I/L/TX

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Vellore Institute of Technology

Final Assessment Test – November 2024

Course: BECE308L - Optical Fiber Communications
Class NBR(s): 2779 / 2782 / 2784
Time: Three Hours
Slot: F1
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

General Instructions: Non Programmable calculator is permitted.

Answer ALL Questions
(10 X 10 = 100 Marks)

1. a) Compare step index and graded index fibres in all aspects. [5]

   b) Explain highly nonlinear fibers with their key features and applications. [5]

2. a) Find the optical input power in mW, if 39.81 mW of optical power is received from the fiber of 10-km long that has an attenuation of 0.4 dB/km at 1310 nm. [5]

   b) Discuss the concept of radiation loss in optical fibers with respect to bending of fiber in its path with appropriate diagrams. [5]

3. a) The threshold optical power for stimulated Brillouin scattering at a wavelength of 0.85 μm in a long single-mode fiber using an injection laser source with a bandwidth of 800 MHz is 127 mW. The fiber has an attenuation of 2 dB km^{-1} at this wavelength. Determine the threshold optical power for stimulated Raman scattering within the fiber at a wavelength of 0.9 μm assuming the fiber attenuation is reduced to 1.8 dB km^{-1} at this wavelength. [5]

   b) A multimode step-index fiber has a numerical aperture of 0.3 and a core refractive index of 1.45. With a material dispersion parameter of 250 psnm^{-1} km^{-1}, material dispersion is the predominant chromatic dispersion mechanism. Estimate: (a) the total root mean square (rms) pulse broadening per kilometer when the fiber is used with an LED source having an rms spectral width of 50 nm; and (b) the corresponding bandwidth-length product for the fiber. [5]

4. a) A GaAs laser operating at 850 nm has 500 μm length and a refractive index 'n' is 3.7.

   a) What will be frequency spacing and the wavelength spacing? [5]

   b) If at the half power point λ-λ_0 is 2 nm, what is the spectral width 'σ' of the gain? [5]

OR

4.b) a) The longitudinal modes of a Gallium Phosphide injection laser emitting at a wavelength of 0.89 μm are separated in frequency by 258 GHz. Determine the length of the optical cavity and the number of longitudinal modes emitted. The refractive index of gallium phosphide is 3.6. [5]

   b) If this laser diode has the above calculated optical cavity length and an effective absorption loss coefficient of 10 cm^{-1} with uncoated facets reflectivities as 0.33 at each end. What will be the optical gain at the lasing threshold? [5]

c) If one end of the laser is coated with a dielectric reflector so that its reflectivity is now 0 .62, what is the optical gain at the lasing threshold?

5. a) The diameter of the optical receiving area of Silicon p-i-n Photodiode is 0.06 cm. It is limited with an incident optical intensity of 0.2 mW/cm^2 at a wavelength of 800 nm to generate a photocurrent of 3×10^{-4} mA. What are the responsivity and the quantum efficiency of the p-i-n photodiode? [5]

b) Mention the benefits and drawbacks of APD. [5]

6. Consider an Avalanche photodiode operating with a gain of 50 and a bulk dark current of 10 nA. The surface leakage noise is 1 nA and the responsivity of the device is 0.6 A/W. The excess noise factor of the device is $M^{0.4}$ operated at 300° K with a 50 kΩ load. The noise bandwidth is 10 MHz. Calculate the signal to noise ratio in dB of this detector when irradiated with 5 nW of light.

7. a) Explain the need of isolator in optical network. Give its principle of operation. [5]

b) Write short notes on fiber grating filters. [5]

8.a) An engineer has the following components available:

(a) GaAlAs laser diode operating at 850 nm and capable of coupling 1 mW (0 dBm) into a fiber. [2]

(b) Ten sections of cable each of which is 500 m long, has a 4-dB/km attenuation, and has connectors on both ends. [2]

(c) Connector loss of 2 dB/connector. [2]

(d) A pin photodiode receiver. [2]

(e) 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? [2]

OR

8.b) An Engineer plans to design a 2.5 Gbps optical fiber link over 30 km path length. For the 30 km cable span, there is a splice with a loss of 0.1 dB at every 5 km. The Laser diode at the transmitter can launch -2 dBm of optical power into the fiber and an InGaAs APD at the receiver has a sensitivity of -32 dBm. A short jumper cable is needed at each end introducing a loss of 1.5 dB. In addition, there are 4 connectors at each fiber joint introducing a loss of 0.6 dB each. The problem of the Engineer is to determine whether he can operate the link at 1310 nm or to use the costlier 1550 nm equipment. Fiber attenuation at 1310 nm and 1550 nm are 0.6 dB/km and 0.3 dB/km respectively.

9. A 4-port multimode fiber FBT coupler has 60 μW optical power launched into port 1. The measured output powers at ports 2, 3 and 4 are 0.004, 26 and 27.5 μW respectively. Determine the excess loss, the insertion losses between the input and output ports, the crosstalk and the split ratio for the device.

10. Draw a clear diagram and describe the EDFA arrangement in co-directional, counter-directional, and dual pumping.

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