Code No: R05410403 **Set No. 1**

IV B.Tech I Semester Regular Examinations, November 2008
OPTICAL COMMUNICATIONS
(Common to Electronics & Communication Engineering and Electronics & Telematics)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Give any three applications of optical fibers for instrumentation and explain them with the necessary figures.
   (b) Calculate the number of modes at 1550 nm and 1300 nm in a graded index optical fiber having a parabolic index profile, a 20 μm core radius, $n_1 = 1.48$ and $n_2 = 1.46$. [8+8]
2. (a) Write short notes on Plastic Optical Fibers".
   (b) Find the radius of curvature R at which the number of modes decreases by 50 percent in a graded index fiber take $\alpha = 2$, $n_2 = 1.5$, $\Delta = 0.01$, a = 25 μm, λ = 1.3 μm. [8+8]
3. Define and distinguish between the different types of signal distortion in optical fibers. [16]
4. Explain the modulation capability of the laser diode and its temperature effects. How to compensate for variations in temperature? [16]
5. (a) Discuss the dependence of equilibrium numerical aperture on power coupling from a source into a fiber.
   (b) Estimate the losses encountered while coupling power from a source to a fiber due to mismatch in their numerical apertures and surface areas. [6+10]
6. Describe the following briefly:
   (a) Functioning and performance of an analog fiber optic receiver.
   (b) Noise sources in a PIN photo detector. [8+8]
7. (a) Discuss the effect of mode mixing factor on modal dispersion for calculating the maximum allowable transmission data rate in a fiber optic link.
   (b) The rise times for various components of intensity modulated fiber optic link are listed below. Determine if these specifications support a 5 Km repeater-less fiber optic link with 6 MHz optical bandwidth: [8+8]

Risetime of LED transmitter electronics	= 10ns
Inter modal dispersion induced	= 8ns/Km
Intra modal dispersion induced	= 2ns/Km
Risetime of Detector and receiver electronic	= 3ns

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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Code No: R05410403 **Set No. 2**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. (a) Explain step index fiber structure in detail.
   (b) The core of an optical fiber is made of glass of refractive index 1.55 and in clad with another glass of refractive index 1.0. Determine:
      i. Numerical Aperture
      ii. Acceptance angle
      iii. Critical angle. [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) 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) Two multimode step index fibers have NAs of 0.2 and 0.4 respectively and both have the same core refractive index which is 1.48. Estimate the insertion loss at a joint in each fiber caused by a 5^0 angular misalignment of the fiber core axes. It may be assumed that the medium between the fibers in air.
   (b) Explain the intrinsic coupling losses at fiber joint due to mismatch of core diameter, NA and refractive index profile difference. [8+8]

5. (a) Sketch the radiation patterns from a surface emitting LED in both axial and perpendicular planes with reference to active emitting region. Support the sketches with corresponding mathematical expressions.
   (b) Derive an expression for power coupling from a large surface emitting LED into a smaller step-index fiber. [8+8]

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. Write a short note on the following:

   (a) System considerations in the design of a fiber optic link.

   (b) System rise time calculation with the help of an example. [8+8]

8. (a) List the conditions under which cut-back method of measurement of fiber attenuation yields more accurate values.

   (b) Suggest a non-destructive method for measurement of fiber attenuation. Mention the principle behind this method.

   (c) Output of a PIN detector preamplifier of an optical receiver for 1.6Km fiber is 2.26 Volts at 820nm wavelength. The output of PIN preamplifier increases to 9.06 Volts when this fiber is cutback to 4m length at the same wavelength. Compute the total attenuation and attenuation per unit length (dB/Km) of the cut-off fiber. [5+5+6]

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Code No: R05410403 **Set No. 3**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Explain the following:
   i. Total internal reflection
   ii. Axial Numerical aperture in a graded index fiber.

   (b) What is V-number in connection with optical fiber? What is its significance?

   (c) A single mode step index fiber has a core diameter of 7 μm and core refractive index of 1.49. Estimate the shortest wavelength of light which allows single mode operation when the refractive index difference for the fiber is 1%. [4+4+8]

2. (a) Derive the expression for critical radius of curvature for single mode and multi mode fibers.

   (b) Explain light propagation conditions single mode fibers with neat figures.[8+8]

3. Derive the expression for the relationship between material dispersion and wavelength of the optical fiber with suitable examples. [16]

4. (a) A laser diode has maximum average output of 1mw (0 dBm). The laser is to be amplitude modulated with a signal x(t) has a DC component of 0.5 and a periodic component of $\pm$ 2.6. If the current input to optical output relationship is
   $p(t) = \frac{i(t)}{25}$, find the values of I_O and m if the modulating current is.
   i(t) = $I_0[1 + mx(t)]$

   (b) Obtain the expression for the 3 dB modulation bandwidth of LED and discuss the importance of radiative recombination lifetime. [8+8]

5. Write short notes on the following:

   (a) Radiation patterns of a Lambertian source with necessary equations.

   (b) Radiation from a monochromatic source and power coupling into a fiber.[8+8]

6. (a) Reason out if the two parameters, 'quantum efficiency' and 'responsivity' signify the same properties of a detector diode.

   (b) A PIN diode is characterized by a quantum efficiency of 72% at a wavelength of 900 nm. Calculate:
   i. Responsivity of the PIN diode at 900 nm.
   ii. Received optical power if the mean photo current is 10 mA at 900 nm.

iii. Number of received photons for 1 mA mean photo generated current. [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. Write brief notes on the following:
   (a) Measurement of Dispersion in single mode optical fiber.
   (b) Requirement and merits of Line coding in optical communication systems. [8+8]

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Code No: R05410403 **Set No. 4**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. (a) Distinguish between leaky modes and guided modes in optical fiber transmission.
   (b) For a multimode step index optical fiber of glass core of refractive index 1.5 and quartz cladding of refractive index 1.46, determine:
      i. Critical angle
      ii. Acceptance angle
      iii. Numerical value
      Derive the relations used. [8+8]

2. (a) A graded index fiber with a parabolic refractive index profile core has a refractive index at the core axis of 1.5 and a relative index difference of 1%. Estimate the maximum possible core diameter which allows single mode operation at a wavelength of 1.3 μm.
   (b) Discuss material absorption losses in silica glass fibers. [8+8]

3. Explain the pulse dispersion with suitable diagrams in detail. [16]

4. (a) A Ga Al As laser diode has a 600 μm cavity length has an effective absorption coefficient of 15cm^{-1}. For coated facts, the reflectiveness are 0.30 at each end. What is the optical gain at the lasing threshold.
   (b) If one end of the laser is coated with a dielectric reflector so that its reflectivity is now 80%. What is the optical gain at the lasing threshold?
   (c) If the internal quantum efficiency is 0.6, what is external quantum efficiency in case (a) and (b). [16]

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. (a) Define quantum limit of a fiber optic receiver. Compute the average number of photons per pulse required by a digital fiber optic receiver operating at 850 nm for the BER to be.

i. 10^{-9}

ii. 10^{-10}

(b) Discuss briefly about various sources of errors in a digital fiber optic link.[8+8]

7. (a) List the estimates and conclusions possible from transmission distance versus bit rate plot for a given wavelength-LED-PIN diode combination.

   (b) Discuss the difference between a dispersion limited and an attenuation limited fiber optic link.

   (c) Explore the possibility to include system margin in rise-time budget analysis also. [6+6+4]

8. Describe the following briefly:

   (a) Transmission distance versus bit rate diagram.

   (b) Attenuation measurement using cutback method. [8+8]

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