(13) Mention the advantages and disadvantages of fiber optics communication.

Advantages:

- Greater Bandwidth
- Longer Distance
- Thin and light weight
- High-level security

Disadvantages

- Installation cost
- Fragility
-

14. Differentiate between step index and Graded index fiber.

Step Index	Graded index
• constant refractive index	• Non-constant refractive index.
• path of light propagation is zig-zag	• path of light is helical in manner
• Attenuation is more	• Attenuation is less
• Lower bandwidth	• Higher bandwidth.
• Diameter of the core is 50-200μm	• 50μm

② Explain how attenuated and distorted signals recovered in the transmission link

→ To use repeaters

→ Hubs that will boost the signal strength

→ connection should be checked if the installation of cables is done properly

→ Amplification of the signal can be increased.

(17) Refractive index of the core is higher than the cladding. Justify the statement.

→ Optical fiber communication works on the principle of the Total Internal reflection.

→ The core should have greater refractive index than cladding for TIR to take place because TIR will happen only when light travels from denser to rarer medium.

15. Differentiate between single-mode and multimode fiber.

Single-mode fiber	Multimode fiber
• only one propogating mode	• More than one propogating mode.
• core dia is small	• core dia is large
• we use LASER	• we use LED
• more bandwidth	• less Bandwidth.
• Low cost	• High cost.

4. Using Snell's law, define the relationship at the interface between two different media.

→ The ratio of the sine of ∠ of incidence to the sine of ∠ of refraction is constant, for the light of a given colour and for the given pair of media.

$$\frac{\sin i}{\sin r} = \mu$$

constant value is called refractive index of the second medium wrt first.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

① Explain in detail the advantages of optical fiber over conventional copper systems:

→ An especially important feature of an optical fiber relates to the fact that it is a dielectric material, which means it does not conduct electricity.

→ This makes optical fibers immune to the electromagnetic interference effects seen in copper wires such as inductive pickup from other adjacent signal-carrying wires or coupling of electrical noise into the line from any type of nearby equipment.

Acceptance ∡ $= \dfrac{\sqrt{(1.5)^2-(1.48)^2}}{1.33}$

$\sin\theta = \dfrac{\sqrt{2.25-2.19}}{1.33}$

$\sin\theta = \dfrac{\sqrt{0.06}}{1.33}$

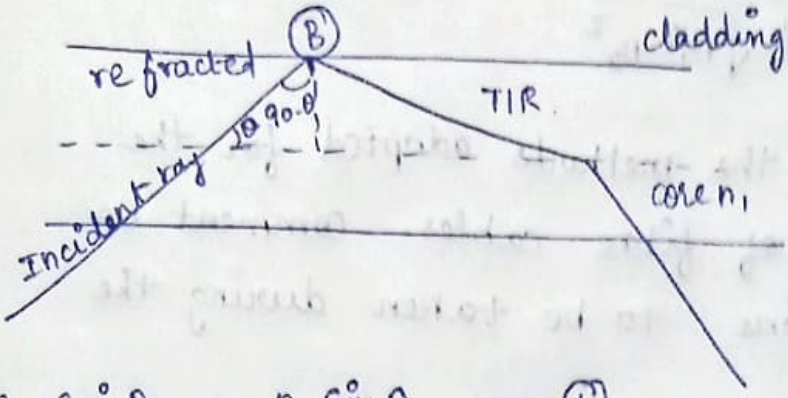
$= \dfrac{0.244}{1.33}$

$\sin\theta = 0.183$

$\theta = \sin^{-1}(0.183)$

$\boxed{\theta = 10.54}$

(2) i) Derive the expression for acceptance angle and numerical aperture.



$$n_0 \sin\theta_0 = n_1 \sin\theta_r \quad \text{—(1)}$$

$$\sin\theta_0 = \frac{n_1}{n_0} \sin\theta_r \quad \text{—(2)}$$

$$\sin\theta_0 = \frac{n_1}{n_0} \left(\sqrt{1-\cos^2\theta_r}\right) \quad \text{—(3)}$$

By applying Snell's law at point B.

$$n_1 \sin(90-\theta_r) = n_2 \sin 90 \quad \text{—(4)}$$

$$n_1 \cos\theta_r = n_2 \quad \text{—(5)}$$

$$\cos\theta_r = \frac{n_2}{n_1} \quad \text{—(6)}$$

Substituting (6) in (3)

$$\sin\theta_0 = \frac{n_1}{n_0}\left(\sqrt{1-\frac{n_2^2}{n_1^2}}\right) \quad \text{—(7)}$$

$$= \frac{n_1}{n_0}\left(\sqrt{\frac{n_1^2-n_2^2}{n_1^2}}\right) \quad \text{—(8)}$$

$$= \frac{n_1}{n_0}\left(\sqrt{n_1^2-n_2^2}\right) \quad \text{—(9)}$$

$$\sin\theta_0 = \frac{\sqrt{n_1^2-n_2^2}}{n_0}$$

Numerical aperature :-

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

for air $n_0 = 1$

$$NA. \Rightarrow \sqrt{n_1^2 - n_2^2}$$

(7) A boy is in a pool and shines a flashlight toward the level of it at a 35° angle to the vertical. At what angle does the flashlight beam leave the pool?

$n_1 \Rightarrow$ air $\Rightarrow 1$

$n_2 \Rightarrow$ water $\Rightarrow 1.33$

$n_1 \sin\phi_1 = n_2 \sin\phi_2$

$$\phi_2 = \sin^{-1}\left[\frac{n_1}{n_2} \times \sin\phi_1\right]$$

$$= \sin^{-1}\left[\frac{1}{1.33} \times \sin 35\right]$$

$$= \sin^{-1}\left[0.751 \times 0.573\right]$$

$$= \sin^{-1}\left[0.4303\right]$$

$$= 25.48^\circ$$

(3) (i) Describe the methods adopted for the installation of fibre cables. comment on the precautions to be taken during the installation.

