QUESTION BANK

Name of the Department : **Electronics and Communication Engineering**

Subject Code & Name : **EC8751 – OPTICAL COMMUNICATION**

Year & Semester : **IV & VII**

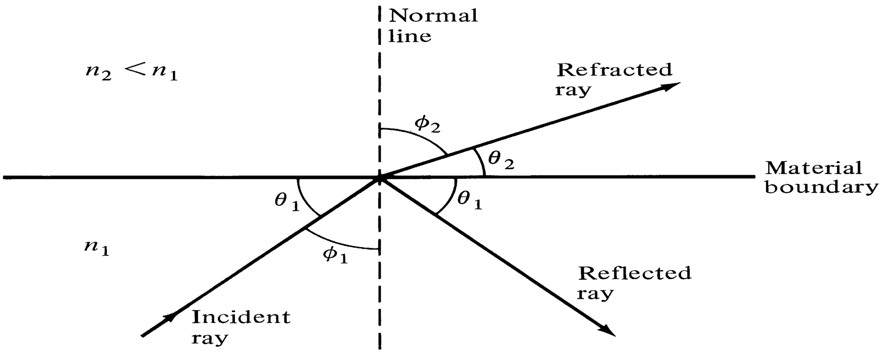
UNIT I - INTRODUCTION TO OPTICAL FIBERS

PART-A

1. State Snell's law. (May15)

At a material boundary, Snell's Law gives the angular relationship between a part of the ray which is reflected at the interface and a part of the ray refracted into the next material.

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



Where n_1, n_2 - refractive indicies of first and second medium

2. **It is desired to make a single-mode fiber operating wavelength=1300 nm with n_{core}=1.505 and n_{clad}=1.502.Findthe Numerical Aperture and core radius or core size(May14)(Nov18)**

Numerical Aperture= $(n_{core}^2 - n_{clad}^2)^{1/2}$ = $(1.505^2 – 1.502^2)^{1/2}$= 0.094979

Numerical Aperture= v. λ/2πa, v= 2.405,

Core radius(a)= v.λ/2π (Numerical Aperture)=5239nm.

3. Give the refractive index expression of a graded index fiber.(Dec06)

$n(r)=n_1[1-2\Delta(r/a)^{\alpha}]^{1/2}$ for $0 \le r \le a$

$= n_1 [1-2\Delta]^{1/2} = n_1[1-\Delta] = n_2$ for $r \geq a$

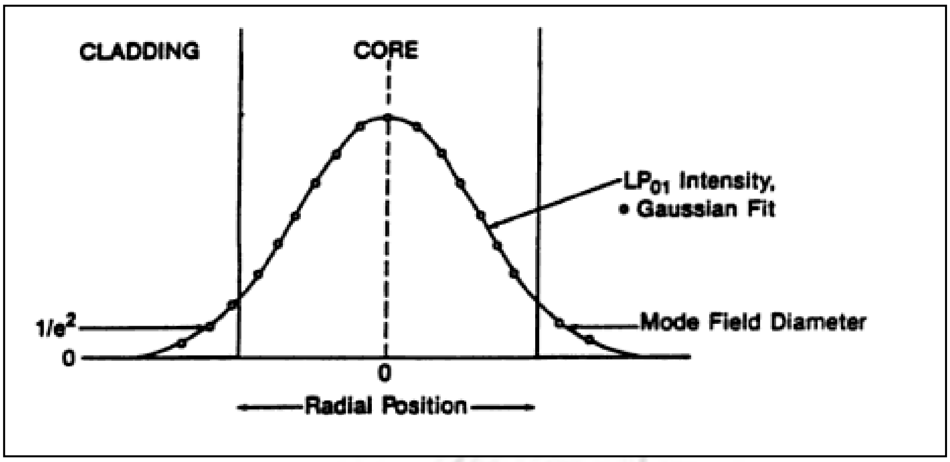
4. Define Numerical Aperture of a step index fiber. (Dec14) (Nov16)

Numerical aperture is the light gathering capability of a fiber. It is related to the refractive indices of core and cladding. For step index fiber it is expressed as

$NA = (n_{core}^{2} - n_{clad}^{2})^{1/2}$

5. Define Mode-field diameter.

Although most light travels inside an optical fiber's core, the light actually spreads through a slightly larger volume including the inner edge of the fiber cladding. This effective area is called the fiber's mode field diameter or MFD. Mode field diameter is a measure of the spatial extends of the fundamental mode and it is only important for single mode fibers. Mode field diameter plays an important role in estimating splice losses, source to fiber coupler losses, macro bending and micro bending losses, etc. For single mode fibers manufacturing, MFD is used as a rather more important parameter than fiber's core size.



6.Commonly available single mode fiber shave beat length sin the range10 cm<Lp<2 m. What range of refractive index differences does this correspond to(for λ =1300 nm)? (May'06)

$L_1 = 10cm = 0.1m$

$B_{f1} = n_y - n_x = \lambda/L_1 = 1300 \times 10^{-9}/0.1 = 1.3 \times 10^{-5}$

$L_2 = 2m$

$B_{f2} = \lambda/L_1 = 1300\times10^{-9}/2 = 6.5\times10^{-7}$

The range of refractive index differences varies between 6.5×10^{-7} to 1.3×10^{-5}

7. Write down the wavelength regions corresponding to 1^{st} 2^{nd} and 3^{rd} windows.

The wavelength regions corresponding to 1^{st} 2^{nd} and 3^{rd} windows are

(a) 1^{st} window-800-900nm,(b) 2^{nd} window-1100-1350nm,(c)3^{rd} window-1500-1650nm

8. What's critical angle of incidence?

If the angle of incidence is increased, appoint will eventually be reached where the refracted light ray travels at the interface between two medium. This angle is known as critical angle.

9. What are all the advantages offered by multimode fibers than single mode fibers?

Advantages of multimode fiber are(a) A larger core radio of multimode fibers makes launching optical power into the fiber easier.(b) It also facilitates the connection of similar fibers. (c) LED can be used as a source.

Dis advantage : They suffer from intermodal dispersion.

10. What is cut-off condition?

The boundary between truly guided modes and leaky modes is defined by the cutoff condition $\beta = n_{clad}k$. A mode remains guided as long as β satisfies the condition $n_{clad}k < \beta < n_{core}k$ where $k = 2\pi/\lambda$.

11. Consider a parabolic index waveguide with n_1 =1.75, n_2 =1.677and core radius 25µm. Calculate the numerical aperture at the axis and at a point 20 µm from the axis.

<u>At axis</u>: Numerical Aperture (NA (0))= $(n_{core}{}^2 - n_{clad}{}^2)^{1/2} = 0.5$

This is the numerical aperture, it does vary at the center at a point 20µm from the axis.

NA (0)$\{1-(r/a)^{\alpha}\}^{1/2} = 0.5\{1-(20/25)^2\}^{1/2} = 0.3$ (Where α = 2sinceprofileis parabolic)

12. What are the advantages and disadvantages of the ray optics theory? (Nov08)
Advantages:
(a)Ray Optics gives more direct physical interpretation of light propagation characteristics in an optical fiber.

(b) It provides good approximation to the light acceptance and guiding in fiber at small wavelength unit.

Disadvantages: (a)Ray optics does not predict every mode of curve fiber, (ii) It does not solve the interference problem. (b)Inaccurate for non-zero wavelength unit when number of guided mode is large.

