Final Assessment Test (FAT) - May 2024

Programme	**B.Tech.**	Semester	**WINTER SEMESTER 2023 - 24**
Course Title	**OPTICAL FIBER COMMUNICATIONS**	Course Code	**BECE308L**
Faculty Name	**Prof. Brintha Therese A**	Slot	**C1**
		Class Nbr	**CH2023240500856**
Time	**3 Hours**	Max. Marks	**100**

General Instructions:

- Write only Register Number in the Question Paper where space is provided (right-side at the top) & do not write any other details.

List of Constants

Planck's constant $h = 6.626\times10^{-34}$ joule-hertz^{-1}

Charge of electron $q = 1.6 \times 10^{-19}$ coulombs

Boltzmann constant $k = 1.38\times10^{-23}$ J·K^{-1}

Speed of light in vacuum $c = 3\times10^{8}$ m.s^{-1}

Section - I

Answer all questions (1 X 10 Marks = 10 Marks)

01. Draw and explain the Erbium-Doped Fiber Amplifier (EDFA) with different pumping schemes. Also, write the significance of these schemes. **(8+2 marks)** [10]

Section - II

Answer all questions (6 X 15 Marks = 90 Marks)

02. a) With the help of schematic diagram of an optical fiber transmission system, explain each block and its functions. **(7 marks)** [15]

b) A typical relative refractive index difference for an optical fiber is 1%. Estimate the Numerical Aperture and solid acceptance angle in air when the core index is 1.4. Further calculate the critical angle at the core cladding interface within the fiber. **(3+2+3 marks)**

03. a) A certain optical fiber has an attenuation of 0.6 dB/km at 1300 nm and 0.3 dB/km at 1550 nm. Suppose two optical signals are launched simultaneously into the fiber: an optical power of 150 μW at 1300 nm and an optical power of 100 μW at 1550 nm. What are the power levels in μW of these two signals at (a) 8 km and (b) 20 km? **(4+4 marks)** [15]

b) An optical signal undergoes pulse broadening and distortion as it travels along the fiber. List the reasons for this effect and discuss the methods to rectify the same. **(7 marks)**

04. a) Explain in detail about Edge Emitting LED with a neat sketch. Also, compare the direct and indirect bandgap materials. **(8 marks)** [15]

b) In a GaAs laser, the gain factor (β) and loss coefficient (α) are $18\text{x}10^{-3}$ A/cm^3 and 12/cm, respectively. The laser's cavity length is 300 μm, width is 150 μm, and the reflectivity at the light-emitting region (GaAs-Air interface) is 0.4. Calculate the required threshold current for this

laser. **(7 marks)**

05. a) With a suitable diagram, elucidate the construction and working principle of RAPD with suitable expression for multiplication factor. Also, list the merits of RAPD over PIN diode. **(7 marks)** **[15]**

b) A digital optical fiber communication system operating at a wavelength of 1.3 μm requires a maximum BER of 10^{-9}.

calculate

(i) The quantum limit when the quantum efficiency of the detector is 90%.

(ii) Minimum incident optical power required at the detector in order to achieve the above BER when the system is employing ideal binary signaling at 100Mbit/s. Assume the detector is ideal. **(4+4 marks)**

06. a) An engineer has the following components, **[15]**

(i) GaAlAs laser diode operating at 850 nm and capable of coupling 1mW into a fiber.

(ii) Ten sections of cable, each of which is 500 m long, has a 4-dB/km attenuation, and has connectors on both ends.

(iii) Connector loss of 2dB/connector.

(iv) A pin photodiode receiver.

(v) An avalanche photodiode receiver.

Using these components, the engineer wishes to construct a 5-km link operating at 20 Mb/s. If the sensitivities of the PIN and APD receivers are –45 and –56 dBm, respectively, which receiver should be used if a 6-dB system operating margin is required? **(7 marks)**

b) A 90-Mb/s NRZ data transmission system that sends two DS3 (45-Mb/s) channels uses a GaAlAs laser diode that has a 1-nm spectral width. The rise time of the laser transmitter output is 2 ns. The transmission distance is 7 km over a graded-index fiber that has an 800-MHz·km bandwidth-distance product. Assume D_{mat} = 0.07 ns/(nm-km),

(i) If the receiver bandwidth is 90 MHz and the mode-mixing factor q = 0.7, what is the system rise time? Does this rise time meet the NRZ data requirement of being less than 70 percent of a pulse width?

(ii) What is the system rise time if there is no mode mixing in the 7-km link; that is, q = 1.0? **(4+4 marks)**

07. (a) With neat sketch explain about Fiber Bragg Grating (FBG) and illustrate how the grating can separate/combine individual wavelengths in an optical fiber. Also, write a brief note on dispersion compensation using FBG. **(9 marks)** **[15]**

(b) For a specified tap coupler, with an input power of 250 μW, the throughput is 230 μW, and the coupled power is 5 μW. **(2+2+2 Marks)**

calculate the (i) coupling ratio (ii) insertion losses and (iii) excess loss of the coupler.

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