The two methods that are adopted for the installation of fibre cables are Pulling and blowing method.

Pulling method:

The basic approach is to pull the copper or aluminium power cables. In this method, the optical fibre cable can be pulled by hand or using a cable-pulling winch.

Blowing method:

→ Cable blowing is the process of blowing optical fibre cable through a duct while simultaneously pushing the cable into the duct.

→ Advance technique.

→ very fast process

→ Effective for longer distance.

Precautions

→ wear safety glasses
→ Do not eat / drink near the installation area
→ Be careful while handling the fibers
→ Do not stick the broken ends of fiber to fingers
→ Do not have exposure to nose, skin, eyes
→ Do not smell the optical fibre
→ Be careful with the smaller pieces.

⑨ An unknown glass has an index of refraction
* of $n = 1.5$. For a beam of light originating in the glass, at what angles the light 100% reflected back into the glass.

(100% reflected)

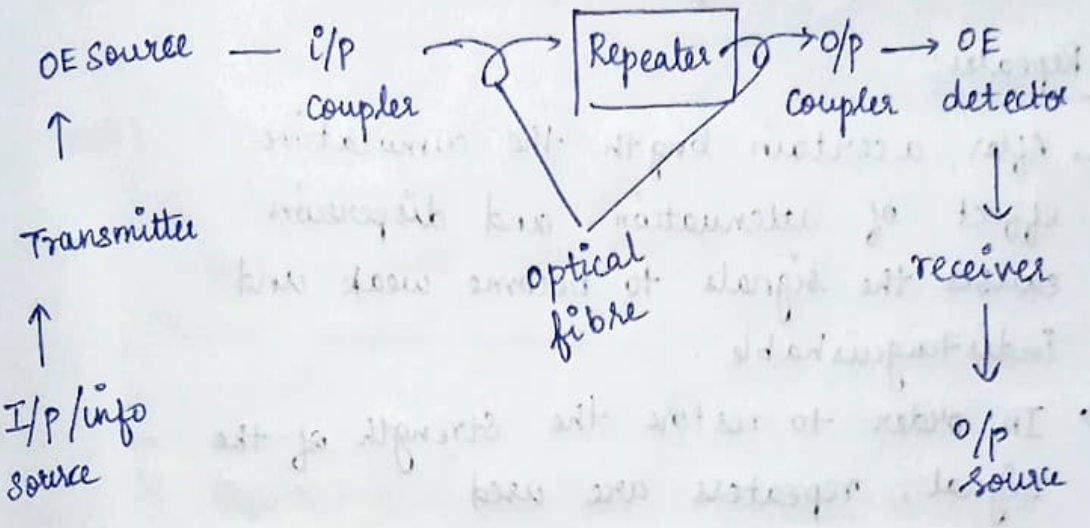
$$\sin\theta = \frac{n_1}{n_2}$$

$$\theta = \sin^{-1}\left(\frac{1}{1.5}\right)$$

$$\theta = 41.8^\circ \Rightarrow 42^\circ$$

CT-1 FOO 12 marks

① with the aid of neat diagrams, discuss various components of optical fiber transmission



Information source:

→ Multimedia data
→ They are voice, video or data.
→ we need a transducer for converting.

Transmitter:

→ Modulation purpose
→ To reach signal to a longer distance
→ converts the signal to proper form → (EH wave)

OE Source:

→ EH wave to optical range which acts as information carrier
→ most of them are LED and injection laser diode.

Channel couplers:

→ The function of a coupler is to collect the light signal from OE source & send to optical fiber cable

Repeater:

→ After a certain length the cumulative effect of attenuation and dispersion causes the signals to become weak and indistinguishable.

→ In order to restore the strength of the signal, repeaters are used.

OE - detector

→ The reconversion of an optical signal into an electrical signal takes place at OE detector

→ we use semiconductor p-i-n

Receiver:

Filteration and amplification is performed by receiver

O/p info:

Interpreted by a human observer

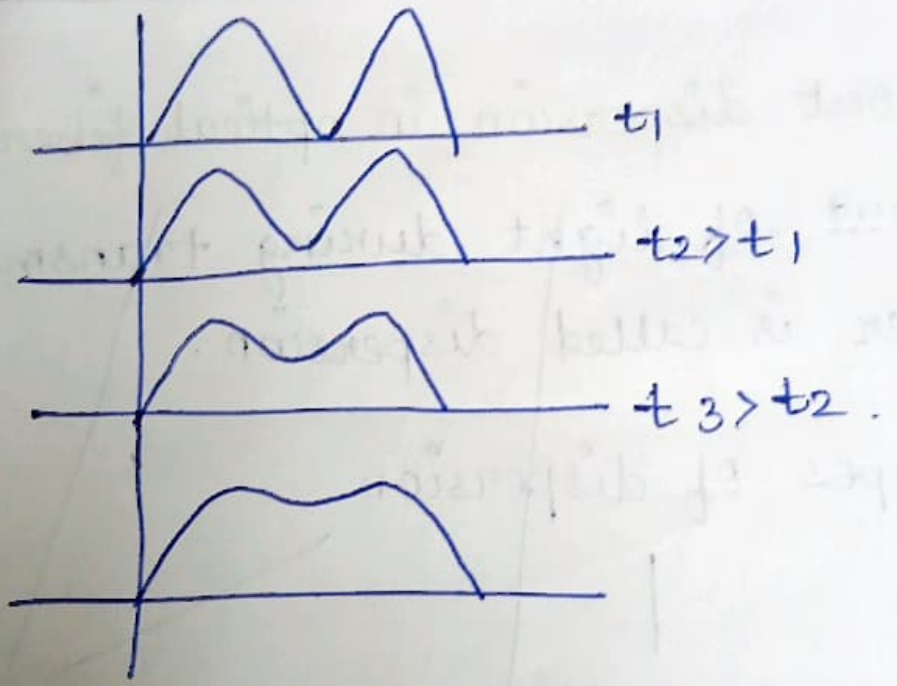
4marks

① compare intramodel and intermodel dispersion

intramodel	Intermodal
→ Used in singlemode fiber	→ Used in multimode fiber
→ aka material dispersion	aka modal dispersion
→ less pulse broadening	→ more pulse broadening
→ The main cause is difference in wavelength of light	→ The main cause is difference in propogation modes of light
→ measure of unit is ps/km	→ ns/km

② Explain about dispersion in optical fiber.