13.For a fiber with core refractive index of 1.54 and fractional refractive index difference of 0.01, calculate its numerical aperture (Nov13)

n1=1.54 , Δ =0.01

NA= n_1 $(2\Delta)^{1/2}$= $1.54(2 \times 0.01)^{1/2}$=0.218

14. For n1=1.55 and n2=1.52, calculate the critical angle and Numerical aperture. (May13) (May15)

NA=$(n_1^2-n_2^2)^{1/2}$=0.3035; Critical angle $\O_c=\sin^{-1}(n_2/n_1)=17.4^o$

15. What is a linearly polarized mode? (May13)

In electromagnetics, linear polarization or plane polarization of electromagnetic radiation is a confinement of the electric field vector or magnetic field vector to a given plane long the direction of propagation.

16. List any two advantages of single mode fibers. (Nov14)

The two advantages of single mode fibers are

1. Intermodal dispersion is absent.
2. supports larger bandwidth.

17. Determine the normalized frequency at 820 nm for a step index fiber having a 25µm radius. The refractive indices of the cladding and core are 1.45 and 1.47 respectively. How many modes propagate in this fiber at820nm? (Nov13)

Normalized frequency is given by, V=(2π/λ)(a)(NA)

Numerical Aperture =$(n_{core}{}^2 - n_{clad}{}^2)^{1/2}$= $(1.47^2-1.45^2)^{1/2}$= 0.255

Normalized frequency= (6.18/820nm)(25µm)(0.255)=4.18KHz.

18. Distinguish meridional rays and skew rays. (May14) (Nov18)

Meridional rays	Skew rays
Meridional rays pass through the fiber	Skew rays doesn't pass through the fiber axis
Meridional rays follows zig zagpath	Skew rays follow helical path

19. What is total internal reflection in a fiber?(Nov 15) (Nov16)

Total internal reflection is the phenomenon which occurs when a propagated wave strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface. Where, the critical angle is the angle of incidence for which the angle of refraction is 90°. The angle of incidence is measured with respect to the normal at the refractive boundary.

20. What are the conditions for light to get propagated inside a fiber? (Nov16)

a) Light should travel from denser medium to rarer medium.

b) The angle of incidence should be greater than the critical angle of the denser medium.

21. What are the conditions for the single mode propagation? (May '16)

Single-mode propagation exists only above a certain specific wavelength called the cut-off wavelength. Where, the cut-off wavelength is the smallest operating wavelength when SMFs propagate only the fundamental mode. At this wavelength, the second-order mode becomes loss and radiates out of the fibre core.

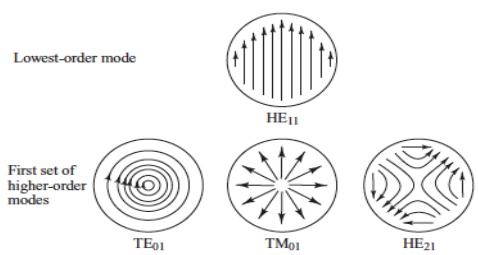
22. What are the advantages of Optical fibre and State the reason to opt for Optical Fiber Communication. (April 17) (Apr 18)
The following are the major advantages of Optical fibre- wide band, lower loss, light weight, small size, strength, security, interference immunity and safety. Optical Fiber Communication have much higher Bandwidth and lower loss.

23. A multimode silica fibre has a core refractive index n1=1.48 and cladding refractive index of n2=1.46. Find the numerical aperture of the fibre.(April17)
Numerical Aperture = $(n_{core}^2 - n_{clad}^2)^{1/2} = (1.48^2 - 1.46^2)^{1/2} = 0.2423$

24. Why partial reflection does not suffice the propagation of Light? (Nov17)
The reason is that, at each reflection a part of the optical energy launched into the optical fiber would be lost and after a certain distance along the length of the fiber the optical power would be negligibly low to be of any use. Thus total internal reflection is an absolute necessity at each reflection for a sustained propagation of optical energy over long distance e along the optical fiber. This precisely is the sole reason of launching light into the fiber at particular angles so that light energy propagates along the fiber by multiple total internal reflections at the core-cladding interface.

25. A graded index optical fiber has a core with a parabolic refractive index profile which has a diameter of 50 μm. The fiber has a numerical aperture of 0.2. Calculate the total number of guided modes in the fiber when it is operating at a wavelength of 1μm. (Nov17)
$V=(\pi d/\lambda)NA = (3.14x50x10^{-6}/1x10^{-6})0.2= 785$
Total number of guided modes in graded index fiber = $V^2/4$

26.Sketch the cross sectional view of the transverse electric field vectors for the four lowest order modes in a step index fiber.(Apr18)



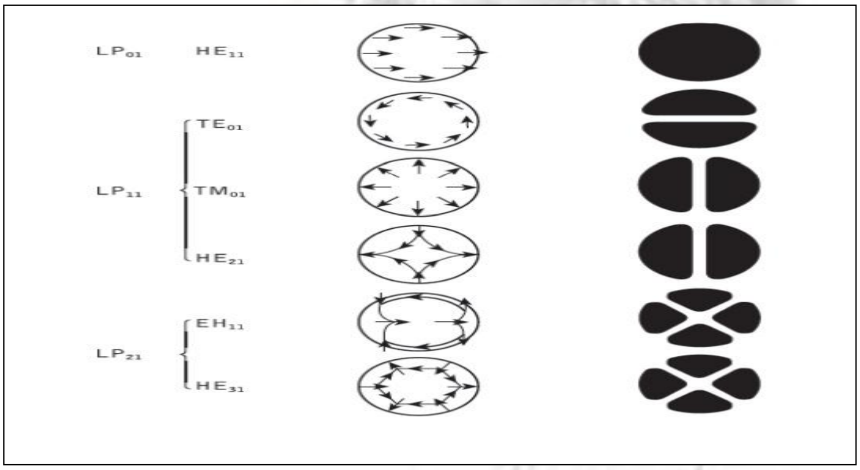
27.Find the value of normalized frequency (V) for a given fiber with n_1= 1.455, n_2 = 1.448 and a = 5 µm for wavelength λ0 = 1550 nm. (Nov 19)

$$V = \frac{2\pi a}{\lambda}\sqrt{n_1^2 - n_2^2} = \frac{2\pi \times 5\times 10^{-6}}{1550\times 10^{-9}}\sqrt{(1.455)^2 - (1.448)^2} = 2.8659$$

28. Give the spectral bands used for optical communication with its name and designation. (Nov 19)

Original band (O-band): 1260 to 1360 nm
Extended band (E-band): 1360 to 1460 nm
Short band (S-band): 1460 to 1530 nm (shorter than C-band)
Conventional band (C-band): 1530 to 1565 nm (EDFA region)

29. Show the correspondence between the lower order in linearly polarized (LP) modes and the traditional exact modes from which they are formed along with the schematic diagram of the electric field configurations for the three lowest LP modes in the cylindrical fiber. (April 19)



30. Define Goos - Haenchen effect. (April 19)

The linearly polarized light undergoes a small lateral shift when totally internally reflected. The shift is perpendicular to the direction of propagation in the plane containing the incident and reflected beams.

31. What is fiber birefringence? (April 19)

In single mode fiber, there are two independent degenerative modes. These two modes are very similar, but their polarization planes are orthogonal. These two modes propagate with different phase velocities and the difference between their effective refractive indices is called fiber birefringence.

32.Why do we prefer step index SM fiber for long distance communication? (Apr 19)

Step index single-mode fiber has less attenuation, larger bandwidth and very less dispersion. So, it is preferred for long distance communication.

33.What is the necessity of cladding for an optical fiber? (Apr 19)

a) To provide a lower refractive index at the core interface in order to cause reflection within the core so that light waves are transmitted through the fiber b) To avoid leakage of light from fiber c)To provide proper light guidance inside the core d) To provide mechanical strength to the fiber.

