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Code No: R5410403

IV B.Tech I Semester(R05) Regular/Supplementary Examinations, December 2009

OPTICAL COMMUNICATIONS

(Electronics & Communication Engineering)

Time: 3 hoursMax Marks: 80

Answer any FIVE Questions

All Questions carry equal marks

1. (a) Calculate the numerical aperture of a step index fiber having n_1 = 1.48 and n_2 = 1.46. What is the maximum entrance angle max for this fiber of the outer medium is the i) air with n = 1.0. ii) water with n = 1.33.

   (b) Discuss various modes of propagation supported in optical fibers. [8+8]

2. (a) A single mode step index fiber with a core refractive index of 1.49 has a critical bending radius of 10.4 mm when illuminated with light at a wavelength of 1.3 μm. If the cut off wavelength for the fiber is 1.15 μm, calculate the relative refractive index difference.

   (b) Compare stimulated Brillouin and stimulated Raman scattering in optical fiber. [8+8]

3. (a) Explain about double eccentric and multiple fiber connectors.

   (b) A single mode fiber operating at the wavelength of 1.3 μm is found to have a total material dispersion of 2.81 ns and a total wave guide dispersion of 0.495 ns. Determine the received pulse width and approximate bit rate of the fiber if the transmitted pulse has a width of 0.5 ns.[8+8]

4. (a) What is hetero junction structures? Describe the two basic LED configurations that are suitable for fiber optics with neat schematics.

   (b) Define the terms.

      i. Quantum efficiency

      ii. Power bandwidth product
         and explain their significance. [8+8]

5. Write short notes on the following:

   (a) Radiation patterns of Lambertian sources and relation to power coupling into an optical fiber.

   (b) Dependence of coupled power from a fiber optic source into a fiber on wavelength of source emission and length of the fiber.[8+8]

6. (a) Define quantum limit of a fiber optic receiver. What is the effect of detector dark current on quantum limit?

   (b) Describe briefly various sources of noise in a general fiber optic receiver. Identify the PIN receiver noise component that is dominant in receiver SNR computation.[8+8]

7. Describe about the following briefly:

   (a) Component choice for design of a fiber optic link.

   (b) Power Budget analysis of a fiber optic link with an example. [8+8]

8. (a) Describe the principle and necessity of WDM technique in optical communication systems.

   (b) With the help of suitable diagrams, explain how uni-directional and bi-directional WDM optical communication links operate.

   (c) Is it possible to multiplex number of closely spaced wavelengths within the same wavelength window of optical communication?[5+6+5]

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   (b) Discuss various modes of propagation supported in optical fibers. [8+8]

2. (a) Explain how mode field diameter (MFD) can be determined in single mode fiber.

   (b) A single mode optical fiber has a beat length of 8 Cm at 1300 nm. Calculate the birefringence. [8+8]

3. (a) Explain the theory of material dispersion and find an expression for RMS material dispersion.

   (b) A single mode step index fiber has a zero dispersion wavelength of 1.29 µm and exhibits total first order dispersion of 3.5 ps m^{-1} km^{-1} at a wavelength of 1.32 µm. Determine the total first order dispersion in the fiber at a wavelength of 1.54 µm.[8+8]

4. (a) Draw the schematic of an edge emitting LED and explain the reasons for such construction.

   (b) Discuss the major requirements of an optical fiber emitter. [8+8]

5. (a) With the help of neat diagrams describe lens coupling mechanisms to improve coupling efficiency from a fiber optic source.

   (b) Differentiate between Lambertian and monochromatic optical sources in terms of power coupling into a single mode fiber.

   (c) What is equilibrium numerical aperture? Explain the significance of equilibrium numerical aperture on source to fiber power coupling.[6+5+5]

6. Describe the following briefly:

   (a) Error sources in a digital fiber optic link.

   (b) Avalanche gain and temperature dependence. [8+8]

7. (a) Describe a method to carryout rise time budget analysis for a fiber optic link

   (b) Explain the procedure to determine the maximum allowable RZ and NRZ data rates from rise time budget analysis.

   (c) Explain the effect of mode mixing factor, q, on modal dispersion induced rise time. [8+4+4]

8. (a) Describe eye pattern technique to assess the performance of digital fiber optic link.

   (b) Explain in detail the operational principle, key features and benefits of WDM scheme in optical links. [8+8]

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1. (a) List out all the elements of typical optical fiber transmission link with the help of a neat block diagram. Explain the working principle of fiber link.