Dispersion : Splitting of white light into 7 constituent colors.



Intermodal dispersion

→ occurs only in multimode fibers
→ Has different group velocity.

Intra modal dispersion

→ main wavelength that cause intra modal is material dispersion & wavelength dispersion

polarisation dispersion:

Both in single/multimode there occurs polarisation of light & this causes polarisation dispersion

chromatic:

combination of inter & intramodal dispersion

4) Difference btwn luminescence & incandescence

	Luminescence	Incandescence
→	Emission of light without heating to high temp	with
→	Eg: Fluorescence, Phosphorescence:	Eg: Fire, Candles, light bulbs
→	does not involve high temp.	→ Involves high temp
→	High energy efficiency	→ Low
→	UV to excite the e^-	Heat is used.

(5) comment on Quantum efficiency

Measure of the effectiveness of an imaging device to convert incident photons into e^-.

~~(6) Advantages of photodiode~~

Important parameter for evaluating the performance of photosensitive devices, provides measure of devices ability to convert light energy into electrical energy.

$$\eta = \frac{I_p/q}{P_o/h\nu}$$

Amount of light energy absorbed according to e^--hole recombination.

(6) List out the types and advantages of photodiode.

Photodiode converts light energy into electrical energy.

Types

PN - photodiode : consisting of a PN junction that absorbs light & generates photocurrent.

PIN :→ wider depletion region
→ Detect light with longer wavelength

Avalanche photodiode : higher voltage than PN, PIN

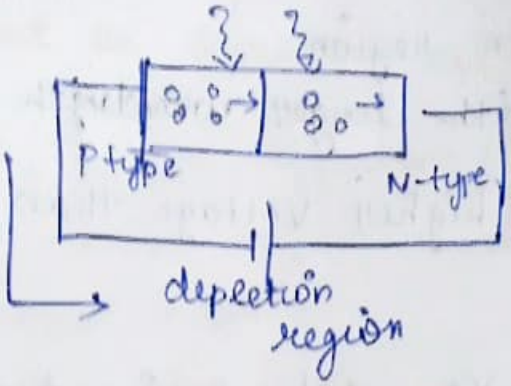
Schottky photodiode : uses metal - semiconductor junction

Advantages :

→ high sensitivity
→ fast response time
→ Low noise
→ wide Dynamic range
→ small size
→ low power consumption

7) Give the principle of photo detection in semiconductor.

→ Converts an optical signal into a signal of another form
→ most convert optical signals into electrical signal
→ All photodetectors are sq-law detectors that respond to the power or intensity, rather than the field amplitude of an optical signal
→ when a photon with sufficient energy is absorbed by semiconductor, it generates an e⁻-hole pair by exciting an e⁻ from the valence band to conduction band



⑧ Factors that cause Rayleigh scattering

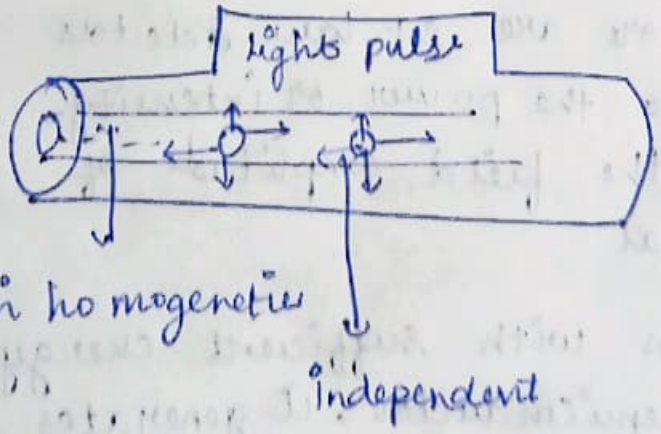
→ Scattering of light by particles much smaller than the wavelength of light.

→ light scattered by a small spherical vol of variant R.I as bubble, droplet

→ It results from non-ideal physical properties of the manufactured fiber

→ It results from inhomogeneities in the core & cladding

→ Because of these inhomogeneities prob like ↳ ~~fluction~~ fluctuation in R.I
↳ Density & composition variation



(5) compare fluorescence and phosphorescence.

Fluorescence	Phosphorescence
→ Immediate light emission	→ Delayed light emission
→ short life time	→ long lifetime
→ non-radiative	radiative
→ sensitive	Less sensitive
used in Biological imaging, chemistry	security inks, OLED technology

Part-C

① A 6Km optical link ... and also derive the expression involved in it.

