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Subject : Optical Communication

Programe : Bs Telecom

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(Q1)

PART (a) Why Fiber Optic Communication

Explain in detail the basic of fiber optic Communication System?

(Answer) ⇒ Optical Fiber is the backbone of the modern Communication networks.

⇒ The optical Fiber Carries:

- Almost all long distance phone calls.
- Most Internet traffic.
- Most Television channels (Cable or DSL)

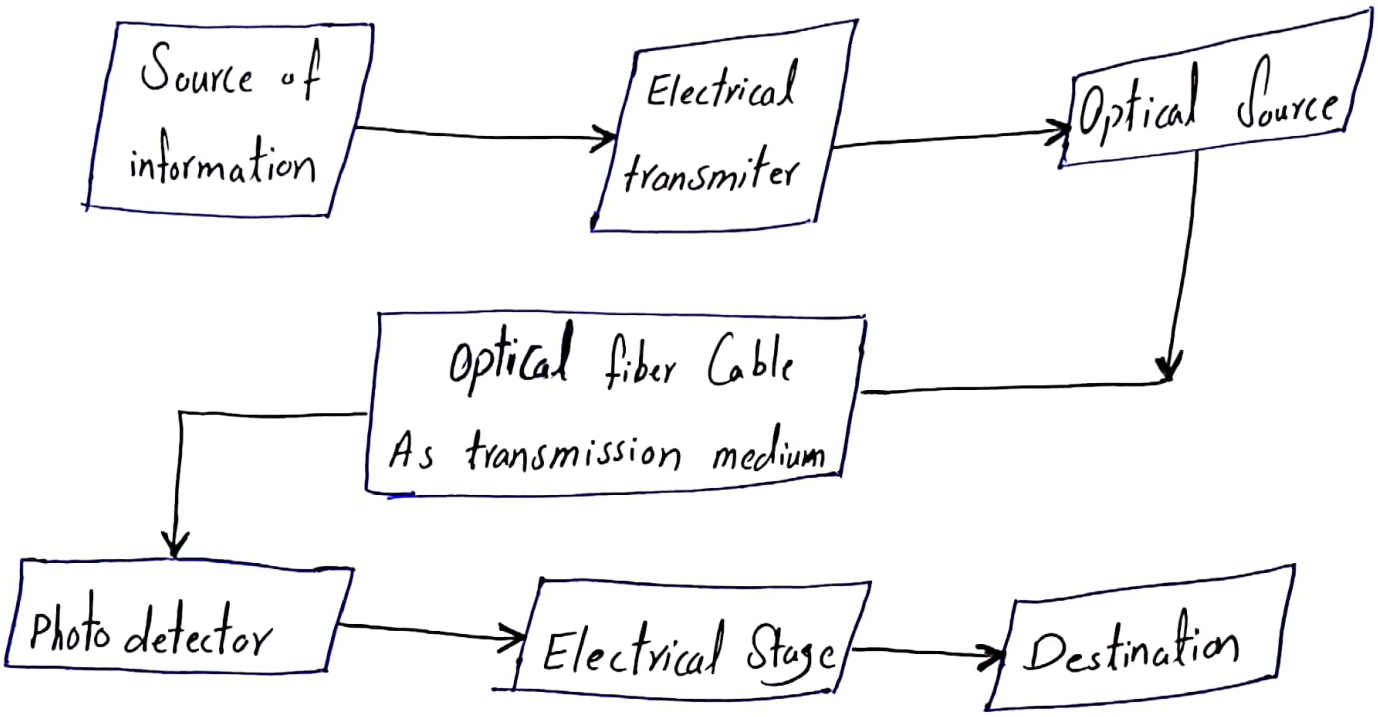
⇒ One fiber Can Carry up to 6.4 Tb/s (10^{12} b/s) or 100 million Conversations Simultaneously.

⇒ Information revolution wouldn't have happened without the optical Fiber.