PART-B

1. With the neat block diagram, explain the fundamental block of Optical Fiber Communication. **(Apr18) (Nov18)**

2. i) Derive the expression for numerical aperture of the fiber. ii) A graded index fiber has a core with a parabolic refractive index profile which has a diameter of 50 μm. The fiber has a numerical aperture of 0.2. Calculate the total number of guided modes propagating in the fiber when it is operating at a wavelength of 1 μm. **(Apr 19)**

3. i) With a neat sketch, illustrate the modes in a planar guide. ii) An optical fiber in air has a numerical aperture of 0.4. Compare the acceptance angle for meridional rays with that for skew rays which change direction by 100 degrees at each reflection and also comment on the result. **(Apr 19)**

4. Discuss the evolution of fibre optic communication system. **(Nov 19)**

5. Describe with the aid of simple ray diagram. (i) The multimode step index fiber (ii) The single mode step index fiber (iii) Compare the advantages and disadvantages of these two types of fiber for their use as an optical channel. **(Nov 19)**

6. i) Briefly indicate with the aid of suitable diagrams the difference between meriodinal and skew ray paths in step index fibers. Derive an expression for the acceptance angle for a skew ray which changes direction by an angle 2γ at each reflection in a step index fiber in term of the fiber NA and γ. It may be assumed that ray theory holds for the fiber. ii) A step index fiber with suitably large core diameter for ray theory considerations has core and cladding refractive indices of 1.44 and 1.42 respectively. Calculate the acceptance angle for skew rays which change direction by 150 degrees at each reflection. **(Nov 19)**

7. A silica fiber with core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.50 and cladding refractive index of 1.47. Determine (a) The critical angle at the core cladding interface(b) The NA for the fiber(c) The acceptance angle in air for the fiber. **(Apr18)**

8. A step index fiber with numerical aperture of 0.2 supports approximately 1000 modes at an 850nm wavelength. What is the diameter of its core? How many modes does the fiber supports at 850nm and 1550nm? **(Apr19)**

9. (i) Find the core radius necessary for single mode operation at 1320nm of a step index fiber with n1=1.48 and n2=1.478.Determine NA and acceptance angle of the fiber? (ii) Derive the wave equation for cylindrical fiber. **(Apr17)**

10. Consider a multimode fiber that has a core refractive index of 1.480 and a core cladding index difference of 2%. Find the numerical aperture, the acceptance angle and the critical angle of the fiber.**(Nov18)**

11. i)Explain in detail about linearly polarised modes in optical fibers and their relationship to V number. ii)Consider a fiber with 25 µm core radius, core index n_1= 1.48 and Δ = 0.01. If λ = 1320 nm, what value of V and how many modes propagate in the fiber. What percent of optical power flows in the cladding? If the core cladding difference is reduced to Δ = 0.003, how many modes does the fiber support and what fraction of the optical power flows in the cladding?**(Apr 19)**

12. i) Draw and explain refractive index profile and ray transmission in multimode step index fiber and single mode step index fiber. ii) Consider a multimode step index fiber with a 62.5 µm core diameter and a core cladding index difference of 1.5%.If the core refractive index is 1.480, estimate the normalized frequency of the fiber and the total no of modes supported in the fiber at the wavelength of 850 nm. **(Apr 19)**

UNIT-II TRANSMISSION CHARACTERISTICS OF OPTICAL FIBER

PART-A

1. Define signal attenuation. (Nov13)(May15) (Nov17)

Signal attenuation is defined as the ratio of the optical output power P_{out} from a fiber of length L to the optical input power P_{in}.Attenuation (α) = 10/L log {P_{in}/P_{out}} dB/Km

2. What are the causes of absorption? (Nov 16)

Absorption is caused by3 different mechanisms.(a) Absorption by atomic defects in the glass composition. (b) Extrinsic absorption by impurity atoms in the glass material. (c)Intrinsic absorption by the basic constituent atoms of the material.

3. **What are the types of bends that can be subjected to a fiber? (May 15)**

Two types of bends are (i)Macroscopic bends having radii that are larger compared to the fiber diameter. (ii) Random microscopic bends of the fiber axis that can arise when the fibers are incorporated into cables.

4. How does intrinsic absorption occur? (Nov14) (Nov 16)

The intrinsic absorption occurs when the material is in perfect state with no density variations, impurities, material inhomogeneity etc. Intrinsic absorption thus sets the fundamental lower limit on absorption for any particular material.

5. Identify the causes of scattering loss. (May14)

Scattering losses in glass arise from microscopic variations in the material density, from compositional fluctuations ,and from structural in homogenities or defects occurring during fiber manufacture.

6. How can you minimize micro bending losses?

Micro bending losses can be minimized by extruding a compressible jacket over the fiber. When external forces are applied to this configuration ,the jacket will be de formed, but the fiber will tend to stay relatively straight.

7. How does waveguide dispersion occur?

Waveguide dispersion occurs because a single mode fiber only confines about 80% of the optical power to the core. The 20% of the optical power travels in the cladding because of the speed difference between the set two dispersion occurs.

8. List the basic attenuation mechanisms in an optical fiber. (Dec14)

1. Absorption, 2.Scattering, 3.Radiativelosses of the optical energy 4. Bending Losses are the basic attenuation mechanism in an optical fiber.

9. What is Rayleigh Scattering?(May13)

This scattering occurs in all directions and produces attenuation proportional to $1/\lambda^4$. This loss occurs in the ultra violet region. It tail extends up to infrared region.

10. What is Mode Coupling?

It is an other type of pulse distortion which is common in optical links. The pulse distortion will increase less rapidly after a certain initial length of fiber due to this mode coupling and differential mode losses . In initial length coupling of energy from one mode to another arises because of structural irregularities, fiber diameter etc.

11. What is elastic and inelastic scattering? (Apr18)

Linear scattering(i.e. Rayleigh), which is said to be elastic because the scattered wave has the same frequency as the incident wave, whereas nonlinear scattering process are inelastic.

12. Distinguish between Intra modal and Intermodal Dispersion. (Nov18)

Intra modal Dispersion	Intermodal Dispersion
Pulse broadening within a single mode is called as intra modal dispersion or chromatic dispersion.	Dispersion caused by multipath propagation of light energy is referred to as intermodal dispersion.
It occurs in Single Mode Fiber	It occurs in Multimode fiber

13. What do you mean by polarization mode dispersion in a fiber?(Nov15) (Nov 16)(Apr18)(Nov18)

The difference in propagation times between the two orthogonal polarization modes will result in pulse spreading. This is called as polarization Mode Dispersion.

14. What do you understand by phase and group velocity? (May 16)

The group velocity is the velocity with which the *envelope* of a pulse propagates in a medium, assuming a long pulse with narrow and the absence of nonlinear effects

The phase velocity of light is the velocity with which phase fronts propagate in a medium. It is related to the wave number (k) and the (angular) optical frequency (ω),

15. What is chromatic dispersion? (May16)

The chromatic dispersion of an optical medium is the phenomenon that the phase velocity and group velocity of light propagating in a transparent medium depend on the optical frequency; that dependency results mostly from the interaction of light with electrons of the medium.

16. What are atomic defects?

Atomic defects are imperfections of the atomic structure of the fiber material such as missing molecules, high density clusters of atom groups, or oxygen defects in the glass structure.

17. How does impurity absorption loss occur?

Impurity absorption loss occurs either because of electronic transitions between the energy levels associated with the incompletely filled inner subshell of charge transitions from one ion to another.

18. What is effective cut-off wavelength?

It is defined as the largest wavelength at which the higherorderLP11 mode power relative to the fundamental LP_{01}mode power is reduced to 0.1db.