For Slowest mode:

$$\sigma_s = \frac{L n_1 \Delta}{2\sqrt{3}\, c}$$

$L = 6 \quad n_1 = 1.5 \quad \Delta = 0.01 \ (1\%)$

$C = 3 \times 10^8$

$$= \frac{6 \times 1.5 \times 0.01}{2\sqrt{3} \times 3 \times 10^8}$$

$$= \frac{0.09}{10.3923 \times 10^8}$$

$$= 8.660 \times 10^{-3} \times 10^{-8}$$

$$= 8.66 \times 10^{-11}$$

$$= 86.6 \times 10^{-12} = 86.6 \text{ ps}.$$

For Fastest mode

$$\sigma_s = \frac{L n_1 \Delta^2}{20\sqrt{3}\, c}$$

$$= \frac{6 \times 1.5 \times 0.01 \times 0.01}{20 \times \sqrt{3} \times 3 \times 10^8}$$

$$= \frac{9 \times 10^{-4}}{103.923 \times 10^8}$$

$$= 0.086 \times 10^{-4} \times 10^{-8}$$

$$= 0.0866 \times 10^{-12} \Rightarrow 0.0866 \text{ ps}$$

② Discuss the attenuation encountered in optical fiber due to Bending, Scattering and Absorption

→ Signal Attenuation (signal loss) is one of the most important properties of optical fiber because it largely determines the unamplified seperation between transmitter and a receiver.

→ Basic mechanisms are due to bending, scattering and absorption.

1) Absorption

caused by 3 different mechanisms

- atomic defects
- extrinsic absorption
- Intrinsic absorption

Atomic defects

→ imperfection in atomic structure..
→ Eg: missing molecules, high-density atom grps
→ Atomic defects absorption are negligible compared with extrinsic & intrinsic

Extrinsic absorption:

→ impurity in glass material
→ They contain transition metal impurities
Fe, Cu, Co, Ni
→ Pure silica fibers with low Ge doping → lowest loss
→ Dominant factor in silica fiber is the presence of minute quantities of impurities

Intrinsic absorption:

→ by basic constituent atom of the fiber material

→ For silica molecules electronic resonance in UV region, Vibrational resonance in IR region.

2) Scattering Losses.

Scattering can occur due to structural discontinuities, compositional fluctions, microscopic variations, defects in manufactures.

→ Spreading of light

Formula :- $\frac{8\pi^3}{3\lambda^4}(n^2-1)^2 K_B T_f \beta_T$

K_B → Boltzmann const

β_T → iso thermal compressibility

T_f → Fictive temp

n → refractive index

Rayleigh Scattering:-

Scattering of light rays that are smaller than the light rays is called Rayleigh Scattering.

constituents to 96% of scattering loss.

96% of loss → unavoidable thing.

3) Bending:

- Microscopic bending (wrt internal)
- macroscopic bending (wrt external)

When radius of curvature is small loss is more

when radius " " large loss is small.

③ Discuss & compare surface emitting & edge emitting LED structures

Surface emitting LED :-

→ Construction of LED is easier.
→ LED has faster emmission
→ It has high radiance
→ LED has isotropic radiation
→ Finite direction of intensity
→ Best light source choice

Surface emitting LED:

→ Light source contain III - V ternary & quaternary compounds
→ Double heterojunction layer :- 2 diff combination of materials to spread charge carriers evenly.
→ Heat sink to cool off.
→ metalisation to provide metal contact
SiO_2.
→ To avoid dispersion of light we use substrate.

Edge emitting diode:

→ used for generating narrow band signals.
→ central active layer is made using InGaAs.
→ They have two cladding layers.
→ Light is emitted from edge of the LED.
→ output has low divergence in vertical direction.
→ This increases the efficiency of coupling

Adv:

→ Greater coupling efficiency
→ better modulation
→ radiates less power
→ High data rate.

Disad:

→ Difficult to design heat sink
→ structure is complex.
→ Expensive.

comparison

Surface	Edge
→ Easy to fabricate	→ Difficult
→ Easy to handle	→ Difficult to handle
→ less reliable	→ highly reliable.
→ LED emitted from surface	↔ from edge
→ wide spectral width	→ narrow spectral width
→ efficiency 60%.	60% to 80%.

4) with a neat sketch explain the principle & operation of PIN & avalanche photo diode.

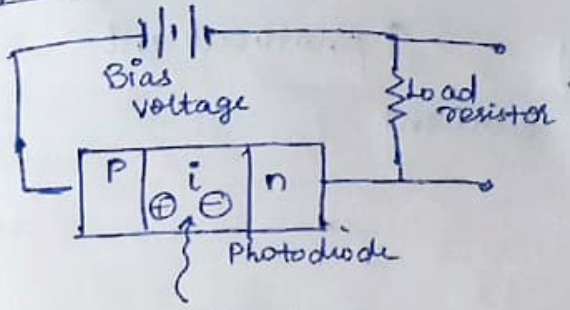
photo detectors converts light to electrical signals.

PIN & avalanche photo diode comes under the mechanism called Internal photo electric effect.

Internal photo electric effect:

Free charge carriers are generated by absorption of incident photons in semiconductor junction detectors.

PIN photo diode :



The high electric field present in the depletion region causes photo-generated carriers to seperate and be collected across the reverse-biased junction. This give rise to a current flow in an external circuit known as photo current.

