BH/K/TX

Reg. No:

VIT
Vellore Institute of Technology

Final Assessment Test – November 2024

Course: BECE308L - Optical Fiber Communications

Class NBR(s): 2791 / 2793 / 2798 / 2803 / 2805 / 2807 Slot: B2

Time: Three Hours Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

Answer ALL Questions

(10 X 10 = 100 Marks)

1. (a) (i) Enumerate the causes of the signal deterioration as it travels through the fiber at longer distances. [5]

   (ii) Explain the key features and applications of Double and Triple-clad fibers.

   (b) Using ray theory transmission approach, explain the following [5]

   (i) Total internal reflection and critical angle.

   (ii) Acceptance angle.

   (iii) Numerical aperture

2. (a) Find the optical output power, if 100 mWatt of optical power is launched into the fiber of 10-km long that has an attenuation of 0.4 dB/km at 1310 nm. [4]

   (b) Describe intrinsic and extrinsic material absorption losses in optical fibers. [6]

3. (a) Estimate the optical power coupled into a step index fiber of 50 μm core diameter with an NA of 0.18 from a DH surface emitter with an emission area diameter of 75 μm and a radiance of 60 W/sr/cm^2. The Fresnel reflection at the index-matched semiconductor–fiber interface is 30%. [7]

   (b) If this LED launches the optical power into a multimode step index fiber, with a forward current of 25 mA is flowing through the device, determine the overall power conversion efficiency when the corresponding forward voltage across the diode is 1.5 V. [3]

4. (a) The longitudinal modes of a Gallium Arsenide injection laser emitting at a wavelength of 0.87 μm are separated in frequency by 278 GHz. Determine the length of the optical cavity and the number of longitudinal modes emitted. The refractive index of gallium arsenide is 3.6. [5]

   (b) Determine the ratio of the threshold current densities at 20°C and 80°C for an AlGaAs injection laser with T_0 =160K. [5]

5.(a) An InGaAs pin photodiode has the following parameters at a wavelength of 1300 nm: I_D= 4nA, η= 0.90, R_L= 1000 Ω, and the surface leakage current is negligible. The incident optical power is 300 nW (–35 dBm), and the receiver bandwidth is 20 MHz. Find the mean square values of (i) shot noise current $\langle i_{shot}^2 \rangle$ (ii) dark current $\langle i_{DB}^2 \rangle$ and (c) thermal noise current $\langle i_T^2 \rangle$. **[10]**

OR

5.(b) silicon *p–i–n* photodiode incorporated into an optical receiver has a quantum efficiency of 60% when operating at a wavelength of 0.9 μm. The dark current in the device at this operating point is 3 nA and the load resistance is 4 kΩ. The incident optical power at this wavelength is 200 nW and the post-detection bandwidth of the receiver is 5 MHz. Compare the shot noise generated in the photodiode with the thermal noise in the load resistor at a temperature of 20 °C. **[10]**

6.(a) i) A given silicon avalanche photodiode has a quantum efficiency of 65 percent at a wavelength of 900 nm. Suppose 0.5 μW of optical power produces a multiplied photocurrent of 10 μA. What is the multiplication M? **[5]**

ii) A silicon pin photodiode has a quantum efficiency of 65% when photons of energy 1.5 X 10^{-19} J are incident upon it. At what wavelength is the photodiode operating? Find the responsivity. Calculate the incident optical power required to obtain a photocurrent of 2.5 μA, when the photodiode is operating as described above. **[5]**

OR

6.(b) A DH injection laser has an optical cavity of length 350 μm and width 15 μm. At normal operating temperature the loss coefficient is 28 / cm and the threshold current density for the device is 2×10^3 A / Cm^2. When the mirror reflectivity at each end of the optical cavity is 0.5 and 0.65, estimate the gain factor β, threshold current and also the threshold gain for the device. It may be assumed that the current is confined to the optical cavity. **[10]**

7. (a) An optical fiber system is to be designed to operate over an 8 km length without repeaters with the following specifications of t_{TX}=8 ns, t_{sys}= 46.2 ns, fiber intra modal dispersion as 5 ns/km, fiber intermodal dispersion as 1 ns/km. Consider its input function as NRZ format. Calculate the receiver time? [5]

(b) Explain the following with respect to digital link? [5]

(i) Point to point links. (ii) Power penalties.

8. a) What are the underlying theories behind WDM techniques? [5]

b) Summarize the benefits and drawbacks of implementing WDM in an optical fiber communication system. [5]

9. A 2 X 2 biconical tapered coupler has an input optical power of P_0= 200μW. The output power at the other three ports are P_1= 90um, P_2= 85 um and P_3= 6.3 nW. Estimate the following:

a) Coupling ratio [2.5]

b) Excess loss [2.5]

c) Insertion loss between the input and all other output ports [2.5]

d) crosstalk [2.5]

10. (a) What are the attributes that distinguishes an amplifier from a laser diode. [3]

(b) Justify why EDFA are best suited in WDM than SOA [3]

(c) Give a succinct explanation of the 3R regenerator's features along with a block diagram. [4]

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