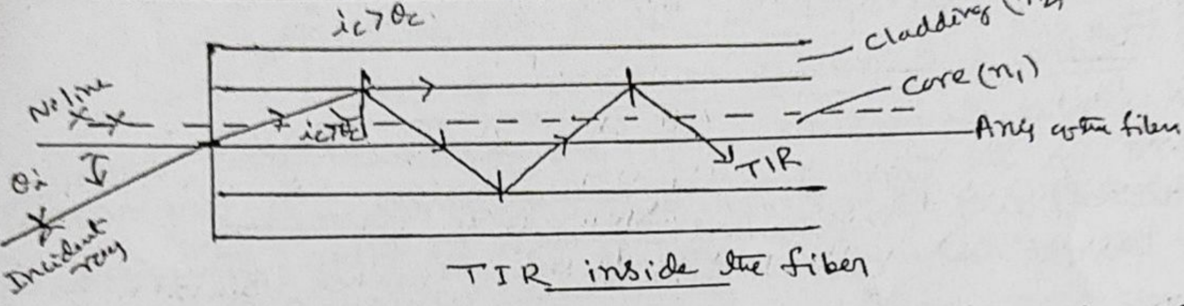
$$\frac{\sin\theta_1}{\sin\theta_2} = \text{const} \qquad \frac{\sin\theta_1}{\sin\theta_2} = {}_1n_2 \qquad \frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$

At critical angle $\theta_1 = \theta_c$ and $\theta_2 = 90°$

$$\frac{\sin\theta_c}{\sin 90°} = \frac{n_2}{n_1} \qquad \sin\theta_c = \frac{n_2}{n_1} \qquad \therefore \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

This equation gives the value of the criticle angle for the Total internal reflection.
Thus Total internal reflection takes place when angle of incidence is greater than the criticle angle.

Total internal reflection in optical fiber:-



TIR inside the fiber

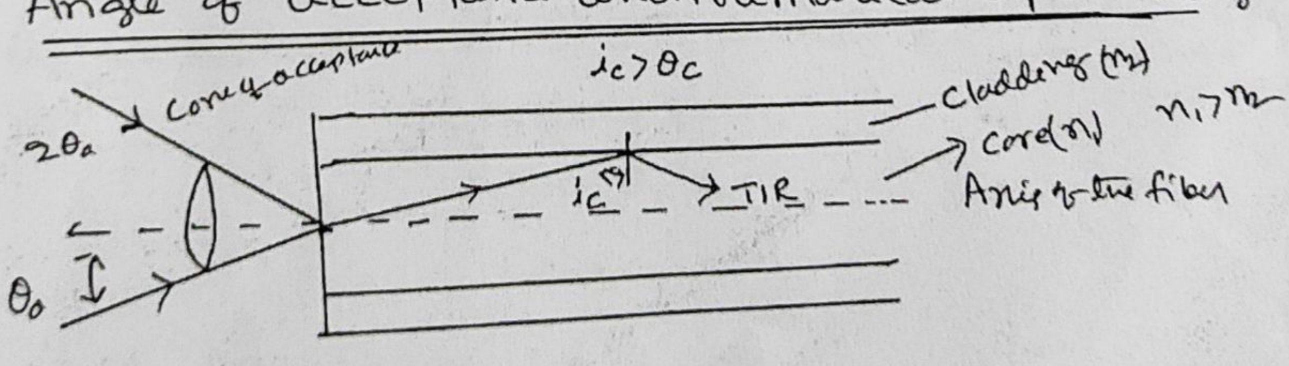
Consider an optical fiber, having core and cladding with refractive indices n_1 and n_2. where $n_1 > n_2$.

When light is incident on one end of the fiber at small angle θ_i. it gets refracted. This refracted ray again incident at the core-cladding interface, at an angle of incidence greater than the criticle angle ($i_c > \theta_c$) Then the ray propagate through the core by Total internal reflection. The TIR inside the fiber occurs only if the following two conditions are satisfied.

i) $n_1 > n_2$
ii) The light is incident at the interface with the angle of incidence greater than the criticle angle ($\theta_i > \theta_c$)

The criticle angle is given by $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

Angle of acceptance and Numarical aperture :-



Angle of acceptance :-

Consider the light ray that enters the core at an angle of incidence is less than angle θ_a ($\theta_i < \theta_a$). So that it will propagate in the core by Total internal refrection.