19. What's Urbach's rule?

The UV edges of the electron absorption bands of both amorphous and crystalline materials follow the empirical relationship, $\alpha_{UV}=C\,e^{E/E_0}$ which known as Urbach's rule. Here C and E0 are empirical constants and E is the photon energy.

20. What are micro bends? How are they caused in the fiber?

Micro bends are repetitive small-scale fluctuations in the radius of curvature of the fiber axis. They are caused either by non-uniformities in the manufacturing of the fiber or by non-uniform lateral pressures created during the cabling of the fiber.

21. What is intermodal dispersion? (April 17)

Intermodal dispersion is also called modal dispersion and is the phenomenon that the group velocity of light propagating in a multi-mode fiber or other waveguide depends not only on the optical frequency but also on the propagation mode involved. Other ways it is a time or arrival differences of signal between Zero Order and highest order modes.

22. A manufacturer's data sheet lists the material dispersion D_{mat}=110ps/nm.km at a wavelength of 860 nm. Find the RMS pulse broadening per Km due to material dispersion if the optical source has a spectral width = 40 nm at b an output wavelength of 860nm. (Nov 17)

The RMS of material dispersion $\sigma_{mat}/L=\sigma_\lambda D_{mat}$ =(40nm)x(110ps/(nm.km)) = 4.4 ns/km.

23.A fiber has an attenuation of 0.5 dB/Km at 1500 nm. If 0.5 mW of optical power is initially launched into the fiber, estimate the power level after 25 km. (Apr 19) (Nov 19)

$$P_{out(dbm)} = P_{in(dbm)} - \alpha z$$

α – attenuation in dB, z - distance in Km

$$P_{out(dbm)} = 10\log\left(\frac{0.5\times10^{-3}}{1\times10^{-3}}\right) - 0.5\times25 = -12.8\,\text{dBm}$$

24.A manufacturer's data sheet lists the material dispersion Dmat of GeO2 doped fiber to be 210 ps/(nm km) at a wavelength of 860 nm. Find the rms pulse broadening per km due to material dispersion if the optical source is a GaAIAs LED that has spectral width σλ of 40 nm at an output wavelength of 860 nm. (Nov 19)

$$\sigma_{mat}/\text{Km} = \sigma_\lambda - D_{mat} = 40\text{ nm}\times 210\text{ (ps/nm.km)} = 8.4\text{ ns/km}$$

25.When the mean optical power launched into a 8 Km fiber is 120 µw. The mean optical power at the fiber output is 3 µw. Calculate the overall attenuation in dB assuming there are no splices. (Apr 19)

$$\text{attenuation (dB)} = P_{in(dbm)} - P_{out(dBm)} = 10\log\left(\frac{120\times10^{-6}}{1\times10^{-6}}\right) - 10\log\left(\frac{120\times10^{-6}}{1\times10^{-6}}\right) = 16.02$$

$$\text{attenuation (dB/Km)} = 16.02/8 = 2.0025$$

PART-B

1.Explain in detail with necessary mathematical expressions the various attenuation mechanisms in optical fiber. **(Nov18) (Apr18)**

2. When the mean optical power launched into an 8km length of fiber is 120µW, the mean optical power at the fiber output is 3 µW. Determine (a) Overall signal attenuation in dB/km (b) The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1Km intervals, each giving an attenuation of 1dB.(c) Numerical input/output power ratio.**(Apr18)**

3. (i) Describe the mechanism of intermodal dispersion in a multimode step index fiber. Show that the total broadening of a light pulse due to intermodal dispersion in multimode step index fiber may be given by $\delta Ts = L(NA)^2/2n1c$, where L is the fiber length, NA is the numerical aperture, n_i is the core refractive index and c is the velocity of light in a vacuum. (ii). A multimode step index fiber has a numerical aperture of 0.2 and a core refractive index of 1.47. Estimate the bandwidth distance product for the fiber assuming only intermodal dispersion and return to zero code when (i) there is no mode coupling between the guided modes, (ii) mode coupling between the guided modes gives a characteristics length equivalent of 0.6 of the actual fiber length. **(May 16)**

4. A multimode step index fiber has a numerical aperture of 0.3 and a core refractive index of 1.45. The material dispersion of the fiber is 250 ps $nm^{-1}Km^{-1}$ which makes the material dispersion the totally dominating chromatic dispersion mechanism. Estimate (a) the total RMS pulse broadening per km. when the fiber is used with an LED source of rms spectral width 50nm and (b) the corresponding band width-length product of the fiber. **(Nov17)(Apr18)**

5. A 6 km optical link consist of multimode step index fiber, with a core RI of .5 and relative refractive index difference of 1%. Estimate(1)Delay difference between slowest and fastest modes at the fiber output.(2)RMS pulse broadening due to intermodal dispersion on the link.(3)Maximum bit rate that may be obtained without sustainable errors on the link assuming only intermodal dispersion.**(Nov 18)**

6. A continuous 40km long optical fiber link has a loss of 0.4dB/km i)What is the minimum optical power level that must be launched into the fiber to maintain an optical power level of

2 µw at the receiving end? ii)What is the required input power if the fiber has a loss of 0.6 dB/km?**(Nov 18)**

7.Discuss about the absorption losses in optical fibers and compare and contrast the intrinsic and extrinsic absorption mechanisms. **(Nov 19)**

8.Suggest and validate the techniques employed and the fiber structures utilized to provide(i) Dispersion shifted single mode fibers (ii) Dispersion flattened single mode fibers (iii)Non zero dispersion shifted single mode fibers. **(Nov 19)**

9. A long single mode optical fiber has an attenuation of 0.5 dB/km when operating at a wavelength of 1.3 µm. The fiber core diameter is 6 µm and the laser source bandwidth is 600 MHz. Compare the threshold optical powers for stimulated Brillouin and Raman scattering within the fiber at the wavelength specified. **(April 19)**

10.A multimode graded index fiber exhibits total pulse broadening of 0.1µs over a distance of 15 km. Estimate (i) The maximum possible bandwidth on the link assuming no inter symbol interference (ii)The pulse dispersion per unit length (iii)The bandwidth length product for the fiber

11. (i) How does waveguide dispersion affect the performance of the transmission in an optical fiber? Explain in detail. (ii) A manufacture's data sheet lists the material dispersion D_{mat} of GeO_2 doped fiber to be 110 ps/(nm.km) at a wavelength of 860 nm. Find the rms pulse broadening per kilometer due to material dispersion if the optical source is a GaAIAs LED that has a spectral width σλ of 40 nm at an output wavelength of 860 nm.**(Apr 19)**

12. (i) Discuss about the intermodal dispersion that occurs in a multimode graded index fiber. (ii) A Continuous 12 km long optical fiber link has a loss of 1.5dB/km. Propose a proper solution to find the minimum optical power that must be launched into the fiber to maintain an optical power level of 0.3 µw at the receiving end **(Apr 19)**

UNIT III OPTICALSOURCES AND DETECTORS

PART-A

1. What are the laser light properties? How are they produced?

Laser light properties are
1. High radiance output,
2.Fast emission response time
3. High quantum efficiency. Dimensional characteristics compatible with those of optical fibers. High radiance and high quantum efficiency are achieved through carrier and optical confinement using double hetero structure.

2. What are the mechanisms behind lasing action? (Nov 16)

Laser action is the result of three key processes Photon absorption, Spontaneous emission and Stimulated emission. The conditions to achieve laser action are (i) Magnitude of guided mode should be greater than the threshold value, (ii) At the lasing threshold , a steady state oscillation takes place, and (iii) the magnitude and phase of the returned wave must be equal to those of the original wave.

3. What are direct band gap and indirect band semiconductors?

Indirect band gap materials direct transition is possible from valence band to conduction band. e.g. GaAs,InP, InGaAs, In indirect band gap materials direct transition is not possible from valence band to conduction .e.g. Silicon, germanium.