⇒ Optical fiber has very low loss (0.25 dB/km @ 155 nm

- Suitable for long distance transmission

Block Diagram of Optical Fiber Communication System :



Electrical transmiter : is to Convert the electrical Signal into optical form.

Optical Source : a device that Converts an electrical Signal into an optical Signal.

Photo detector : is a detector that Convert an optical Signal into an electrical Signal.

Electrical Stage : a device that Converts an ~~electrical~~ optical Signal into an electrical form.

(Q1)

PART (B): Describe and differentiate between LED and LD. Explain its Principle of action and types of LD.

(Ans). LED: (Light Emitting diode):

A light Emitting diode is a Semi Conductor light Source that Emits light when Current flow throw it.

LD: (Laser Diode).

A laser diode is a Semi conductor device Semilar to a light Emitting diode in which a diode Pumped with electrical can create a lasing condition at diode's junction.

Difference between LASER and LED

LASER

* Lasers are monochromatic (Single color wavelength), Colimated (non-divergent) and Coherent (wavelengths in phase)
* The peak output power is measure in watt

LED

* LED's are neither Coherent nor Colimated and generate a braader band of wavelengths (multiple).
* The peak output power is measured in milliwatt.

LASER Diode Principle :

- Consider a p-n junction
- In order to design a laser diode, the p-n junction must be heavily good.
- In other word, the p and n materials must be degenratedly doped.
- The principle of laser is based on Simulated emission of light.

Types of Laser Diode :

There are several types of LASER Diode:

* Multi - longitudinal mode (MLM) or Febry - Perot laser.
* Single longitudinal mode laser (SLM).
* SLM with distributed feedback laser (DFB) laser
* Vertical - Cavity Surface - emitting laser (VCSEL).

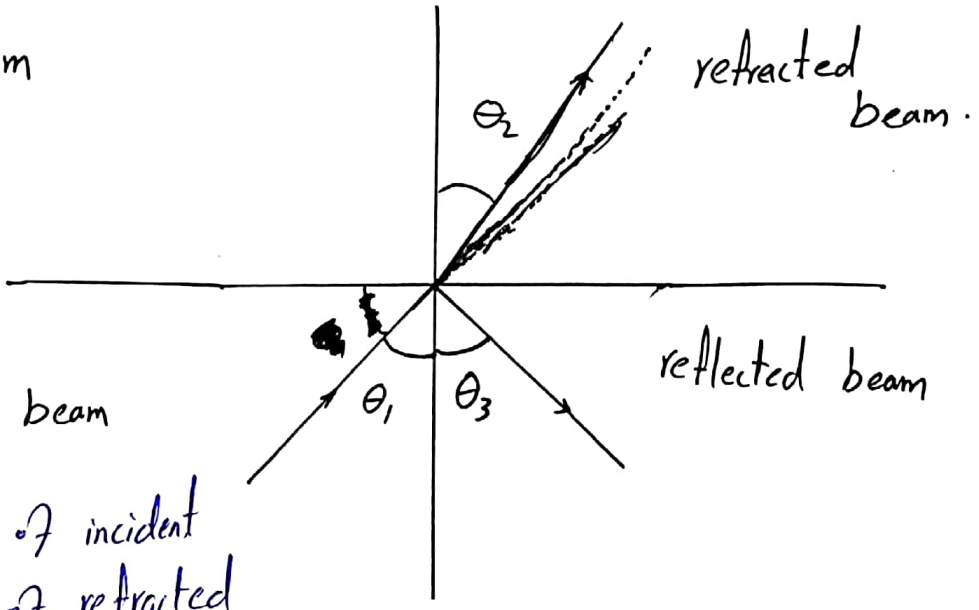
(Q2).

PART (A). Explain the Phenomena of Total Internal Reflection. Support your answer with the help of diagram.

(Ans). Total Internal Reflection:

When the light travel from a denser medium to rarer medium. if the angle of incident is greater than the critical angle.
There is no refracted light (The light return to denser medium are known TIR.