The angle made by the incident light ray is called angle of acceptance. it is represented by θ_a.

Cone of acceptance or Acceptance Cone:-

In three dimensions, All the incident light rays with in the cone having a full angle $2\theta_a$ are accepted (collected) and propagated through the fiber. This cone is known as cone of acceptance, which is shown in figure

Numerical aperture :-

The numerical aperture of an optical fiber is defined as The sine of the angle of acceptance. Mathematically it is given by the relation

$$N.A = \sin\theta_a$$

where θ_a is the acceptance angle. it measures the light gathering ability of the fiber or How much of light is accepted by the fiber. it depeds on the acceptance angle. it is not depend on the Physical dimension of fiber. its value ranges from 0.14 to 0.50. it is a dimension less quantity.

$$NA = \sin\theta_a = \frac{\sqrt{n_1^2-n_2^2}}{n_0} = \sqrt{n_1^2-n_2^2} \qquad \text{But } n_0 = 1$$

The N.A is also represented by relative refractive index difference(Δ)

$$N.A = \sqrt{n_1^2-n_2^2} = n_1\sqrt{2\Delta} \qquad \text{But } \Delta = \frac{n_1-n_2}{n_1}$$

Expression for Numerical aperture and angle of acceptance :-

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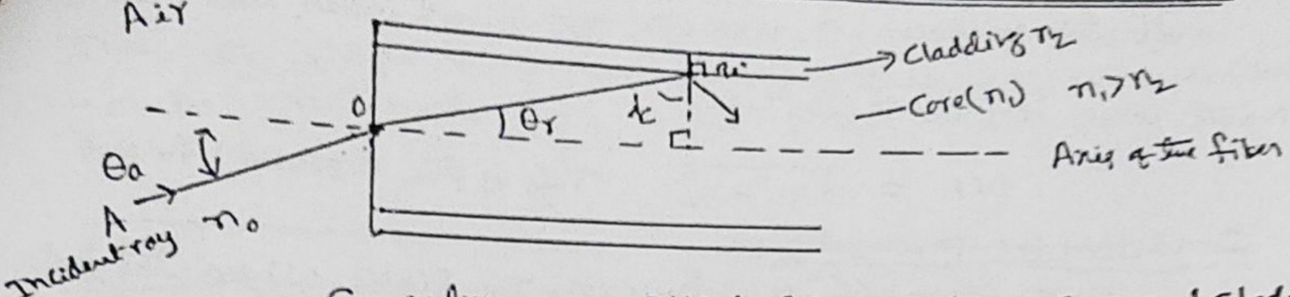


Consider an optical fiber with a core and cladding. Let n_1, n_2 and n_0 be the refractive indices of the core, cladding and the surrounding medium respectively. Let $n_1 > n_2$ such that the ray undergoes TIR inside the core.

Consider a ray of light enter the core from air at an angle θ_a

Applying Snell's law of refraction at the point 'O' we get

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

$$n_0 \sin\theta_a = n_1 \sin\theta_r$$

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

$$\sin\theta_a = \frac{n_1}{n_0}\sqrt{1-\cos^2\theta_r} \quad \text{—①}$$

Using the relation

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

$\sin^2\theta = 1 - \cos^2\theta$

$\sin\theta = \sqrt{1-\cos^2\theta}$

Again at the point B, (at the interface) the angle of refraction is 90°

Using Snell's law $n_1 \sin i_c = n_2 \sin 90°$

The angle of incidence at the interface $i_c = 90 - \theta_r$

$$n_1 \sin(90-\theta_r) = n_2$$

$$n_1 \cos\theta_r = n_2$$

$$\cos\theta_r = \frac{n_2}{n_1}$$

Substituting in equation ①

$$\sin\theta_a = \frac{n_1}{n_0}\sqrt{1-\frac{n_2^2}{n_1^2}} = \frac{n_1}{n_0}\left[\frac{\sqrt{n_1^2-n_2^2}}{n_1}\right]$$