4. Define internal quantum efficiency of a LED(Nov 14, May14, Nov15, Nov18)

The internal quantum efficiency in the active region is the fraction of electron hole pairs that recombine radiatively . It's given by $\eta_i = R_r / (R_r + R_{nr})$

Where, $\eta_i$is the internal quantum efficiency$_r$ is the radiative recombination per unit volume.

$R_{nr}$is the non-radiative recombination rate.

5. Why do we prefer laser diodes over LED's for communication applications?

1. High intensity radiation 2.Narrow spectral width of the laser source, are the preferable features of Laser compared to LED.

6.. What is meant by hetero junction structure?(Nov15)

To achieve carrier and optical confinement ,two different alloy layers on each side of active region is known as hetero junction structure.

7. What are the different factors that determine the response time of photo detector?(Apr18)

i) The transit time of the photo carriers in the depletion region.

ii) The diffusion time of the photo carriers generated outside the depletion region. iii)The RC time constant of the photodiode and its associated circuit.

8. Write two differences between an ILD and a LED. (May16)(April17)

S.No	LED	ILD
1.	Optical output is in coherent	Optical output is coherent
2.	Output radiation has broad spectral width	Highly Monochromatic

9. An LED has radiative and non radiative recombination times of 30ns and 100ns. Determine the internal quantum efficiency.(Apr18).

Bulk recombination life time (τ) is $1/\tau = 1/\tau_r + 1/\tau_{nr}$ = 1/30 + 1/100 = 23.07ns

Internal quantum efficiency = τ/τ_{nr}= 23.07/30 =0.769

10. Define external quantum efficiency. (Nov 16)

The ratio of the number of photons emitted from the LED to the number of electrons passing through the device, i.e. how efficiently the device coverts electrons to photons and allows them to escape.

11. A GaAs laser operating at 850 nm has 250 μm length and a refractive index of 3.7. What are the frequency and wavelength spacing? (May 16) (Apr 19)

Frequency Spacing, $\Delta\nu = \left(\frac{c}{\lambda^2}\right)\Delta\lambda = \frac{c}{2L} = \frac{3 X 10^8}{2 X 250 X 10^{-6}} = 0.6 Hz$

Wavelength Spacing, $\Delta\lambda = \frac{\lambda^2}{2L} = \frac{(850 X 10^{-9})^2}{2 X 250 X 10^{-6}} = 1.445nm$

13. Write the Laser diode rate equation. (Nov-2017)

$$\frac{d\Phi}{dt} = Cn\Phi + R_{sp} - \frac{\Phi}{\tau_{ph}}$$

$$\frac{dn}{dt} = \frac{J}{qd} - \frac{n}{\tau_{sp}} - Cn\Phi$$

Where, C is coefficient expressing the intensity of optical emission and absorption process

R_{sp} is the rate of spontaneous emission to the lasing mode

τ_{ph} is photon life time and J is injection current density.

14. State detector response time. (Nov18)

Detector response time refers to the time it takes the photocurrent generated by the detector to rise to 63.2 percent of the final or steady-state value reached after a prolonged period of time.

15. Give some possible lensing scheme to improve optical source to fiber coupling efficiency. (Nov17)

Rounded end fiber, Non-imaging Microsphere (small glass in contact with both the fiber and source), Imaging sphere (a large spherical lens used to image the source on the core of the fiber end), cylindrical lens (generally formed from a short section of fiber), Spherical surface LED and spherical ended fiber and Taper ended fiber.

16. A given APD has a quantum efficiency of 65 percent at a wavelength 900nm. If 0.5 μW of optical power produces a multiplied photo current of 10 μA, Find the Multiplication factor M (May'05)

$I_p = RP_o = (\eta q/hv)P_o = (\eta q\lambda/hc)\ P_o = \{(0.65)(1.6 \times 10^{-19})(9\times 10^{-7})/(6.625\times 10^{-34}\times 3 \times 10^{8})\}5\times 10^{-7} = 0.235\mu A$

The multiplication factor (M)= $I_m/I_p = 10\mu A/0.235\mu A = 43$

17. Define Responsivity. (Nov04,May05, Nov05,Nov08, May08, Nov18)

Responsivity is used to measure input-output gain of the detector in fiber optic system. In the case of photo detector, it is the measure of electrical output per optical input. Responsivity of photo detector is typically expressed as units of amperes per watt or volts per watt of radiant power. R= $I_p/P_o = \eta q/h\nu$, where I_p-average photo current generated, P_o-incident optical power level & η –quantum efficiency

18. Compare the performance of APD and PIN diode (Nov08)

Avalanche photodiodes (APDs) are widely used in laser-based fiber optic systems to convert optical data into electrical form. They are high-sensitive, high-speed semiconductor light sensors. APD requires a higher operating voltage. APDs also produce a higher level of noise than a PIN diode. APDs need a high reverse bias condition to work. That permits avalanche multiplication of the holes and electrons created by the initial electron-hole pairs. PIN diodes are particularly used in RF applications where there are low levels of capacitance. Their switching and variable resistance properties make them well-suited in switching and variable attenuator applications.

19. Why is silicon not used to fabricate LED or LASER Diode?(Nov18) (Apr 19)

LED and LASER Diode are made of materials which have direct band gaps. Silicon has indirect band gap and hence not used for making LED or LASER Diode.

20.A GaAs optical source with a refractive index of 3.6 is coupled to a silica fiber that has a refractive index of 1.48. What is the reflectivity for normal incidence of a plane wave? (Nov 19)

$$R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2 = 0.4173$$

21.What is meant by population inversion? (Nov 19)

Population inversion is the process of making population of electrons in the excited stste higher than the population of electrons in the ground state.

22.Differentiate between LED and LASER diode.(April 19)

LED	LASER
It is not coherent	It is highly coherent
Spontaneous emission	Stimulated emission
Bandwidth of LED is moderate	Bandwidth of Laser is higher
require drive current is 50 to 100mA	require drive current is Threshold current of 5-40mA
Feedback is not required in LED	Proper feedback is essential in LASER to be treated as an optical source

23.What is the significance of intrinsic layer in PIN diodes? (Apr 19, Nov 19)

1. High reverse breakdown voltage 2. Low level of capacitance 3. carrier storage 4. Light conversion.

24. What are the main advantages of InGaAs photodiodes?

a). Wider operating wavelength range.(1100 to 1700nm) b). High responsivity (0.75to 0.95Amp/watts for PIN) c).Less dark current.(0.5to 2nA) d).Less rise time(0.05 to0.5ns)

e).Larger bandwidth. (1 to2GHz)

25. What are the various error sources in the optical receiver? (Nov12,May14, Apr18)

a).Photon detection quantum noise b).Bulk dark current noise c).Surface leakage current, d).Statistical gain fluctuation (for APD) e).Thermal noise f).Amplifier noise

PART-B

1. Explain surface emitting LED(SLED) and an edge emitting LED (ELED)in detail. ii) A double hetero junction InGaAsP LED emitting as a peakwavelengthof1310nmhas radiative and non-radiative recombinationtimesof30nsand 100 ns respectively. The drive current is 40 mA. (i)Find the bulk recombination time. (ii)Internal quantum efficiency and (iii) Internal power level. **(Apr 19)**

2. Derive an expression for internal quantum efficiency, power and external quantum efficiency of LED.**(May15, 16)(Nov17)(Nov18)**

