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Subject optical communication

QNo1: (a) Why fiber-optic communication? explain in details the basic blocks of fiber optic communication system?

Ans:- Why fiber optics communication: what is telecommunication. Tele means over a distance and communication means exchange of information over a certain distance using some type of equipment.

Orginal light communication:
- light → fire
- Beacon = ~ 780 BC, King you of Ghou.
- early middle age (500-1000 AD), Russian

* Telegraph (1837)
  - carriers current, electro magnetic waves.
  - coding, morse code
* Telephony (1876)
  - voice → electic pulse
  - Anlog signals
* Information.
  - voice
  - video
  - Data

- Media: cooper wire, coaxial cable, air optical fiber
- Modern communication: conversion - Modulation Transmission - Demodulation
- What we want from modern telecommunication:- capacity, capacity and more capacity.

* more information is produce
  postindustrial era → information era.

Internet, telephone, mobile ϕ, credit card, online bank, online TV, movies.

* Analog to Digital:-

- Analog: Amplitude, frequency, phase
- Digital: bits "0" and "1"
- more reliable
- Require more channel capacity.

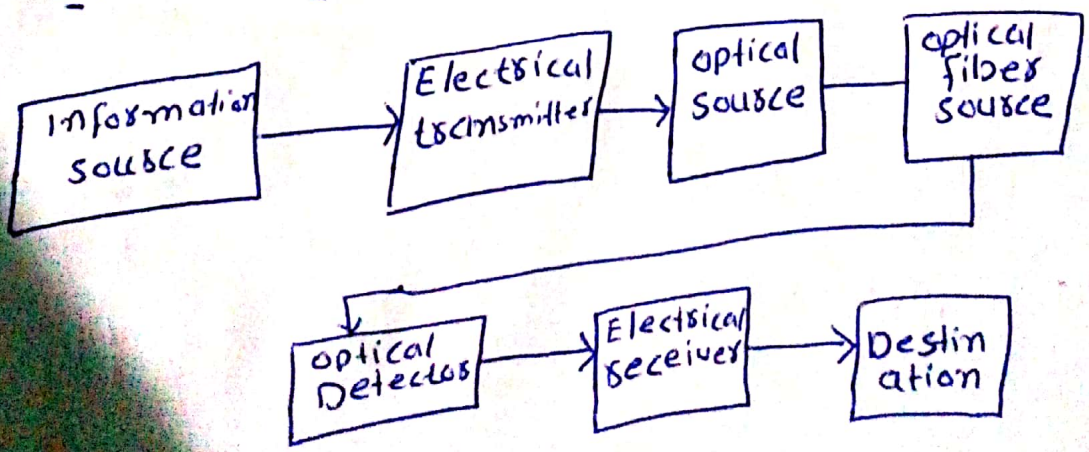
The capacity limit.

$$C = BW \times \log_2 (1 + SNR)$$

- Bandwidth the range of frequencies within which the signal can be transmitted without substantial attenuation.
- The higher the carriers frequency, the greater the channel bandwidth and the higher the information carrier capacity.
  - Copper wire . 1MHz
  - coaxial cable . 100MHz
  - Radio frequency: 500 KHz ~ 100 MHz.
  - microwave: 100 GHz (satellites, Radio over fibers).

* Basic block of fiber communication systems:-

Block diagram:



> Information source: user data.
> Electrical transmitter: where the information is converted into electrical from also modulated and multiplexed.
> optical source: convert the electrical signal to light using (LED) light emitting diodes.
> optical detecator: recive light using (PD) photo diodes.
> Electrical receiver: convert optical information into electrical signal.

QNO1: (B) Describe and differentiate b/w LED and LD. Explain its principle of acation and types of LD.

Ans:- LED:-

- it is polychoumatic
- It is not coherent
- spontaneous emission is responsiable for it.
- Not directional
- poor energy is associated.
- LED's are small in size, longer life reliable and require little power
- Generation of photon by spontaneous emission.
- LED's produce a divergent and incoherent light beam.