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

if the medium surrounding the fiber is air Then $n_0 = 1$

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

$$NA = \sqrt{n_1^2 - n_2^2}$$ This is the expression for N.A

Condition for propagation :-

Light is propagated through the fiber when the below condition is Satisfied. $\theta_i < \theta_a$

$$\sin\theta_i < \sin\theta_a$$

$$\sin\theta_i < \sqrt{n_1^2 - n_2^2}$$

$$\sin\theta_i < NA$$

Two other important parameters connected with light propagation are the Δ and V - Number

Fractional index change or Relative refractive index (Δ) :-

It is the ratio of the refractive index difference in core and cladding to the refractive index of the core Mathematically it is expressed as

$$\Delta = \frac{n_1 - n_2}{n_1}$$

This parameter is always positive and has values less than one. it guides light rays effectively through the fiber and its typical value is 0.01.

Relation between N.A and Δ :-

we have $\Delta = \frac{n_1 - n_2}{n_1}$ $\quad \Delta = 1 - \frac{n_2}{n_1}$ $\quad \frac{n_2}{n_1} = 1 - \Delta$

The numerical aperture in air is

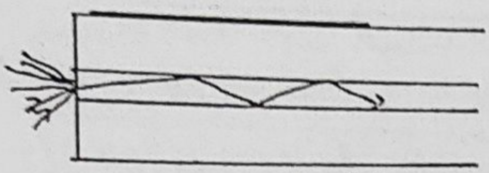
$$NA = \sqrt{n_1^2 - n_2^2} = n_1\sqrt{1 - \left(\frac{n_2}{n_1}\right)^2} = n_1\sqrt{1 - (1-\Delta)^2} = n_1\sqrt{\cancel{1} - \cancel{1} - \Delta^2 + 2\Delta}$$

$$N.A = n_1\sqrt{2\Delta}$$ Δ is Small Δ^2 is neglected

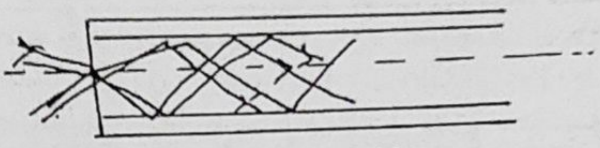
This is relation between Δ and NA

Modes of propagation in a fiber :-

The number of possible paths available for propagation of light in the fiber is called modes of propagation. Thus a single ray propagation is called single mode fiber and in multimode the light takes many paths through the core.



Single mode fiber



Multimode fiber

V – Number or Normalized Frequency :-

The number of modes for propagation in the fiber can be calculated by a factor is called V – number and is also called the Normalized frequency. it gives the information about the three variables namely operating wave length, core radius and the N.A

i.e $$V = \frac{\pi d \sqrt{n_1^2 - n_2^2}}{\lambda} = \frac{\pi d \, NA}{\lambda}$$

where d is the diameter of the core
λ is the wave length of light
NA is the Numerical aperture of the fiber

The maximum number of modes is given by

$$N = \frac{V^2}{2}$$

1) Find the N.A and θ_a of a fiber with a core index of 1.54 and cladding index of 1.5.

$$N.A = \sqrt{n_1^2 - n_2^2} = \sqrt{(1.54)^2 - (1.5)^2} = 0.3487$$

$$\theta_a = \sin^{-1}(NA) = \sin^{-1}(0.3487) = 20.408^\circ$$

(2) The refractive indices of core and cladding are 1.50 and 1.48 respectively in an optical fiber. Find the Numerical aperture and angle of acceptance

$$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.50^2 - 1.48^2} = 0.244$$

$$\sin\theta_a = NA$$

$$\theta_a = \sin^{-1}(NA) = \sin^{-1}(0.244) = 14.1^\circ$$

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[3] The angle of acceptance of an optical fiber is 30° when kept in air. What will be the angle of acceptance when it is in a medium of refractive index 1.33.