Diagram



θ_1 = angle of incident
θ_2 = angle of refracted
θ_3 = angle of reflected

In This phenomena we use Snell's law

$\theta_1 = \theta_3 \rightarrow (1)$

$n_1 \sin\theta_1 = n_2 \sin\theta_3 \quad \cdots (2)$

(Q_2).

PART (B). What is Cable - loss factor?

Explain the relation $P_{out} = P_{in} \times 10^{-AL/10}$.

(Ans): As we know that.

$$A\left(\frac{dB}{km}\right) = \frac{-10 \log_{10}\left(\frac{P_{out}}{P_{in}}\right)}{L\,(km)} \quad \text{by (cross multiplication}$$

$$\frac{-10 \log_{10} \frac{P_{out}}{P_{in}}}{-10} = \frac{A\left(\frac{dB}{km}\right) L\,(km)}{-10}$$

$$= \text{Log}\left(\frac{P_{out}}{P_{in}}\right) = \frac{-A\left(\frac{dB}{km}\right) L\,(km)}{10}$$

$$\frac{P_{out}}{P_{in}} = 10^{-AL/10}$$

$$P_{out} = P_{in}\, 10^{-AL/10}$$

$\Rightarrow$ Cable Loss factor:

1. Microbanding
2. Scattering
3. Macrobanding
4. Absorption

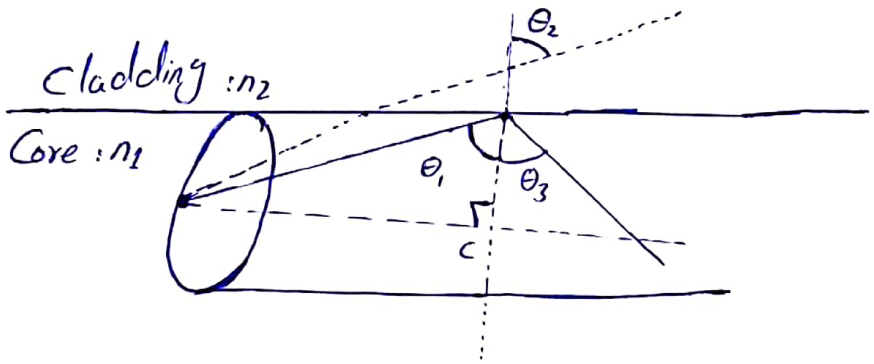
(Q3). The refractive Indexes of the Core and cladding of a Silica fiber are 1.48 and 1.46 respectively. Find:

PART a). Critical Incident angle, show critical incident angle using figure?

(Ans). Critical Incident angle.

The angle the beam makes with the Perpendicular to optical boundary b/w Core and cladding is called Critical incident angle.

Figure:-



(Q3).

PART B). Critical Propagation angle, also Explain Why is Critical propagation angle so important?

(Ans). Critical Propagation angle:

The angle the beam makes with Center line of fiber optic is know as Critical Propagation angle.

Why at is so important:

→ We need to direct the rays inside the Core at critical propagation angle or even lesser angle.

→ $\theta_1 C$ is not useed instead we used αC

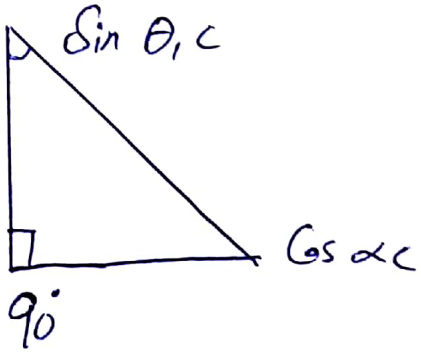
$n_1 = 1.48$ (Core).