Energy band diagram

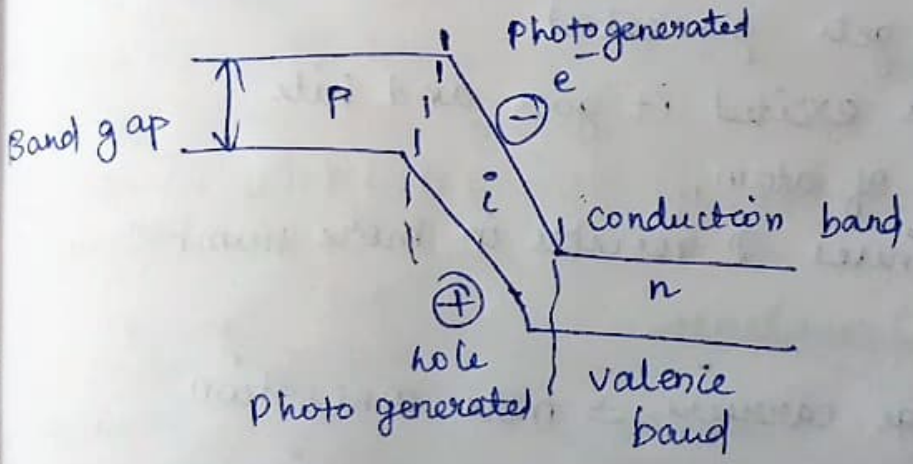


Photo current :

$$I_p = \frac{q}{h\nu} P_o \left(1 - e^{-\alpha s(\lambda) w}\right)\left(1 - R_f\right)$$

Quantum efficiency :

$$\eta = \frac{\frac{I_p}{q}}{P_o / h\nu}$$

Responsivity $= \frac{A}{W}$

Advantages:

1) ↑ width, ↑ light energy → ↑ photocurrent
2) ↑ width, faster drift current.

Avalanche photodiode:

Avalanche :- short period of time more current flows.

In avalanche photodiode we multiply the current.

When light falls on sc material, atoms gets disturbed, e^- jumps out. when e^- gets excess energy it becomes -ve ion, at the same time +ve ion gets generated.

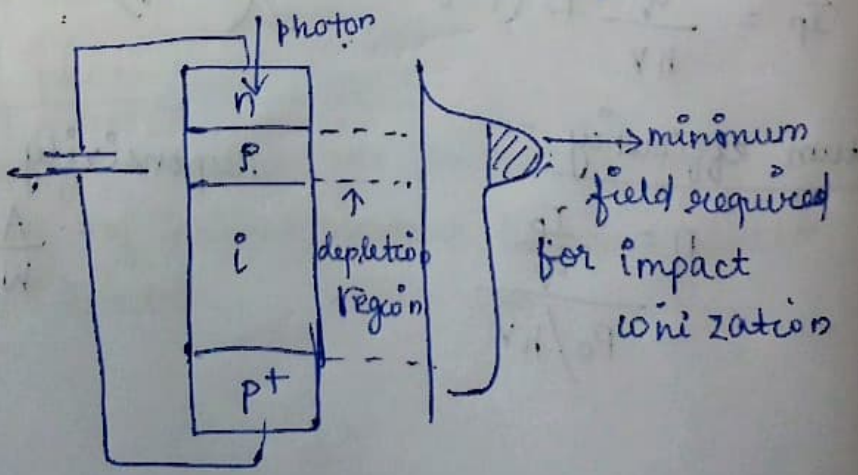
The e^-, h^+ gets excited it goes and hits more number of atom.

This process continues ⇒ results in more number of photocurrent.

more charge carriers ⇒ more ionisation

↳ this is called impact ionisation

↳ this creates: avalanche photodiode



5) Illustrate microbending and macrobending losses with suitable diagram.

→ Losses occur whenever an optical fiber undergoes a bend of finite radius of curvature

→ micro bending (wrt internal) / macroscopic (wrt external)

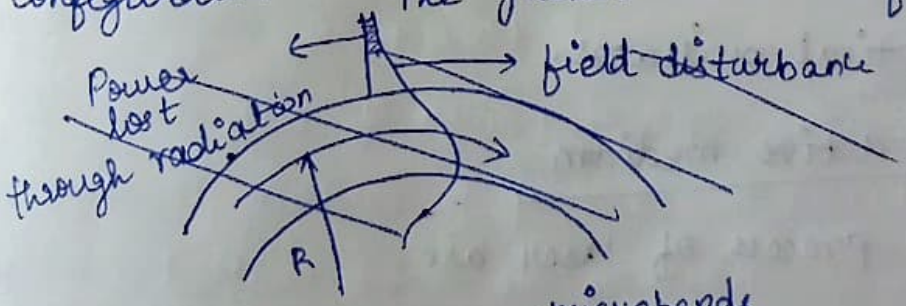
Micro bending:

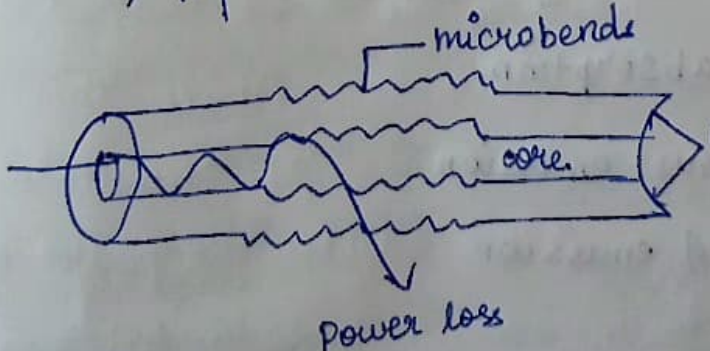
→ Micro bends are repetitive small scale fluctuations in the radius of curvature.

→ caused by non-uniformities in manufacturing or by uniform lateral pressures.

→ can be minimised by placing a compressible jacket over the fiber.

→ when external forces are applied to this configuration the jacket can be deformed.





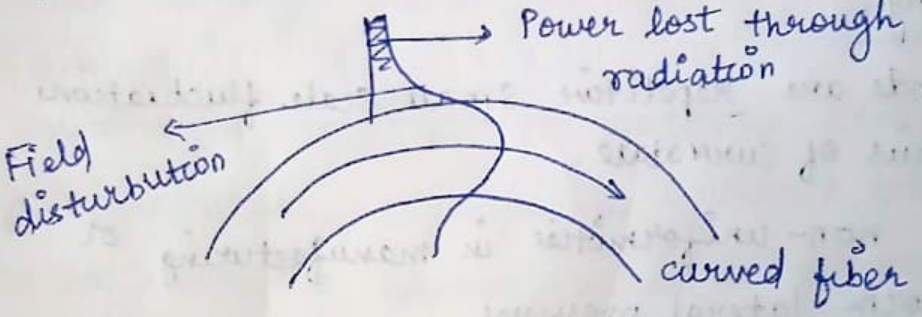
Macro bending :

→ Macro bending occurs when Fiber is bent into visible curvature. Usually due to incorrect installation.