When the fiber is kept in air medium

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

$$\sin 30^\circ = \sqrt{n_1^2 - n_2^2}$$

$$0.5 = \sqrt{n_1^2 - n_2^2}$$

When the fiber is kept in water medium

$$\sin\theta_a' = \frac{\sqrt{n_1^2 - n_2^2}}{n_0'} = \frac{0.5}{1.33} = 0.375$$

$$\theta_a' = \sin^{-1}(0.375) = 22.08^\circ$$

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4) An optical fiber has a numerical aperture of 0.15 and a cladding refractive index of 1.55. Determine the acceptance angle of the fiber in water whose refractive index is 1.33.

When the fiber in water

$$\theta_a = \sin^{-1}\left[\frac{\sqrt{n_1^2 - n_2^2}}{n_0}\right] = \sin^{-1}\left[\frac{NA}{n_0}\right] = \sin^{-1}\left[\frac{0.15}{1.33}\right] = 6.47^\circ$$

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5) The numerical aperture of a fiber is 0.4. Refractive index of the core is 1.47. Determine the refractive index of the cladding.

I method

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$0.4 = \sqrt{(1.47)^2 - n_2^2}$$

Squaring on both sides

$$(0.4)^2 = (1.47)^2 - n_2^2$$

$$0.16 = 2.1609 - n_2^2$$

$$n_2^2 = 2.1609 - 0.16$$

$$n_2^2 = 2.0009$$

$$n_2 = 1.4145$$

OR

II nd method

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$n_2 = \sqrt{n_1^2 - (NA)^2}$$

$$n_2 = \sqrt{(1.47)^2 - (0.4)^2}$$

$$n_2 = 1.4145$$

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6) Find the refractive indices of core and cladding material of the fiber from the following data.

NA = 0.26 and $\Delta = 0.015$

$N.A = n_1\sqrt{2\Delta}$ $\quad n_1 = \frac{NA}{\sqrt{2\Delta}} = \frac{0.26}{\sqrt{2\times 0.015}} = 1.5$

$\Delta = \frac{n_1 - n_2}{n_1} = 1 - \frac{n_2}{n_1}$, $\frac{n_2}{n_1} = 1 - \Delta$, $n_2 = n_1(1-\Delta)$

$n_2 = 1.5(1 - 0.015) = 1.477$

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7) A fiber has diameter of 5 µm and its core refractive index is 1.45 and cladding R.I is 1.447. If $\lambda = 1\mu m$. How many modes can be propagated in side the fiber.

$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{(1.45)^2 - (1.447)^2} = \sqrt{0.0085} = 0.092$

$V = \frac{\pi d \, NA}{\lambda} = \frac{\pi \times 5\times 10^{-6} \times 0.092}{1\times 10^{-6}} = 1.4643$

$N = \frac{V^2}{2} = \frac{(1.4643)^2}{2} = 1.04 = 1$ Mode

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8) Find the N.A, Δ and V-number for a fiber of core diameter 40 µm and with refractive indices of 1.55 and 1.50 respectively for core and cladding. The wave length of the propagating wave is 1400 nm. Assume that the fiber is in air

$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.55^2 - 1.50^2} = 0.3905$

$\Delta = \frac{n_1 - n_2}{n_1} = \frac{1.55 - 1.50}{1.55} = 0.03226$

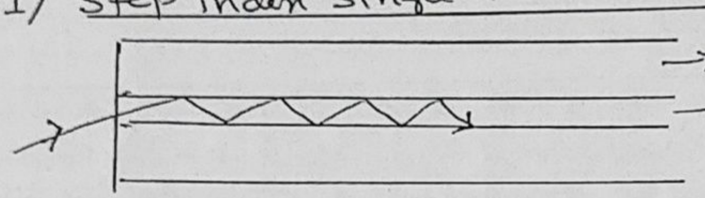
$V = \frac{\pi d \, NA}{\lambda} = \frac{\pi \, 40\times 10^{-6} \times 0.3905}{1400\times 10^{-9}} = 35.05$