3. Explain the structure and working of a silicon PIN and Avalanche photo diode. **(May14) (Apr 19)**

4. A double hetero junction InGaAs LED emitting as a peak wavelength of 1310nm has radiative and non-radiative recombination times of 25ns and 90 ns respectively. The drive

current is 3.5 mA.(i)Find the internal quantum efficiency and internal power level. (ii)If the refractive index of the light source material is n=3.5. Find the power emitted from the device. **(Nov18)**

5. Explain the working principle of laser diode and derive its rate equation.**(Nov16)(Nov17)**

6. Give a brief account on resonant frequency of LASER Diode. **(Apr 18)**

7.(i) A planar LED is fabricated from gallium arsenide which has a refractive index of 3.6. a) Calculate the emitted power into the air as a percentage of the internal optical power for the device when the transmission factor at the crystal-air interface is 0.68. b) When the optical power generated internally is 50% of the electric power supplied, determine the external power efficiency. **(Nov 18)**

8. When a current pulse is applied to a laser diode, the injected carrier pair density n within the recombination region of width 'd' changes with time according to the relationship. dn/dt = J/qd - n/r (i) Assume r is the average carrier lifetime in th recombination region when the injected carrier pair density is n_{th} near the threshold current density J_{th}. That is in the steady state we have $\delta n/\delta t=0$, so that $n_{th} = J_{th}\tau/qd$. If a current pulse of amplitude Ip is applied to an unbiased laser diode, show that the time needed for the onset of stimulated emission is $t_d = \tau \ln [I_p/(I_p-I_{th})]$. Assume the drive current I=JA, where J is the current density and A is the area of the active region.(ii) If the laser is now pre-biased to a current density $J_B = I_B/A$, so that the initial excess carrier pair density is $n_B=J_B\tau/qd$, then the current density in the active region during a current pulse I_p is $J=J_B+J_P$. Show that in this case $t_d = \tau \ln [I_p/(I_{p+(}I_B\text{-}I_{th}))]$ **(Nov 18)**

9. Draw and explain the different structures used to achieve carrier and optical confinement in laser diodes. **(Nov 19)**

10.Discuss the necessary expressions that different types of noises that affect the performance of a photo detector. **(Nov 19)**

11. Describe with the aid of suitable diagrams the mechanism giving the emission of light from a LED. Discuss the effects of this mechanism on the properties of the LED in relation to its use as an optical source for communication. **(Nov 19)**

12. (i) Discuss the principle of gain guided laser and index guided laser diodes along with the schematic diagram. (ii)When 3×10^{11} photons each with a wavelength of 0.85 μm are incident on a photodiode, on average 1.2×10^{11} electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at 0.85 μm. **(Apr 19)**

13. i)Demonstrate the structure and working of silicon Avalanche photodiode. (ii) The radiative and non radiative recombination lifetimes of the minority carriers in the active region of a double-hetro junction LED are 60 ns and 100ns respectively. Determine the total carrier recombination lifetime and the power internally generated within the device when the peak emission wavelength is 0.87 μm at a drive current of 40 mA. **(Apr 19)**

14. Draw and explain the structure of Fabry Perot resonator cavity for a laser diode. Derive laser diode rate equation **(Apr 19)**

UNIT IV- OPTICAL RECEIVER,MEASUREMENTS AND COUPLING

PART-A

1.What are the requirements for a preamplifier?

a).Pre amplifier bandwidth must be greater than or equal to signal bandwidth. b).It must reduce all source of noise ,c).It must have high receiver sensitivity.

2. Why down prefer trans-impedance preamplifier rather than high impedance preamplifier? (Nov 14)

Since the high impedance produces large input RC time constant ,the front end bandwidth is less than the signal bandwidth. This drawback is overcome in the trans-impedance preamplifier.

3. **Define receiver Sensitivity.(Nov 17)**

Receiver sensitivity is the lowest power level at which the receiver can detect an RF signal and demodulate data. Sensitivity is purely a receiver specification and is independent of the transmitter.

4. Define quantum limit.(May14, Nov13, May 16, Apr18, Apr19)

The minimum received optical power required for a specific bit error rate performance in a digital system is known as quantum limit.

5.**Distinguish between splice and connector.**

SPLICE	CONNECTOR
1. A permanent joint between two	A demountable joint between two fibers.
2. It is used to establish long-haul optical fiber links where smaller fiber lengths need to be joined, and there is no requirement for repeated connection and disconnection.	The connector design must allow for repeated connection and disconnection without problems of fiber alignment, which may lead to degradation in the performance of the

6. Define BER. (May 15) (Nov 16) (April 17)

The number (N_e) of errors occurring over a certain time interval (t)divided by the number of pulses transmitted(N_t) during this interval is called as the error rate or the bit error rate.Bit error rate, $BER=N_e/N_t$

7. What are connectors? What are the types of connectors?

The connectors are used to join the optical sources as well as detectors to the optical fiber temporarily. They are also used to join two optical fibers. The 2 majortypesofconnectorsare:1. Lensed type expanded beamconnector2. Ferrule type connector

8. What are the requirements of a good connector?

The requirements of a good connector are as follows:

1. Low loss 2. Repeatability3. Predictability 4. Ease of assembly and use 5. Low cost & reliability 6 . Compatibility

9. Mention the different techniques used for measurement of fiber refractive profile.

The different techniques used for measurement of fiber refractive profile are

(a).Inter fero metric Method, (b).Near field scanning method, (c).Refractive near field method

10. What are the methods of fiber splicing?

There are 3 methods of fiber splicing. They are:

1. Electric arc fusion splicing or fusion splicing 2. Mechanical splicing

3. V-groove splicing or loose tube splicing

11. Mention types of preamplifiers.

Types of preamplifiers are

(a)Low impedance preamplifiers, (b) High impedance preamplifiers (c)Trans impedance preamplifiers

12. Mention the techniques used for determination of fiber numerical aperture.

(a) Far field angle from fiber using a scanning photo detector and a rotating stage

(b) Far field pattern by trigonometric fiber

(c) Far field pattern of NA measurement using a rotating stage.

13. Define effective cutoff wavelength.

The effective cutoff wavelength is defined as wavelength greater than the ratio of the total power launched to higher order modes to the total power launched to fundamental mode.

14. List out the advantages of outer diameter measurement.(Nov 14)(Nov 19)

The advantages of outer diameter measurement are

(a). High speed (b). High accuracy, (c) Faster diameter measurements

15. What are the standard measurement techniques?

The standard measurement techniques are (i) Reference Test Method,(ii) Alternative Test Method

16. How is Internal Noise caused?

Internal Noise is caused by the spontaneous fluctuation of current or voltage in electric circuits.

17. What are the requirements of an optical receiver?

The requirements of an optical receiver are

a).Light detector b).Preamplifier c).Equalizer d).Signal discriminator circuits

18. What are the advantages of preamplifier?(May15)

The advantages of preamplifier are

(a)low noise level,(b) high bandwidth,(c)high dynamic range, (d)high sensitivity,

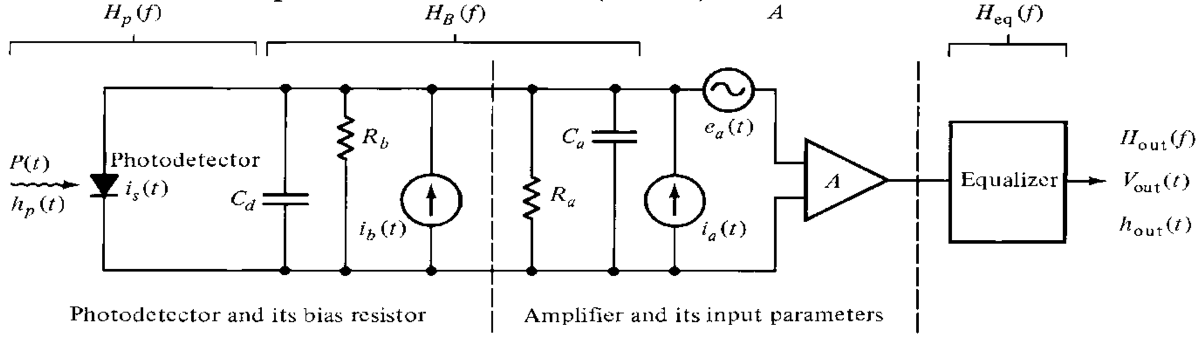
(e)high gain

19.What are the standard measurement techniques? (Apr 17)