   (b) Find the core radius necessary for single mode operation at 850 nm of step index fiber with n_1 = 1.480 and n_2 = 1.465.[8+8]

2. (a) Explain about "chalgenide glass fibers".

   (b) Commonly available single mode fibers have beat lengths in the range 10cm<Lp<2m. What range of refractive index differences does this correspond to for λ= 1300 nm? [8+8]

3. (a) Compare the optical parameters of free space with dispersive and non dispersive mediums.

   (b) A butt jointed fiber convector used on multimode step index fiber with a core refractive index of 1.42 and a relative refractive index difference of 1% has an angular misalignment of 9_0 . There is no longitudinal or lateral misalignment but there is a small air gap between the fibers in the convectors. Estimate the insertion loss of the convector.[8+8]

4. Explain the modulation capability and transient response of LED. [16]

5. Write short notes on the following:

   (a) Radiation patterns of Lambertian sources and relation to power coupling into an optical fiber.

   (b) Dependence of coupled power from a fiber optic source into a fiber on wavelength of source emission and length of the fiber.[8+8]

6. (a) Define quantum limit of a fiber optic receiver. What is the effect of detector dark current on quantum limit?

   (b) Describe briefly various sources of noise in a general fiber optic receiver. Identify the PIN receiver noise component that is dominant in receiver SNR computation.[8+8]

7. (a) Describe a method for determining the dispersion limitation of a given fiber optic link. Explain all the factors involved in the analysis.

   (b) Compute the modal-dispersion induced fiber rise time for the specifications of the fiber listed below. [8+8]
   Bandwidth-distance product of the fiber= 400 MHz-Km
   Mode mixing factor over the length of the fiber = 0.7
   Length of the optical fiber= 6Km

8. (a) How can the maximum achievable transmission distance with a set of active and passive components in an optical link be calculated? Explain with the help of necessary transmission curves.

   (b) Describe eye patterns analysis for assessing the performance of a digital fiber optic link. Is it possible to estimate BER also from eye patterns?[8+8]

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1. (a) Explain numerical aperture with reference to ray theory transmission.

   (b) A multi mode step index fiber has a relative refractive index difference of 1% and a core refractive index of 1.5. The number of modes operating at a wavelength of 1.3μm is 1100. Estimate the diameter of the fiber core.[8+8]

2. (a) Explain the mechanisms losses in resulting in optical fibers.

   (b) An optical signal, after propagating through a fiber has lost 80% of its power in a length of 600m of fiber. Calculate the loss in dB/Km of this fiber.[8+8]

3. Define and distinguish between the different types of signal distortion in optical fibers. [16]

4. (a) An optical fiber has a core refractive index of 1.5. Two lengths of the fiber with smooth and perpendicular (to the core axes) end faces are butted together. Assuming the fiber axes are perfectly aligned, calculate the optical loss in decibels at the joint (due to fresnel reflection) when there is a small air gap between the fiber end faces.

   (b) Write short notes on “Fusion splices”. [8+8]

5. (a) Describe all the factors giving rise to losses while coupling optical power between any two devices of a fiber optic link.

   (b) What is a pig-tailed device? List out the advantages and disadvantages of pig-tailing either a fiber optic source or a fiber optic detector.

   (c) Write expressions for power coupling from an LED into a step index fiber for larger and smaller active area relative to the area of the fiber.
   [5+5+6]

6. (a) List out the materials used and the desired features of a photo diode for usability in fiber optic links.

   (b) Derive an expression for total mean-square noise signal in a photo detector and hence the Signal-to-Noise Ratio at the output of a receiver.[8+8]

7. (a) Estimate the maximum possible link length for operation at 60Mbps and BER of 10^{-9} for the long haul single mode optical fiber system operating at 850nm and specified below.
   Mean power launched from transmitter= -3dBm
   Attenuation in optical fiber cable= 2dB/Km
   Loss in all splices= 0.3 dB/Km
   Connector loss at the transmitter and receiver= 1.2dB/connector
   Receiver sensitivity at 60Mbps for BER of 10^{-9} = -48dBm
   Required safety margin= 8dB

   (b) Is the above specified link attenuation limited for a 26 Km link length? If yes, suggest a solution for eliminating the limitation.[10+6]

8. Describe the following:

   (a) Estimation of noise margin, best sampling time and timing gitter using eye pattern analysis.

   (b) Quality improvement in signal transmission due to line coding. [8+8]