Types of optical fibers

The optical fibers are classified on the basis of refractive index and the number of modes. They are

i) Step - index single mode fiber
ii) Step - index Multimode fiber
iii) Graded index Multimode fiber

1) Step index single mode fiber :-



Ray propagation

The Step-index single mode fiber is shown in figure. it has smaller core diameter and high cladding diameter In this fiber only one mode can propagate through the fiber. In this fiber, the core has a uniform refractive index and the cladding has also uniform refractive index, but the refractive index of core is greater than cladding The refractive index at the core-cladding interface varies in a step by step manner, so it is called Step index fiber. The diameter of the core is very small about 8-10 μm and external diameter of cladding is 60 - 70 μm

Characteristics of single mode fiber

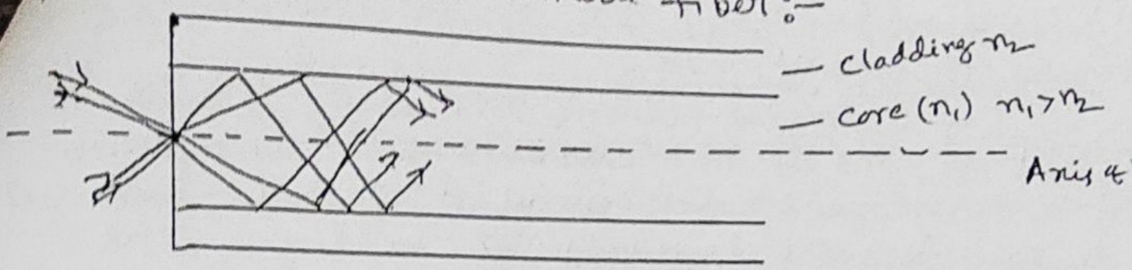
1) The diameter of the core is very small
2) A very high bandwidth is found
3) A very small N A value
4) The light is passed into the fiber using laser diodes

Advantages
1) it has very high capacity
2) Information can be carried to larger distance

Disadvantages
1) it has very expensive
2) They are very difficult to manufacture

Applications :-
it is used as telephone lines for long distance communication.

2) Step-index Multimode fiber:-



Ray propagation inside the fiber

The propagation of light in multimode fiber is shown in figure. The core diameter is about 50 - 200 μm. Therefore light propagates in many modes. The core and cladding have uniform refractive index such that $n_1 > n_2$. Due to the change in the refractive index at the core-cladding interface, so its refractive index varies in a step by step manner.

Characteristics of Multimode fiber:-

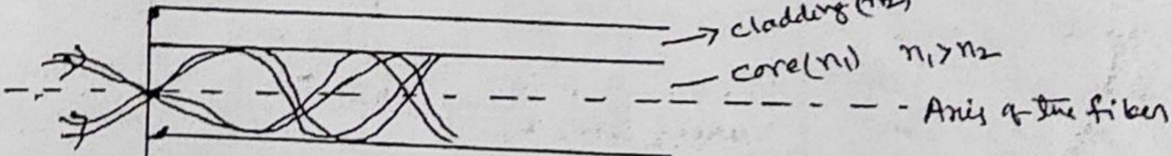
1) it has high core diameter
2) it has low band width
3) it has high numerical aperture
4) it has high attenuation
5) The light is passed in to the fiber using LED source

Advantages:- They are easy to manufacture and so they are cheaper or less expensive

Disadvantages The information can be carried only to the shorter distances

Applications They are used in short distance communication.

(3) Graded index Multimode fiber:-



Ray propagation inside the fiber

The propagation of light in multimode fiber as shown in fig. The core diameter is about 50 – 200 µm. Therefore light propagates in many modes.

The refractive index of the cladding is uniform. The R.I of core is not constant but the refractive index of the core is maximum at the centre and gradually decreses towards the cladding. The variation in refractive index of core causes light rays to follows a curved path along the length of the fiber.