→ Macro bending is reversible.

→ when roc is small loss is more

→ when roc is ↑ " " small



6) Laser

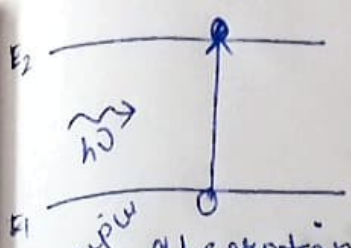
→ Light Amplification by Stimulated Emission Of Radiation.

→ It is an optical oscillator.

~~3 main active medium~~

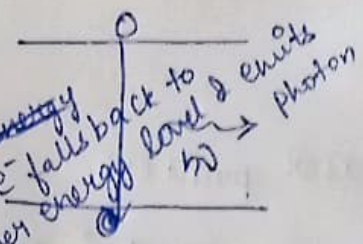
3 main process of laser are

1) Photon absorption
2) Spontaneous emission
3) Stimulated emission

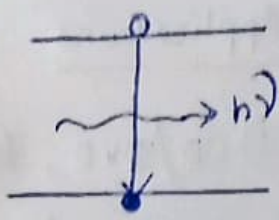


e⁻ occupies higher energy level by absorption

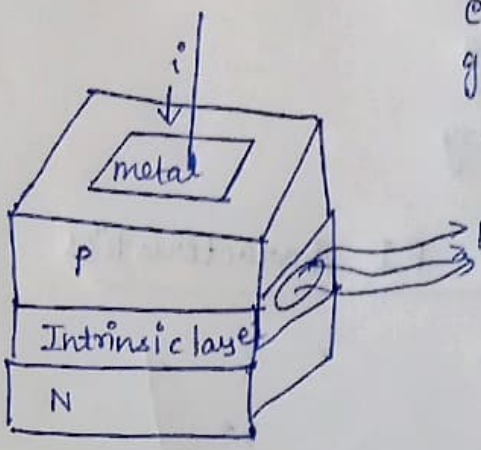
construction:



Spontaneous emission



stimulated emission
e⁻ returns to ground state.



working:

→ The input terminals are connected to a metal plates which are sandwiched to n type and p-type layers.

→ The intrinsic layer between P-type and n-type is used to increase the volume of active region. so that more no of holes & e⁻ can accumulate at the junction.

→ This allows more no of e⁻ to recombine with h^+ to get better power

→ The laser light is emitted from elliptical region.

Applications

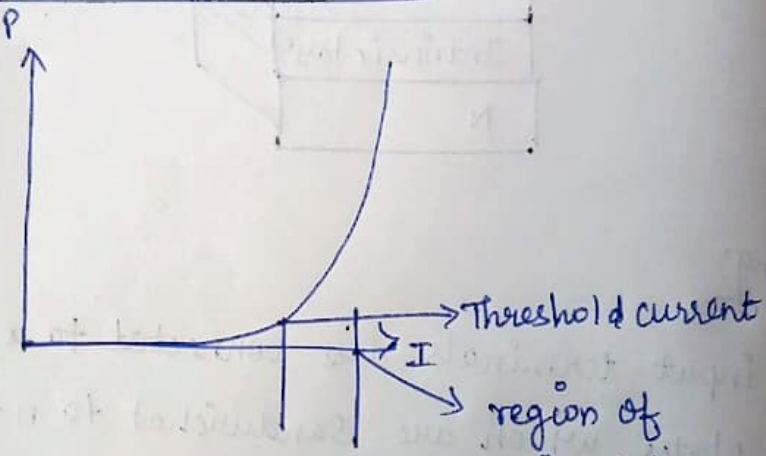
1) CD/DVD, Laser printers.

2) Laser Diode are used in machines used to remove unwanted tissues.

3) 3D printing

4) Spectrometry.

Laser Diode PI characteristics



As we increase the current flow to the laser diode, the optical power of output light gradually increases up to certain threshold. Until this point, most of the light emitted is due to spontaneous emission. Above this threshold current, the process of stimulated emission increases. This causes the power of output light to increase a ~~liven~~ lot even for smaller increases in input current.

4 marks

① Demonstrate the principle of a photonic switch based on Self electro optic Device (SEED).

→ It is optically bistable device used for photonic switching.

→ It is constructed of multiple quantum well biased by an external voltage that shifts the wave length & varies the transmitted light.

→ The principle operation : Quantum Confined Stark Effect (QCSE)

→ This effect changes the energy level of a quantum well under an applied E.F

Incident light

↓

absorbed by QCSE

↓

Passes / blocked based on direction of E.F

↓

O/P is sent to detector

② Explain about electro-optic Modulators.

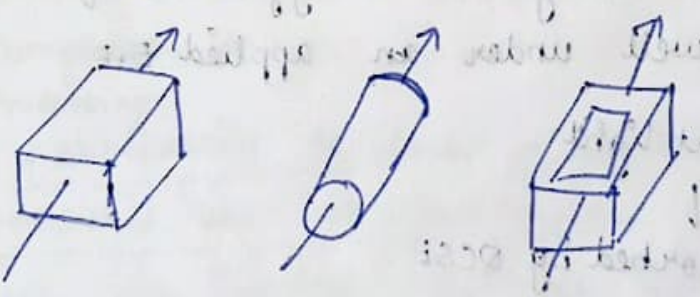
→ EOM is an optical device in which a signal controlled element exhibiting an electro-optic effect is used to modulate a beam of light.

