



Final Assessment Test – November 2024

Course: **BECE308L - Optical Fiber Communications**

Class NBR(s): **2788 / 2792 / 2796 / 2799 / 2804 / 2806 / 2808**

Slot: **B1**

Max. Marks: **100**

Time: **Three Hours**

- **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) Illustrate the basic and necessary elements of the optical communication system and differentiate how it is different from other communication systems. Discuss the merits and demerits of it. [5]
- b) Explain Bend-Insensitive fibers with their key features and applications. [5]
2. a) Determine the optical power received from 100 km single mode fiber (SMF) with attenuation loss of 0.25 dB/km and source power of 1 mWatt. [5]
- b) Describe linear scattering losses in optical fibers with regard to [5]
 - (i) Rayleigh scattering
 - (ii) Mie scattering.
3. a) A singlemode optical fiber, characterized by an attenuation rate of 0.4 dB/km at a wavelength of 1.5 μm , features a core diameter of 8 μm and operates with a laser source bandwidth of 900 MHz. Compare the threshold optical powers necessary to initiate stimulated Brillouin and Raman scattering within the fiber at the specified wavelength. [5]
- b) Compare the following two multimode fibers: (i) a step-index fiber with a core index of $n_1 = 1.458$ and a core-cladding index difference $\Delta = 0.01$; and (ii) a parabolic-profile graded-index fiber with the same n_1 and Δ values. Determine the root mean square (rms) pulse broadening per kilometer for both fibers. [5]
- 4.(a) Planar LED is fabricated from gallium arsenide which has a refractive index of 3.6.
 - (i) Calculate the optical power emitted into air as a percentage of the internal optical power for the device when the transmission factor at the crystal-air interface is 0.50. [4]

- (ii) When the optical power generated internally is 48% of the electric power supplied, determine the external power efficiency. [4]
- (iii) Comment on the external power efficiency with respect to the internal power generated. [2]

OR

- 4.(b) i) A GaAlAs laser diode has a 500 μm cavity length which has an effective absorption coefficient of 10 cm^{-1} . The reflectivities are 0.32 and 0.63 at each end. What is the optical gain at the lasing threshold? [5]
- ii) For the above mentioned laser, if the internal quantum efficiency is 0.68, what will be the external quantum efficiency? [5]
5. Consider a Si APD operating at 300°K and with a load resistor $R_L = 1000\ \Omega$. For this APD assume the responsivity $R = 0.65\text{ A/W}$ and let $x = 0.3$.
- (i) If dark current is neglected and 100 nW of optical power falls on the photodetector, what is the optimum avalanche gain? [4]
- (ii) What is the SNR if $B_e = 100\text{ MHz}$? [2]
- (iii) How does the SNR of this APD compare with the corresponding SNR of a Si pin photodiode? Assume the leakage current is negligible. [4]
6. a) A p-i-n photodiode has a quantum efficiency of 95 % when photons of energy 1.5eV are incident upon it. [5]
- i) At what wavelength is the photodiode operating?
- ii) Calculate the incident optical power required to obtain a photocurrent of $4.5\ \mu\text{A}$.
- b) When 4.68×10^{11} photons per second each with an energy of $6.09 \times 10^{-19}\text{ J}$ are incident on an ideal photodiode, calculate: [5]
- i) the wavelength of the incident radiation;
- ii) the output photocurrent;
- iii) the output photocurrent if the device is an APD with a multiplication factor of 32.
- 7.(a) An edge-emitting LED operating at a wavelength of $1.3\ \mu\text{m}$ launches -22 dBm of optical power into a single-mode fiber pigtail. The pigtail is connected to a singlemode fiber link which exhibits an attenuation of 0.4 dB km^{-1} at this wavelength. In addition, the splice losses on the link provide an average loss of [10]

0.05 dB km⁻¹. The transmission rate of the system is 280 Mbit s⁻¹ so that the sensitivity of the *p-i-n* photodiode receiver is -35 dBm. Penalties on the link require an allowance of 1.5 dB and a safety margin of 6 dB is also specified. If the connector losses at the LED transmitter and *p-i-n* photodiode receiver are each 1 dB, calculate the unrepeated distance over which the link will operate.

OR

- 7.(b) I. An LED together with its drive circuit has a rise time of 15ns. Taking a typical LED spectral width of 40nm, the material dispersion rise time degradation is 21ns over the 6-km link. Assuming the receiver has a 25-MHZ bandwidth, [6]
- (i) Find the rise time degradation from the receiver.
 - (ii) If the fiber we select has a 400-MHz.km bandwidth-distance product and with $q=0.7$, find the modal dispersion-induced fiber rise time.
 - (iii) Calculate the total rise time of the link.
- II. Discuss in detail the major system design considerations and choice of components in designing a digital fiber optical link. [4]
8. Explain function of a polarization independent isolator with neat diagram. [10]
9. A 32 X 32 port multimode fiber transmissive star coupler has 1 mW of optical power launched into a single input port. The average measured optical power at each output port is 14 μ W. Calculate the total loss incurred by the star coupler and the average insertion loss through the device. [10]
10. a) Compare the EDFA, SOA and Raman amplifier in terms of input power, output power, gain, cross talk and application. [5]
- b) Discuss the cause for the following [5]
- i. What factors contribute to the EDFA amplifier's success?
 - ii. Interpret the limitations of the SOA amplifier.

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