Characteristics of graded index fiber are as follows
1) it accept both Laser or LED as a source of light
2) it is most expensive among all types of fibers
3) it is very difficult to manufacture.
4) it has higher band width
5) it has low attenuation

advantages :-
Since LEDs are used as source of light

Dis advantages :-
it is very expensive

Applications :- it is used for short distance communication like local area net work,

Differences between the different types of optical fibers.

Step index Single mode fiber	Step index Multimode fiber	Graded index Multimode fiber
1) The core diameter is very Small	The core diameter is very Large	The core diameter is very large
2) it is used to transmit one mode	it is used to transmit many modes	it is used to transmit many modes.
3) The R.I at the interface varies step by step	The R.I at the interface varies step by step	The R.I of core varies with distance.
4) The B.W is high	The B.W is low	The B.W is high
5) The N.A value is very small	The N.A is small	The N.A is high
6) it is very difficult to connect two fibers	End to end connections are easy	End to end connections are easy.
7) it is used for long distance communication	it is used for short distance communication	it is used for short distance communication.

Attenuation or Transmission loss

When light travels through the fiber, there is always a loss of light energy. The loss of light energy in the fiber is known as attenuation.

Attenuation may be defined as the power loss per unit length and is defined by this equation

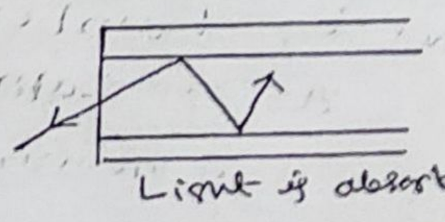
$$\alpha = -\frac{10}{L} \log \frac{P_{out}}{P_{input}} \quad dB/Km$$

where α is the attenuation per unit length
L is the length of the fiber
P_{out} is the output power at the end
P_{in} is the input power in to the fiber

The loss of energy in an optical fiber because of three important factors. They are

1) Light absorption
2) Light scattering
3) Fiber bending

1) Light absorption :-

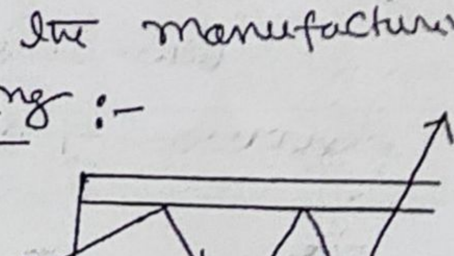


Light is absorbed

The absorption of light in an optical fiber can be either due to the materials absorb energy or due to impurities in the material.

This can be reduced by using high purity silica glass and by controlling the amount of impurities during the manufacturing process.

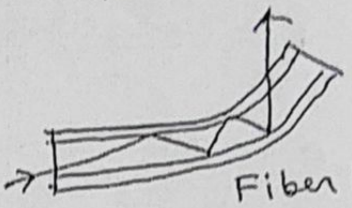
② Light scattering :-



Scattering

Light travelling through the core can get scattered by impurities or imperfection. This is called Scattering. The Scattered light does not propagate in the fiber as shown in figure. The Scattering can be reduced by removing imperfection and impurities due to glass manufacturing process.

③ Fiber bending :-



Fiber bending

The light is away from the fiber due to bending of fiber. Due to the bending of fiber, the light signal fails to undergo T.I.R. The bending losses can be reduced by keeping the fiber relatively straight.

Expression for Attenuation Coefficient :-

When light travels in an optical fiber, there is a loss in its intensity. Such a loss of intensity is governed by Lambert's law.

As per Lambert's law

Rate of decrese of intensity with distance $\propto$ P (Initial intensity)

i.e $\quad -\dfrac{dP}{dL} \propto P \quad$ [-ve Sign indicate decrese of Intensity as L increases]

$$-\frac{dP}{dL} = \alpha P \quad -①$$

where α is attenuation Coefficient

We can arrange equation ① as

$$\frac{dP}{P} = -\alpha \, dL$$

Integrating both sides. we have

$$\int \frac{dP}{P} = -\alpha \int dL \quad — ②$$

By considering an optical fiber of length L, if P_{in} is the initial intensity of the light and P_{out} is the ~~initial~~ intensity of the light received at output.