The standard measurement techniques are

(a)Reference test methods,(b)Alternative test methods

20. Draw the fiber optic receiver schematic.(Nov 15)



21. What is cut back method? (Nov 16)

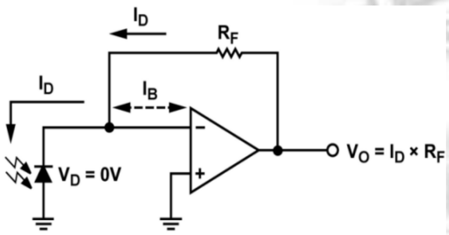
The cutback method is used for measuring the total attenuation of an optical fiber. The cutback method involves comparing the optical power transmitted through a longer piece of fiber to the power transmitted through a shorter piece of the fiber. The cutback method requires that a test fiber of known length 'L' be cut back to a shorter length. It needs access to both ends of the fiber.

22. Mention few fiber diameter measurement techniques. (Nov15)

(i)Inner diameter measurement (ii) Outer diameter measurement

23. List out the various error sources in the receiver section. (April 19)
The various error sources in the receiver section are Quantum Noise, Bulk Dark current Noise, Surface leakage current noise, Thermal Noise and Amplifier noise.

24. Draw the generic structure of trans impedance amplifier.(Nov 17)



25. State the significance of maintaining the fiber outer diameter constant. (Apr 19)

If the Outer diameter is constant within 1% then i)High speed communication ii) accurate fiber-fiber connection and iii) reduced radiative losses.

PART-B

1.Explain the different types of Preamplifiers used in a receiver.

2.Define the term Quantum limit and derive a suitable expression for Probability of Error with respect to receiver.**(May 13) (Nov15)**

3.Discuss with necessary expressions the different types of noises that affect the performance of the photo detector**. (Nov19)**

4.Explain the technique used in frequency domain intermodal dispersion measurement. **(Nov 19)**

5.Explain the insertion loss method that is used for attenuation measurement **(Nov19)**

6.Explain the measurement technique used in the case of (i) Fiber cut-off wave length (ii) Fiber diameter. **(Apr 18) (Nov 18)**

7.Discuss in detail about the methods used for measuring intermodal dispersion and chromatic dispersion. (**Apr17)**

8.Explain in detail about the front end optical amplifiers. **(Nov 18)**

9.i) A photodiode has a capacitance of 6 PF. Calculate the maximum load resistance which allows an 8 MHz post –detection bandwidth. Determine the bandwidth penalty with the same load resistance when the following amplifier also has an input capacitance of6pF**.**ii)Explain the measurement technique used in the case of Numerical aperture **(Nov 17) (Apr19).**

10.A trigonometrical measurement is performed in order to determine the numerical of a step index fiber. The screen is positioned 10 cm from the fiber end face. When illuminated from a wide-angled visible source the measured output pattern size 6.2 cm. Calculate the appropriate numerical aperture of the fiber. **(Apr18)**

11.Discuss the different structures of receiver in the optical fiber communication with neat diagram. **(Apr 18)(Apr 19)**

12.Pulse dispersion measurements are taken over a 1.2 km length of partially graded multimode fiber. The 3dB widths of the optical input pulses are 300 ps, and the corresponding 3dB width for the output pulses are found to be 12.6 ns. Assuming the pulse shapes and fiber impulses response are Gaussian, calculate: **(Apr19)**
(i)The 3 dB pulses broadening for the ns km^{-1}(ii) The fiber bandwidth –length product.

13.Explain in brief the blocks and their functions of an optical receiver with schematic diagram. (**Apr 19)**

14**.(**i)Discuss the various fiber Alignment losses and Joint losses with a neat sketch.(ii) What is meant by fiber splicing? Brief in detail the techniques and methods of fiber splicing**.(Apr 19).**

15**.(i)** Describe the various types of Connectors in detail.(ii)Explain the Lensing Schemes used to improve optical source to fiber coupling efficiency**. (Nov 19)**

UNIT V-OPTICAL COMMUNICATION SYSTEMS AND NETWORKS

PART-A

1. **What are solitons and give its significance? (May13, Nov14,May14, May15, Apr18)**

The term "Soliton" refers to special kinds of waves that can propagate undistorted overlong distances and remain after collisions with each other. Solitons are very narrow, high-intensity optical pulses that retain their shape through the interaction of balancing pulse dispersion with the nonlinear properties of an optical fiber. These to f pulses that do not change in shape are called fundamental solitons, and those that undergo periodic shape changes are called higher-order solitons.

2. What are repeaters?

In optical communications the term repeater is used to describe a piece of equipment that receives an optical signal, converts that signal in to an electrical one, regenerates it, and then retransmits an optical signal. Since such a device convert the optical signal into an electrical one, and then back to an optical signal, they are often known as Optical Electrical Optical (OEO) repeaters.

3. What is frequency chirping?

A chirp is a signal in which the frequency increases ('up-chirp') or decreases ('down-chirp')with time. It is commonly used in sonar and radar, but has other applications, such as in spread spectrum communications. In frequency chirping the rising edge of the pulse experiences are d shift in frequency (toward higher frequencies),where as the trailing edge of the pulse experience blue shift in frequency (toward lower frequencies).

4. Why do we use NRZ coding scheme generally?

For a serial data stream, a non-off(or uni polar)signal represents the symbol 1by a pulse of current or light filling an entire bit period, where as for the symbol 0 is represented by no pulse. These codes are simple to generate and decode, but they possess no inherent error-monitoring or correcting capabilities and they have no self-clocking(timing) features.

5. List out the benefits of SONET and PDH? (Nov 13)(May15)

Synchronous optical networking (SONET)and Synchronous Digital Hierarchy(SDH),are multiplexing protocols that transfer multiple digital bit streams using lasers or light-emitting diodes(LEDs)over the same optical fiber. The method was developed to replace the Plesiochronous Digital Hierarchy(PDH)system for transporting larger amount of telephone calls and data traffic over the same fiber wire with out synchronization problems.

6. What is Kerr effect?

Nonlinearity produces a carrier induced phase modulation of the propagating signal. This is called as Kerr effect.

7. State the concept of WDM. (Nov 14)

Wavelength-division multiplexing(WDM) is a technology which multiplexes multiple optical carrier signals on a single optical fiber by using different wavelengths(colours) of laser light to carry different signals. This allows for a multiplication in capacity, in addition to enabling bidirectional communications over one strand of fiber.

8. What is the significance of rise time budget?(Nov 08, Apr08)

A rise-time budget analysis is a convenient method for determining the dispersion limitation of an optical link. This is particularly useful for a digital link**.** The four basic elements that may significantly limit optical system speed are the transmitter rise time, the group-velocity dispersion (GVD), rise time of the fiber, the modal dispersion rise time of the fiber, and the receiver rise time.

$$t_{sys} = [t_{tx}{}^2 + t_{mod}{}^2 + t_{GVD}{}^2 + t_{rx}{}^2]^{1/2}$$

Where t_{tx} - Transmitter rise time; t_{mod} - Modal dispersion; t_{GVD} - Rise time due to group velocity dispersion; t_{rx} - receiver rise time

9. Compared fiber amplifiers and conventional repeaters. (Nov'08)

Repeater	Fiber Amplifier
(i)Conversion of optical to electrical and amplify this signal and reconvert the electrical to optical (ii)Used in short distance	(i) It directly amplify the optical signal Without any conversion (ii)Used in long distance.

