Code No: 07A70410 **R07** **Set No. 2**

**IV B.Tech I Semester Examinations,December 2011**
**OPTICAL COMMUNICATIONS**
**Electronics And Communication Engineering**

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

**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. (a) Explain the function of each block with a help of neat block diagram of a digital optical fiber communication system.
   (b) Compare the fiber structure and NA in step index and graded index fibers. [8+8]

2. (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]

3. (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 $\mu$m.
   (b) Discuss material absorption losses in silica glass fibers. [8+8]

4. (a) A graded index fiber has a parabolic refractive index profile ($\alpha$=2) and a core diameter of 50 mm. Estimate the insertion loss to a 3 $\mu$m lateral misalignment at a fiber joint when there is index matching and assuming.
      i. There is uniform illumination of all guided modes only,
      ii. There is uniform illumination of all guided and leaky modes,
   (b) Describe possible losses due to lateral and angular misalignments between fibers. [8+8]

5. (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]

6. (a) Explain the principle behind the operation of an Avalanche Photo Diode.
   (b) Compare and contrast the properties of a PIN diode and an APD.
   (c) Compute the responsivity of a silicon APD operating at 850 nm with a quantum efficiency of 72% if only 20% of the internally generated photoelectrons are collected at the detector terminals. [5+6+5]

7. (a) Enumerate the necessity of line coding of signals before transmission over optical fibers?
   (b) Differentiate between Source coding, channel coding and Line coding?
   (c) Describe a method to measure chromatic dispersion in optical fibers?[4+6+6]

8. (a) Write notes on "dispersion shifted fiber and dispersion compensating fiber".
   (b) Explain in detail about the refractive index profile dispersion and dispersion Vs bandwidth of an optical fiber. [8+8]

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Code No: 07A70410 **R07** **Set No. 4**

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**OPTICAL COMMUNICATIONS**
**Electronics And Communication Engineering**

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

**Answer any FIVE Questions**
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1. (a) Discuss the system criteria for design of a point-to-point fiber optic link.
   (b) An optical fiber system uses a fiber cable with a loss of 6 dB/Km. Average distributed splice losses is estimated as 1.4 dB/Km. Determine the maximum possible repeater-less transmission distance if the total permitted fiber loss is 36dB. Allocate system safety margin of 5dB. [8+8]

2. Describe the following briefly:
   (a) Line coding in Optical Communication links.
   (b) Inter modal dispersion measurement in optical fibers. [8+8]

3. (a) A Ga As LED source emits light at 0.85 $\mu$m having a spectrum width of 0.30 nm and the material dispersion parameter is 0.035. Find the value of bandwidth distance product.
   (b) Explain the following with respect to LED.
      i. Radiance
      ii. Emission response time
      iii. Quantum efficiency
      Explain how can one achieve high values for the above parameters. [8+8]

4. (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]

5. (a) Write expression for power coupled into a step index fiber from an LED source.
   (b) An LED with circular emission region of diameter 100$\mu$m and an axial radiance of 100 W / $cm^2$- Sr at 100mA drive current is coupled into a step index fiber of 50 $\mu$m diameter and of 0.22 numerical aperture. Compute the power coupled into this step index fiber. Compute the %difference in coupled power if the radius of the fiber is:
      i. Halved.

ii. Doubled. [4+12]

6. (a) Derive an expression for multiple time difference ($\Delta$t/z) in the multi path dispersion of the optical fiber.
   (b) Mention the principal requirements of a good connector design. [8+8]

7. (a) A manufacturer wishes to make a silica core, step index fiber with V=75 and a NA = 0.30 to be used at 820 nm. If $n_1$ = 1.458, what should be the core size and cladding index of this fiber?
   (b) Explain the following terms:
      i. Meridional rays
      ii. Skew rays
      iii. V - number
      iv. Normalized propagation constant. [8+8]

8. (a) Explain in detail the transmission losses due to absorption mechanism in an optical fiber with necessary equations and prove that this loss is a function of wavelength using graphical analysis.
   (b) The average optical power launched in to 25 km length of fiber is 100 $\mu$w and the average output power is 25 $\mu$w.
   Calculate:
      i. The signal attenuation in dB through the fiber. It is assured that there are no connectors or splices.
      ii. Signal attenuation per km of the fiber.
      iii. Overal signal attenuation for the 27 km optical link using the same fiber with 3 splices, each having an attenuation of 0.9 dB. [8+8]