The equation ② becomes

$$\int_{P_{in}}^{P_{out}} \frac{dP}{P} = -\alpha \int_0^L dL$$

$$[\ln P]_{P_{in}}^{P_{out}} = -\alpha [L]_0^L$$

$$\ln \left[\frac{P_{out}}{P_{in}}\right] = -\alpha L$$

$$\alpha = -\frac{1}{L} \ln \left[\frac{P_{out}}{P_{in}}\right] \quad — ③$$

Equation ③ indicates the dependence of loss of intensity is logarithmic in nature. Incidentally it is same as the variation of sound intensity. it is studied in common logarithm. The unit for attenuation for light in optical fiber communication is Bel.

Therefore α is written as

$$\alpha = -\frac{1}{L} \log_{10}\left(\frac{P_{out}}{P_{in}}\right) \text{ Bel / unit length}$$

In fiber technology, α is always expressed in terms of decibel / kilometer (dB / Km)

Hence the length is expressed in Km and 1 Bel = 10 decibel

∴ 1 Bel / unit length = 10 decibel / Km

$$\boxed{\alpha = -\frac{10}{L} \log_{10}\left(\frac{P_{out}}{P_{in}}\right) \text{ dB / Km}}$$

P_{in} and P_{out} are expressed in watt.

This represents the expression for attenuation of optical fiber

(1) A fiber sample 500m long has an input power of 8.6μW and an out put power of 7.5μW. What is the attenuation.

$L = 500m = 0.5 Km$ $\quad \alpha = -\frac{10}{L} \log_{10} \frac{P_{out}}{P_{in}}$ dB|Km

$P_{in} = 8.6 \mu W$

$P_{out} = 7.5 \mu W$ $\quad \alpha = -\frac{10}{0.5} \log_{10}\left(\frac{7.5}{8.6}\right) = 1.19 dB/Km$

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(2) The optical power after propogating the fiber that is 500m long is reduced by 25 % of its original value. Find the fiber loss in dB/Km.

$P_{out} = 25\% = 0.25 mW$ $\quad \alpha = -\frac{10}{L} \log_{10} \frac{P_{out}}{P_{in}}$

$P_{in} = 100\% = 1 mW$ $\quad \alpha = \frac{-10}{0.5} \log_{10} \frac{0.25}{1} = 12.04 dB/Km$

$L = 0.5 Km$

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(3) if $\alpha = 0.5 dB/Km$, $P_{in} = 1 mW$, $P_{out} = 50 \mu W$. Find the length of the fiber.

$\alpha = -\frac{10}{L} \log_{10} \frac{P_{out}}{P_{in}} = \frac{10}{L} \log \frac{P_{in}}{P_{out}} = \frac{10}{L} \log\left(\frac{10^{-3}}{50 \times 10^{-6}}\right)$

$L = \frac{10}{\alpha} \log\left(\frac{10^{-3}}{50 \times 10^{-6}}\right) = \frac{10}{0.5} \log 20 = 26 Km$

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(4) A fiber with an input power of 0.5 mW has a loss of 3.5 dB/Km. if the fiber is 4 Km long, what is the out put power?

$\alpha = -\frac{10}{L} \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$ dB|Km

$\alpha = 3.5 dB/Km$

$P_{in} = 0.5 \times 10^{-3} W$

$L = 4 Km$

$P_o = ?$

$\log_{10}\left(\frac{P_o}{P_i}\right) = -\frac{\alpha L}{10} = -\frac{3.5 \times 4}{10} = -1.4$

$\log_{10} \frac{P_o}{0.5 \times 10^{-3}} = -1.4$

$\frac{P_o}{0.5 \times 10^{-3}} = 10^{-1.4}$

$P_o = 10^{-1.4} \times 0.5 \times 10^{-3} = 19.9 \mu W$

$$\boxed{\begin{aligned} \log_b a &= x \\ a &= b^x \end{aligned}}$$

Application of optical fibers 19

point to Point communication System using optical fibers

The transmission of information by light waves through optical fibers is called fiber optic communication. This takes place between a transmitter and a receiver. Telephonic conversion between two persons is a good example of it

The communication system consist of a transmitting device which generate the light signal. An optical fiber cable which carries the light from transmitter to receiver. The receiver accept the light signal and it converts light signal to electrical signal.