→ The operation is based on Pockel's effect. (modification of the R.I of a non-linear crystal by an EF).

→ If R.I varies linearly then its Pockel's effect

→ If R.I varies square of applied EF then its Kerr effect.

change in RI wrt applied E.F is given by $\Delta\left(\frac{1}{n^2}\right) - re + PE^2$.



Diff types of pockel cells.

(3) Diff b/n monolithic & hybrid integration of OEIC fabrication

Monolithic	Hybrid
→ All components made on single chip using the same semic material.	→ seperately fabricated & bounded together
→ Highly integrated	→ less integrated
→ Chip size is smaller	→ chip size is larger
→ Speed is faster	→ Speed is slower
→ Low power consumption	→ High power consumption
→ Less flexible	→ more flexible

(5) comment on active couplers.

→ Active couplers are type of electronic component used in communication system to couple energy from one circuit to another.

→ They use transistors, amplifiers or operational amplifiers to actively amplify & transfer energy.

→ one advg: ability to provide gain which helps in long-distance communication systems.

→ provides good signal quality.

→ however it can introduce noise & distortion which can degrade the overall performance of the system.

→ Sometimes it may be complex & expensive.

⑥ List out the advantages of EDFA.

EDFA used in optical communication sys to boost the power of signals.

Advantages

→ High gain : useful for long dist. communication which compensates the losses.

→ Wide bandwidth :- suitable for wavelength division multiplexing system.

→ Low noise : for signal quality

→ simplicity : simple to implement & require minimal maintenance.

→ compatibility : compatible with a wide range of fiber optic cables.

(7) Difference between Longitudinal electro optic modulator & transverse electro optic modulator?

Longitudinal	Transverse
→ Light direction is along the length of the crystal	→ ⊥
→ changes the R.I of crystal along the length of the crystal.	⊥
→ E.F is ‖le to light propogation	⊥
→ Efficiency higher.	lower.
→ Used in optical communications & Laser	→ Used in ∝ switching & optical switching
→ Ex: $LiTaO_3$	Ex: BBO crystals

10) What are the challenges met by optoelectronic Integrated circuit?

→ OEICs are complex systems that integrate both electronic and optical components on the same chip.

several challenges include

→ Integration complexity:

Integration of Both electronic & optical components on the same chip may cause technical challenges

→ Fabrication complexity:

costly & time consuming.

→ Thermal management:

The integration of both electronic & optical components on the same chip may cause local heating which can affect the performance.

→ Packaging & Testing:

These ↑ two requires specialised techniques which can add to overall cost & complexity of the system.

(ii) ~~what~~ wdym by front end photo receivers?

→ Front-end photo receivers are optical receivers that are used to detect & convert optical signals into electrical signals at the front end of an optical communication system.

→ Typically used in high speed communication system

→ consist of ~~f~~ optical detector which converts incoming optical signal to electrical signal using TIA (Transimpedance amplifier) which then converts into voltage signal

→ The main requirements for front-end photo receivers are high sensitivity, high band with & low noise.

→ Sensitivity is the crucial factor to ensure that the receiver can detect weak optical signals.

FOO

Part-C

① Explain in detail about Raman Nath and Bragg modulator.

→ An optical modulator is a device which can be used for manipulating a property of light.

→ A wide range of optical modulators are used in different applications such as optical fiber communications, displays, optical metrology and so on.

Raman-Nath :

In Raman-Nath modulator, the acousto optic diffraction grating is so thin that it behaves like a plane transmission grating.

The mth order diffracted wave propogates along a direction making angle θ_m given by

$$\sin\theta_m = m\left(\frac{\lambda}{n_o \Lambda}\right)$$

n_o → refractive index of medium in absence of acoustic wave.

m → order no.

which is

→ In this, signal carrying the info, modulates the amplitude of the acoustic wave.

→ The light beam incident on the acousto optic medium gets diffracted & zeroth order beam of diffracted output is blocked using a stop.

Relative intensity in first order is given by

$$\eta = \frac{(\Delta n)^2 \alpha^2 \pi^2}{\lambda^2}$$

(peak change in the refrac. index)

→ For small power, efficiency is given by,

$$\eta = \frac{\pi^2 M}{2 \lambda^2 \cos\theta_B} \left(\frac{L}{H}\right) P_a,$$

M → figure of merit

L → Length of transducer

H → Height of transducer.

→ Intensity is directly prop to power.

Bragg:

→ L is larger so, acoustic field creates a thick grating.

→ when light beam gets incident at $\angle\theta$ it is reflected by successive layers of grating.

→ Diffraction occurs at $\angle$ of $\theta - \theta_B$.

condition: $\sin\theta_B = \frac{\lambda}{2 n_0 \Delta}$;

→ when accoustic wave amplitude is modulated, first order diffracted beam is modulated.

② Explain the Gain of SOA. (Semic. Optical Amplifier)

→ A SOA is essential InGaAsP laser which operates below its threshold value & gain can be selected by varying the composition of InGaAsP.

→ The optical signal travels through the device only once.

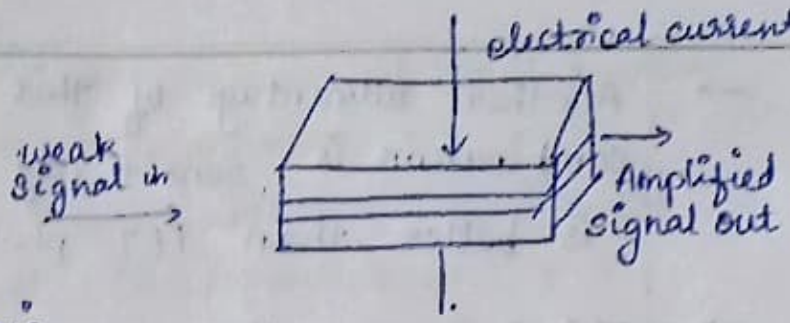
→ During this single passage the signal gains energy & emerges at the other end of the amplifier

→ SOA construction is similar to resonator cavity structure of a Laser diode.

