(i) Assume τ is the average carrier lifetime in the 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 $\partial n / \partial t = 0$, so that

$$n_{th} = \frac{J_{th}\tau}{qd}$$

If a current pulse of amplitude I_p is applied to an unbiased laser diode, show that the time needed for the onset of stimulated emission is

$$t_d = \tau \ln \frac{I_p}{I_p - I_{th}}$$

Assume the drive current I = JA, where J is the current density and A is the area of the active region. (8)

(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

$$t_d = \tau \ln \frac{I_p}{I_p + (I_B - I_{th})}. \quad (7)$$

Or

(b) With schematic diagram, explain the blocks and their functions of the major elements of an optical fiber transmission link. (15)

23/11/18 FN

Reg. No. :

Question Paper Code : 20428

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Seventh Semester

Electronics and Communication Engineering

EC 6702 — OPTICAL COMMUNICATION AND NETWORKS

(Regulations 2013)

(Common to PTEC 6702 – Optical Communication and Networks for B.E. (Part-Time) Sixth Semester – Electronics and Communication Engineering – Regulations 2014)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between meridional rays from skew rays.

2. A manufacturing Engineer wants to make an optical fiber that has a core index of 1.480 and cladding index of 1.478. What should be the core size for single mode operation at 1550 nm?

3. What is polarization Mode Dispersion (PMD)?

4. Distinguish between intramodal and intermodal dispersions.

5. Why is silicon not used to fabricate LED or Laser diode?

6. What is internal quantum efficiency?

7. Define responsivity.

8. State detector response time.

9. Define power penalty.

10. What is EDFA?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Draw a neat diagram and explain the ray theory behind the optical fiber communication with a special mention about the total internal reflection, Acceptance angle and Numerical aperture. (8)

(ii) 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. (5)

Or

(b) (i) Explain about step index and graded index fiber with their index profile diagrams. (8)

(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. Estimate the total number of guided modes propagating in the fiber when it is operating at a wavelength of 1 μm. (5)

12. (a) (i) Prove that, delay difference between axial ray and extreme meridional ray is $\delta T_s = \frac{L\Delta n_1}{C}$. (8)

(ii) A 6 km optical link consists of multimode step index fiber, with a core RI of 1.5 and relative refractive index difference of 1%. Estimate. (5)

(1) Delay difference between the 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 substantial errors on the link assuming only intermodal dispersion.

Or

(b) (i) Describe the attenuation mechanisms in an optical fiber. (9)

(ii) A continuous 40 km long optical fiber link has a loss of 0.4 dB/km.

(1) What is the minimum optical power level that must be launched into the fiber to maintain an optical power level of 2.0 μW at the receiving end? (2)

(2) What is the required input power if the fiber has a loss of 0.6 dB/km? (2)

13. (a) (i) What are the characteristics required for an optical source? With help of neat diagram, describe the operation of surface emitting LED. (8)

(ii) A double heterojunction InGaAsP LED emitting at a peak wavelength of 1310 nm has radiative and non radiative recombination times of 25 and 90 ns respectively. The drive current is 35 mA.

(1) Find the internal quantum efficiency and the internal power level. (3)

(2) If the refractive index of the light source material is n = 3.5, find the power emitted from the device. (2)

Or

(b) (i) Describe the term External quantum efficiency relating to LASER. (8)

(ii) A GaAs optical source with refractive index of 3.6 is coupled to a silica fiber that has a refractive index of 1.48. What is the power loss between source and the fiber? (5)

14. (a) (i) Explain in detail about the front end optical amplifiers. (7)

(ii) Estimate the terms:- Quantum limit and Probability of Error with respect to a receiver with typical values. (6)

Or

(b) Demonstrate the following in detail :

(i) Fiber refractive index profile measurement. (7)

(ii) Fiber cutoff wavelength measurement (6)

15. (a) Explain SONET layers and its frame structure with diagram. (13)

Or

(b) (i) Define and explain the principle of WDM networks. (7)

(ii) State the nonlinear effects on optical network performance. (6)

PART C — (1 × 15 = 15 marks)

16. (a) 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.

$$\frac{dn}{dt} = \frac{J}{qd} - \frac{n}{\tau}$$