LD

- it is highly monochromatic
- it is highly coherent.
- spontaneous emission is responsible for it.
- Highly directional
- Highly energetic
- Laser's are biger in size, longer life, less reliable and require more power than LED.
- Generating photon by stimulated emission
- Laser produce a monochromatic and coherent high beam

* **principle of action:-** The working principle of the light emitting diode is base on the quantum theory. The quantum theory says that when the electron come down from the higher energy level to the lower energy level then, the energy emitts from the photon. the photon energy gap between these two energy level. If the p-n junction diodes is the forword biased. then the current flows thsough the diode. The flow of current in the semiconductors is caused by the both flow of holes in the opposite direcation of current and flow of electron in the direcution of the current. Hence there will be recombination due to the flow of these charges carriers.

* **Types of LD :-**

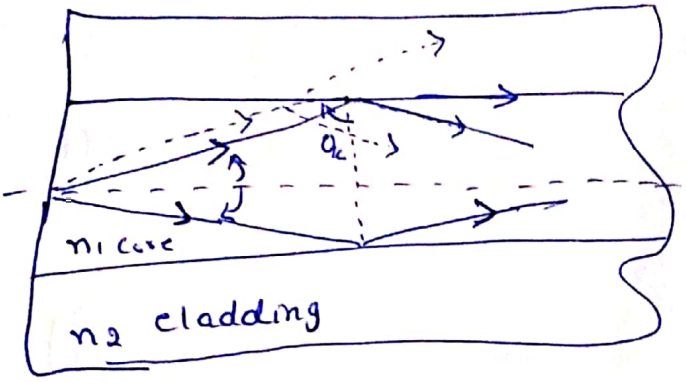
1. Double heterostructure laser diode.
2. Quantum well laser diode
3. separate confinement heterostructure LD.
4. vertical cavity surface emitting laser diode.

Q NO2: (A) Explain the phenomena of total internal reflection. support your answer with the of diagram.

Ans:- Total Internal Reflection:-

critical incident angle: θ_{ic}

critical propagation angle: α_c



to save light inside and optical fiber the propagation angle of rays should have

$$\alpha_2 \leq \alpha_c.$$

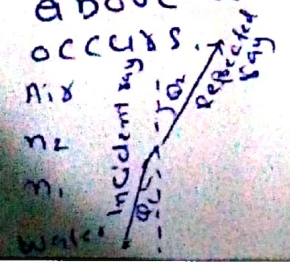
from snell's law, one has

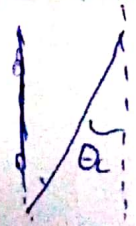
$$\sin = n_2/n_1, \text{ and } \cos \alpha_c = n_2/n_1$$

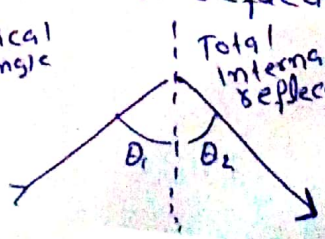
Thus one can derive

$$\alpha c = \sin^{-1}\sqrt{[1-(n_2/n_1)^2]}$$

The total internal reflection is the phenomenon which occurs when a propagated wave strike a medium boundary ed an angle larger than a particular critical angle with respect to the normal to the surface. The critical angle is the angle of incidence above which the total internal reflection occurs.







Q NO2 (B) What is cable loss factor? Explain the relationship $P_{out} = P_{in} \times 10^{-AL/10}$

Ans:- Cable loss factor:- Cable loss is a factor to be considered in system design. The loss introduced by the cable varies with frequency. Mobile mask has tested some of the cables that we use in our designs and the measured results have been plotted against frequency. This gives the system designer an easy way to determine the actual loss introduce by the cables in the overall system. it is to be noted here that these results, so a more practical indication of cable performance versus frequency can be obtained from these plots. The losses are given as dB/100 ft. so the actual length of the cable in the system needs to be used to convert the value from the graph into the loss introduced by the cables in the system.

Q NO2 (B) Relation $P_{out} = P_{in} \times 10^{-AL/10}$

Sol:- • Loss in linear or decibels (fibers, devices...)

$$Loss = P_{out}/P_{in}$$

$$Loss\ (dB) = -10 \log_{10}(P_{out}/P_{in})$$

: Notice the minus sign!