→ The SOA has an active region of length 'L' width 'w' and height 'd'.

→ The reflections are lower in order for optical signal to pass thru the amplification cavity.

→ Lower reflections are achieved by depositing thin layer of silicon oxide, silicon nitride or titanium oxide.



Amplifier Gain

. It is defined as

$$G_1 = \frac{P_{s\,out}}{P_{s\,in}}$$

$P_{s\,out}$ → o/p power

$P_{s\,in}$ → input power

$$G_1 = \exp\left[\Gamma\left(g_m - \frac{1}{\alpha}\right)L\right]$$

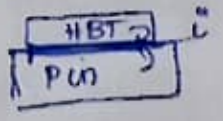
α → absorption coefficient

g_m → material gain

Γ → optical confinement factor

(3) Illustrate the operation of PIN diode integrated HBT photo receiver with a neat diagram

→ The integration of PIN HBT photo receiver involves a single layer epitaxy of HBT, by which PIN modulator was selectively defined for processing



→ collector region of HBT = 'i' region of diode.

→ This region is integrated with passive elements.

→ Here PIN diode → front end photodetection

HBT → pre-amplifiers.

→ Another advantage of this PIN & HBT combination is Sensitivity of HBT is better than FET photo receiver.

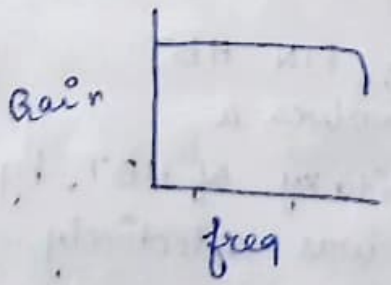
→ This is becoz, the sensitivity of FET $\propto B^3$

and

the sensitivity of HBT $\propto B^2$.

→ There is a technique to enhance photo receive response. That is called Inductive peaking where an inductor is placed in series with photodiode at the input of the diode.

→ The typical values of induction is 2-5nH



(4) with a neat sketch write about guided wave Mach-zehnder interferometer

→ Guided wave componerds are required for routing optical signals on a chip.

→ These are also used for directional coupling, filtering & modulation.

Mach-zehnder Interferometer:

→ A simple guided wave modulation/switching device based on the electro optic effect is called mach-zehnder interferometer.

→ incoming optical beam is split equally between two branches of the input couplers & then recombines at the coupler at the other end.

→ Material growth is such that it is very gradual to reduce bend losses and there is spatial uniformity.

no applied bias = equal phase shift & at o/p coupler 2 wave interfere is constructive & all the power appears at the o/p.

Fields at point 'a' is given by

$$E_1 a = 0 + j \sin \frac{\pi}{4} = \frac{j}{\sqrt{2}} \quad \text{—(1)}$$

$$E_2 a = 0 + \cos \frac{\pi}{4} = \frac{1}{\sqrt{2}} \quad \text{—(2)}$$

At point b,

$$E_1 b = \frac{j}{\sqrt{2}} \exp\{jk n_r l_1\}$$

$$E_2 b = \frac{1}{\sqrt{2}} \exp\left[jk\left[n_r l_2 + \frac{2n_r}{2V} l_v\right]\right]$$

When unequal lengths are introduced.

$$\Delta\phi_1 = k n_r (l_2 - l_1)$$

O/p in arm 1

$$I_{o1} = \frac{1}{2}\left[1 + \cos(\Delta\phi_1 + \Delta\phi E_o)\right]$$

O/p in arm 2

$$I_{o2} = \frac{1}{2}\left[1 - \cos(\Delta\phi_1 + \Delta\phi E_o)\right]$$

Modulation Index is given by $V_\pi = \frac{\lambda d}{l n_r o^3 r_{ij}}$

The switch energy is given by $E_s = \frac{1}{2} C V_\pi^2$

If loss in the device is less then $I_{o1} + I_{o2}$ = i/p intensity.

→ If $l_1 = l_2$ & no bias applied then $I_{o1} = 1$ & $I_{o2} = 0$.

→ If bias = π

$I_{o1} = 0$ $I_{o2} = 1$

(5) Explain with a neat diagram the construction and working of electro optic effect based on logitudinal electro optic modulator.

Electrooptic effect:

The application of an E.F across a crystal may change its refractive index.
This may induce a phenomena called Birefringence in crystal.

Birefringence:

The refractive index of these crystals varies with direction and that crystals are called Birefringent.

+

sir notes

(6) Discuss the materials and processing techniques of OEIC.

OEIC circuits:

OEIC circuits involves integration of electronic and optical components and optical interconnects This integration of electronic & optical devices will lead to high speed, high sensitivity compactness and reliability all at low cost.

Materials & processing for OEICs

The choice of materials used to synthesize OEIC are based on

→ operating wavelength
→ Lattice matching conductor
→ choice of devices.

* The LAN network, depends on GaAs materials
* InP based materials will be applicable to OEICs for long distance fiber communication.
* Another method is heteroepitaxy or use of mismatched materials that includes III-V or II-VI compounds on similar semiconductor of GaAs and InP based components on si.

Processing

→ The fabrication of lower dimension structures, like quantum wires /quantum boxes will involve epitaxy followed by nanolithograph

→ Fabrication of optical device on chips will require advance dry etching capabilities.

Particulary for etching of mirrors and Integrated components.

Plane circuits are fabricated using regrowth.