The transmitter consist of a light source and it is associated with a drive circuit. The receiver consists of a photo detector, an amplifier and a signal converter. These two are connected to the optical fiber.

Sound or Any information is converted into electrical input signal and fed in to drive circuit. The function of the drive circuit and light source is to convert the input electrical signal in to light signal

This light signals are passes inside the fiber and reach the other end of the optical fiber.

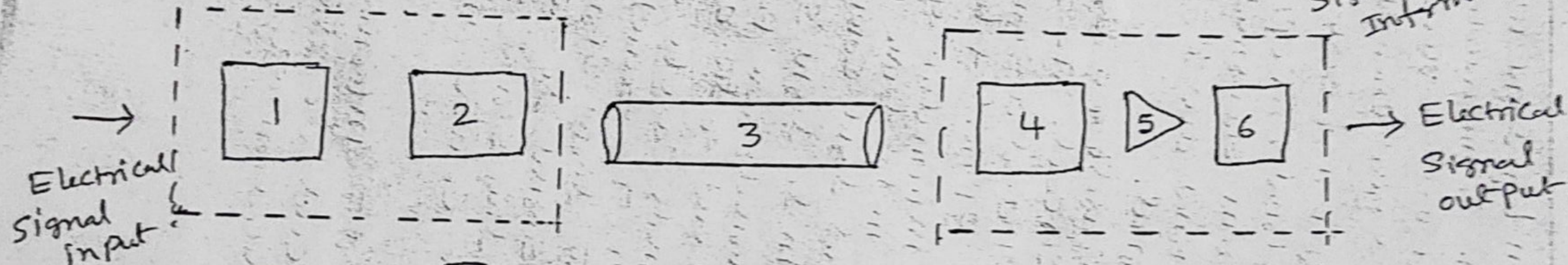
The light signals can be detected by a photodector at the receiver. The function of the amplifier is to amplify the light signals. The signal converter, converts the light signal to the electrical signal as an out put signal and this signal send to suitable instruments and it convert in to an audio or video signals.

This is how the information is transferred from one end to other in an optical fiber communication system.

BLOCK DIAGRAM

Microphone converts information in to electrical signal

Loud speaker converts electrical signal in to information



Transmitter → Send out the information

optical fiber → Transfers the information from the T to the R

Receiver → Pick up the information

1) Drive circuit
2) Light source
3) optical fiber
4) Photo detector
5) Amplifier
6) Signal convertor

Fig Shows Basic units of a communication System

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Advantages of optical fiber communication over the Conventional Communication ~~Systems~~ Systems.

OR

Bring out the advantages of optical fiber over copper cable

1) The ~~tr~~ transmission losses in an optical fiber is very less compared to a copper cable. Therefore, more data can be sent over for long distance.
2) The cost of optic communication system is lower than that of copper cable communication system.
3) optical fibers have many advantageous which are not found in copper cable
4) optical fibers have very small diameters which are very lighter than the copper cables, so the transportation is easier than copper cables.
5) The fibers are free from corrosion. Hence they are more reliable compared to copper cable.
6) There is no voltage problems.

What are the advantages of optical fibers in communication

1) The optical fiber communication has more information carrying capacity
2) optical communication is totally protected from interference between other communication channels.
3) The signal is optical, no sparks are generated
4) optical fibers do not radiate energy
5) Fibres are much easier to transport because light weight
6) Transmission loss is low.

~~what~~ what are the disadvantages of optical fibers in communication

1) optical connectors are used for connecting two fibers which are highly expensive
2) Maintance cost of the system with optical fibers is very high — END —