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1. (a) Describe insertion-loss method of measurement of attenuation in an optical fiber with suitable schematics.
   (b) Compare and contrast insertion-loss technique with cut-back technique of measurement of attenuation.
   (c) What is a mode stripper? Explain the necessity of mode stripper in the measurement of attenuation in an optical fiber. [8+4+4]

2. (a) Explain the following:
      i. Mode field diameter
      ii. Effective refractive index.
   (b) A power of 3 dBm is available at the output of a fiber of length 14 km. If the attenuation coefficient $\alpha$ is 0.5 dB/m, determine the amount of power which was coupled in to the fiber input. [8+8]

3. (a) Explain the necessity of power budget analysis and risetime budget analysis for design of a fiber optic link.
   (b) Describe graphical representation of link loss budget with a set of assumed values. [8+8]

4. (a) Derive an expression for coupled power from an LED into a relatively smaller step index fiber with equal numerical aperture.
   (b) A Ga As source of 200 $\mu$m diameter active area and refractive index of 3.6 radiating into $30^0$ solid angle couples power into an all silica optical fiber of 50 $\mu$m diameter and 0,22 numerical aperture. Estimate the loss in power coupling due to all types of mismatch between the devices. Express the loss computed in dB also. [8+8]

5. (a) Discuss the advantages and drawbacks of the fusion splicing and adhesive splicing.
   (b) With the help of expressions, explain the internal quantum efficiency and modulation capability of LED. [8+8]

6. (a) Derive an expression for Signal-to-Noise Ratio at the output of a PIN diode based analog receiver.
   (b) Write modified expression for SNR at the output of an APD based analog receiver.

(c) What are the differences in specifications, selection of components, performance merit parameters of digital and analog fiber optic receivers? [8+4+4]

7. (a) Explain the mode theory for circular wave guide.
   (b) Compare step index and graded index fibers in all aspects. [8+8]

8. (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]

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Code No: 07A70410 **R07** **Set No. 3**

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

**Answer any FIVE Questions**
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1. (a) Draw the light output versus current curve and explain the operation of LASER.
   (b) Explain the principle and operation of a surface emilting LED with necessary schematics. [8+8]

2. (a) What are reasons for the signal to get distorted as it travels along a fiber?
   (b) Suggest methods to minimize signal distortion in optical fibers. [8+8]

3. Write brief notes on the following:
   (a) Attenuation measurements for optical fibers
   (b) Wavelength division multiplexing for optical communication system. [8+8]

4. (a) Describe a procedure to determine the maximum allowed NRZ or RZ data rate on a given fiber optic link.
   (b) Estimate the maximum NRZ data rate allowed for transmission over an 8 Km optical fiber link operating at 850nm wavelength specified below: [10+6]

| | |
|---|---|
| Source rise time | = 8ns |
| Inter-modal dispersion rise-time | = 5ns/Km |
| Intra modal pulse broadening | = 1ns/Km |
| Detector rise-time | = 6ns. |

5. (a) Derive an expression for power coupled from a surface emitting LED into a step index fiber of acceptance angle,$15^0$. Assume the source emission to be Lambertian and its active area to be larger than the cross section area of the core of the optical fiber. The air gap between the devices can be assumed to be negligibly small. Make assumptions as per the requirement and state all of them.
   (b) Discuss about the losses encountered while coupling optical power from an optical fiber into a fiber optic receiver. [8+8]

6. (a) Describe Photo carrier generation and internal multiplication processes in an Avalanche Photo Detector.
   (b) The quantum efficiency of a silicon APD at 900 nm wavelength is 80%. The final current out of this APD is 16 $\mu$A for an incident optical power of 0.45 $\mu$W on the diode. Compute the Avalanche multiplication factor of the APD.

Use the necessary physical constants listed: [8+8]

Speed of light in vacuum $= 3 \times 10^8$ m/s
Electron charge $= 1.602 \times 10^{-19}$ C
Planck's constant $= 6.6256 \times 10^{-34}$ J-S.

7. (a) The photo-elastic coefficient and the refractive index for silica are 0.286 and 1.46 respectively. Silica has an isothermal compressibility of $7\times 10^{-11}$ $m^2$ $N^{-1}$ and an estimated fictive temperature of 1400k. Determine the theoretical attenuation in dB/ Km due to fundamental Rayleigh scattering in silica at optical wavelengths of 0.85 and 1.55 $\mu$m. Boltzmen constant is $1.381 \times 10^{-23}$ J $K^{-1}$.

   (b) Distinguish between macro bending and micro bending losses in brief. [8+8]

8. (a) Explain the field distribution for lower order modes in a symmetrical wave guide.

   (b) Explain mode theory for circular wave guide. [8+8]

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