Attenuation (loss) per fiber length (fiber)

also called "Attenuation; cable-loss factor, attenuation coefficient)

$$A\,(dB/km) = loss\,(dB) / fiber\ length\,(km)$$

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

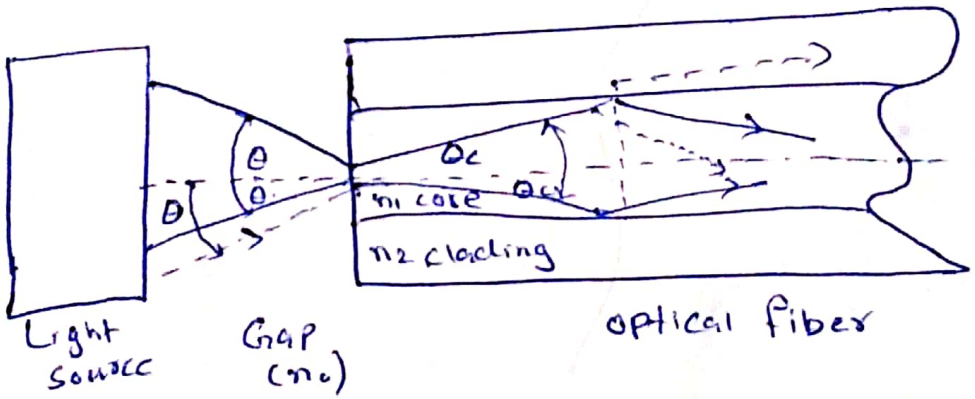
$$L = (10/A)\log_{10}(P_{in}/P_{out})$$

$$P_{out}\,(dBm) = +10\log(P_{out}/1mw)$$

QNo (3) The refractive indexs of the core and cladding of a silica fiber are 1.48 and 1.46 respectively. find.

(a) critical incident angle, show critical incident angle using figure?

critical incident angle figure



Sol:- 7 critical incident angle: $\sin\theta_{ic} = \frac{n_2}{n_1}$

$$= \sin\theta_{ic} = \frac{1.46}{1.48}$$

$$= \sin\theta_{ic} = 0.98$$

$$\theta_{ic} = \sin(0.98)$$

$$80.57^\circ = 0.8304$$

$$= 66.90^\circ$$

(B) Critical propagation angle, also explain why is critical propagation is so important?

Sol:-

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

$$\alpha_c = \sin^{-1}\sqrt{1-\left[\frac{1.46}{1.48}\right]^2}$$

$$= \sin^{-1}\sqrt{1-(0.986)2}$$

$$= \sin^{-1}\sqrt{1-1.972}$$

$$= \sin^{-1}\sqrt{-0.972}$$

$$= \sin^{-1}0.985$$

$$\boxed{\alpha_c = 1.397}$$

Critical propagation is important Because the critical propagation is the angle which is refracted ray emerges parallel to the interface between the dielectrics and this is the limiting case of refrecation and the angle of incidence which is termed as critical angle.

(c) Acceptance angle, what is the relationship between spatial angle and Acceptance angle?

Acceptance angle:

$$\sin\theta_a = n_1 \sin\alpha_c$$

$$\sin\theta_a = 1.48 \sin(1.397)$$

$$\sin(14.033^\circ) = 1.48 \sin(1.397)$$

$$\sin(14.033^\circ) = 1.48\,(0.984)$$

$$\sin(14.033) = 1.456$$

$$0.99 = 1.456$$

$$= 1.47$$

Relation between spatial angle and acceptance angle. The spatial angle and least we have idea on how to construct the angle of 1 radian, but for spatial angle 1 steradian which as define as the angle that depends from the center sphere. and acceptance angle came in an optical fiber, the maximum angle from the axis and which light can remain confined within the core for total internal reflection.

(4) Numerical Aperture and explain the relation $\theta_{ic} \rightarrow \alpha c \rightarrow \theta_a \rightarrow NA$

Numerical aperture (NA) of an optical system is a dimensionless number that characterizes the range of angle over which the system can accept or emit light.

$$NA = n_1\sqrt{(1-(n_1/n_2)^2}$$

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

$$= n_1\sqrt{(1.48)^2-(1.46)^2}$$

$$= 1.48\sqrt{(1.48)^2-(1.46)^2}$$

$$= 1.48\sqrt{2.96-2.92}$$

$$= 1.48\sqrt{0.04}$$

$$= 1.48(0.2)$$

$$NA = 0.296$$

$\theta_{ic} = 80.57^\circ \rightarrow 9.43^\circ \rightarrow \theta a\ 14.033^\circ$

$NA = 0.2425$.

The end