10. Distinguish fundamental and higher order solitons. (Nov07,Apr 19)

The family of pulses that do not change in shape are called fundamental solitons, and those that under go periodic shape changes are called higher-order solitons. In either case, attenuation in the fiber will eventually decrease the soliton energy. Since this weakens then on linear inter action needed to counter act group velocity dispersion, periodically spaced optical amplifiers are required in a soliton link to restore the pulse energy.

11. What is EDFA?(May08, May 16, Nov 18, Apr 19)

An Erbium Doped Fiber Amplifier(EDFA)consists of a piece of fiber of length L, whose core is uniformly doped with Erbiumions. Such ions can be thought of as simple two-level systems, i.e., they can have only two energy states:1)a fundamental state and 2) an excited state.

12. Define Modal Noise. (May07)

Noise generated in an optical fiber system by the combination of mode-dependent optical losses and fluctuation in the distribution of optical energy among the guided modes or in the relative phases of the guided modes.

13. What are the system requirements in analyzing a point-to-point link?(DEC 05)

The following key system requirements are needed in analyzing point-to-point link

(a).The desired (or possible)transmission distance. (b).the data or channel bandwidth

(c).the bit-error rate(BER)

14. What is DWDM?

Dense Wavelength Division Multiplexing is an optical technology used to increase bandwidth over existing fiber optic backbones. It works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fibers.

15. What are the types of broad cast and select network?

a) Single hop networks b) Multi hop networks

16. Distinguish SONET and SDH. (Nov15)

SONET	SDH
(i)Synchronous Optical NET work (ii)Used in North America	(i)Synchronous Digital Hierarchy (ii)Rest of the world

17. What are the three common topologies used in fiber optic networks?(Apr 19)

a)Linear Bus b)Ring c)Star

18. Define the basic signal rate of SONET.

STS-1={(90 bytes/row)x (9 rows/frame)x(8 bits/byte)} /(125μs/frame)= 51.84Mbps

19. What is optical CDMA? (Nov15) (May 16)

An Optical CDMA system being a broad cast system sinks receive all source signals–as is normal in the case of CDMA. The advantage of this scheme is that it doesn't require any central control.

20. How the speckle pattern can form?

The speckle patterns are formed by the interference of the modes from a coherent source w hen the coherence time of the source is greater than the inter modal dispersion time with in the fiber.

21. Give the important features of time slotted optical TDM network.

1. To provide back bone to inter connect high speed networks

2. To transfer quickly very large data blocks

22. Name two popular architecture of SONET/SDH network. (Nov 16)

The two popular architecture of SONET/SDH network are

(a) Hub Network (b) Ring Architecture

23. What is an optical layer? (Apr 17)

Optical layer is a multiplexing hierarchy. Multiple wavelengths or light paths are combined into wavelength bands. Bands are combined to produce a composite WDM signal on a fiber. The network itself may include multiple fibers and multiple-fiber bundles, each of which carries a number of fibers.

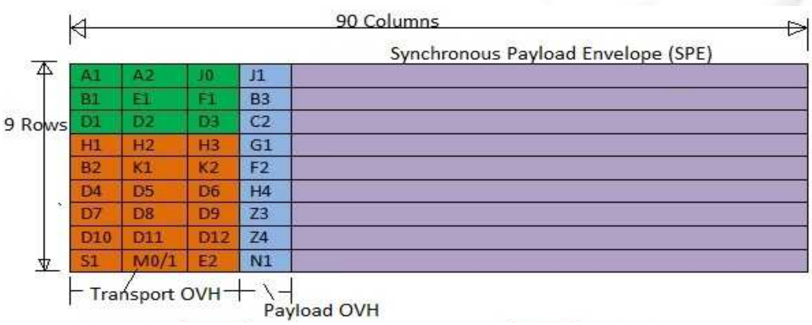
24. What are the key parameters required for analyzing the optical link? (Apr 17)

The major key parameter required for analyzing the optical link is accurate & precise measurements of optical fiber, since this component cannot be readily replaced once it has been installed

25. Mention two non-linear effects present in optical fiber. (Nov 17)

Self phase modulation (SPM), cross-phase modulation (XPM), four-wave mixing (FWM), and distortions in non–return–to–zero (NRZ).

26. Draw the basic structure of STS-1 SONET frame. (Nov 17)



27. Compare the optical link with that of the satellite link.(Nov 19)

1. The data rates in fiber optics are high whereas the data rates in satellite communications are much lower.2.Fiber Optic communication is more reliable than satellite.

28. Mention the drawbacks of broadcast and select networks for wide area network applications. (Apr 18)(Apr 19)

(i) They require a large number of wavelengths, typically at least as many as there are nodes in the network, because there is no *wavelength reuse* in the network. Thus the networks are not scalable beyond the number of supported wavelengths. (ii) They cannot span long distances since the transmitted power is split among various nodes and each node receives only a small fraction of the transmitted power, which becomes smaller as the number of nodes increases.

29. Define power penalty. (Nov 18)(Nov 19)

The signal power has to be increased to achieve the same SNR or BER performance as that of an ideal system to compensate for the system degradation. This increase in power is called the Power Penalty.

PART B

1.Explain the SONET frame structures and SONET rings with neat diagrams. (**Nov18, Apr19)**

2.Explain the principles of WDM Networks. **(Nov 18, Apr19)**

3.Describe Non-linear optical effects in detail. **(May 15, Nov 18, Apr 18, Apr19)**

4.Write notes on Solitons. **(Nov 13, Apr19)**

5.Explain the following requirements for the design of an optically amplified WDM link: (i) Link Band width (ii)Optical power requirements for a specific BER

6.Explain with neat sketch of two popular architecture of SONET. **(May16)**

7.Explain in detail different types of Broad cast-and – select WDM networks. **(May16)**

8.Write a note on optical switching methods. **(Nov17).**

9.What is optical power budgeting? Determine the optical power budget for the below system and hence determine its viability. Components are chosen for a digital optical fiber link of overall length 7 Km and operating at 20 M bits per sec using RZ code. It is decided that an LED emitting at 0.85 μm with graded index fiber to a pin photodiode is a suitable choice for the system components giving no dispersion equalization penalty. An LED which is capable of launching an average of 100 μW of optical power (including connected loss) into a graded index fiber of 50 μm core diameter is chosen. The proposed fiber cable has an attenuation of 2.6 dB km^{-1} and requires splicing every kilometer with a loss of 0.5 dB per splice. There is also a connecter loss at the receiver of 1.5 dB. The receiver mean incident optical power of -41 dBm in order to give the necessary BER of 10^{-10} , and it is predicted that a safety margin of 6 dB will be required. **(Apr18)**

10.Discuss about the concept of routing and wavelength assignment technique in the wavelength routed networks. **(Apr 18)**

11.Briefly explain the layers of SONET. **(Apr18)**

12.(i)Analyze the rise time budget for a fiber link**.** (ii) Assume that LED together with drive circuit has a rise time of 15 ns. LED has spectral width of 40nm. We have a material dispersion related rise time degradation of 21 ns over the 6km link. The rise time degradation from the receiver is 14 ns. The modal dispersion induced fiber rise time is 3.9ns.calculate link rise time. **(Nov19)**

13.With suitable example, explain the condition and constrains in the formulation and finding solution for routing and wavelength assignment problem in a optimal way. **(Nov19)**.