$n_2 = 1.46$ (cladding)

As we know that $\sin \theta_1 C = n_2/n_1$

Here we have

$\alpha C = 90^\circ - \theta_1 C$



$\sin \theta_1 c = \cos \alpha c$

$$\frac{n_2}{n_1} = \cos \alpha c$$

We Can Say that

$\sin \alpha c = \sqrt{1 - \cos^2 \alpha c}$ $\because \sin^2 \alpha c + \cos^2 \alpha c = 1$

$\sin \alpha c = \sqrt{1 - co^2 \alpha c}$

$$\sin \alpha c = \sqrt{1 - \left(\frac{n_2}{n_1}\right)^2}$$

$$\alpha c = \sin^{-1} \sqrt{1 - \left(\frac{1.46}{1.48}\right)^2}$$

$$\alpha c = \sin^{-1} \sqrt{1 - (0.9864)^2}$$

$$\alpha c = \sin^{-1} (0.162)$$

$$\alpha c = 9.43$$

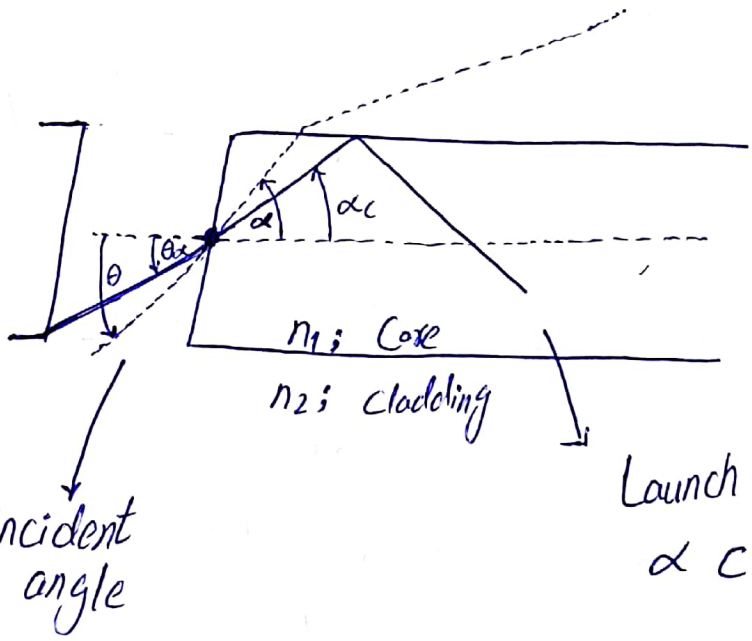
Answer

(PART) c. Acceptance angle, What is the relation b/w acceptance angle and Spatial angle?

(Ans). Acceptance angle (launching the light)

Acceptance angle is the maximum angle at which a light ray inter into core and propagate throw it in zig-zag path.

Figure:



So the relation b/w Acceptance angle and Spatial angle.

Using Snell's law

$n_a \sin\theta_a = n_1 \sin\alpha_C$

as $n_a = 1.0003$

$\sin\theta_a = n_1 \sin\alpha_C \rightarrow \theta_a$ = Spatial angle

So the light will save inside the fiber if at comes out from bounded so the acceptance angle is $2\theta_a$.

$\Rightarrow$ $n_1 = 1.46$, $\alpha_C = 9.43$, $n_a = 1.0003$

Solution: $n_a \sin\theta_a = n_1 \sin\alpha_C$

$1 \sin\theta_a = n_1 \sin\alpha_C$

$\theta_a = \sin^{-1}(1.46 \sin 9.43)$

$\theta_a = \sin^{-1}(1.46 \times 0.1638$

$= \sin^{-1}(0.2392)$

$\theta_a = 13.84$ → Spatial Angle

$2\theta_a = 13.84 \times 2$

$2\theta_a = 27.67$ → Acceptance Angle

(Q3).

PART d). Numerical Aperture and explain the relation

$$\theta_{1c} \rightarrow \alpha c \rightarrow \theta_a \rightarrow NA.$$

(Ans). Numerical Aparture:

⇒ NA is the Light gathering ability.

⇒ The numerical aparture is define as

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

Relation $\theta_1 c \rightarrow \alpha c \rightarrow \theta_a \rightarrow NA$

⇒ NA which describe the ability of an optical fiber to gather Light from a Source and than presave.

⇒ The formula expressing this statement.

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