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53 (IE 703) FOLI

2021

**FIBER OPTICS AND LASER
INSTRUMENTS**

Paper : IE 703

Full Marks : 100

Time : Three hours

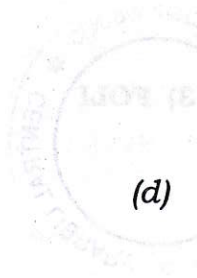
***The figures in the margin indicate
full marks for the questions.***

Answer any five questions.

1. (a) State the advantages of optical fiber communication system. 5
- (b) Define the terms — acceptance angle and numerical aperture. 4
- (c) A silica optical fiber with a core diameter large enough to be considered by ray theory analysis, has a core refractive index of 1.5 and a cladding refractive index of 1.47. Determine —
 - (i) The critical angle at the core-cladding interface

Contd.





- (ii) NA for the fiber
- (iii) Acceptance angle in air for the fiber. 6

(d) A typical relative refractive index difference for an optical fiber designed for long distance transmission is 1%. Estimate the NA and the solid acceptance angle in air for the fiber when the core index is 1.46. 5

2. (a) What are step and graded index fibers? Write and draw their refractive index profiles. 2+2+4=8

(b) What are the advantages of multimode fibers over single-mode fibers? 3

(c) A multimode step index fiber with a core diameter of $80\mu\text{m}$ and a relative refractive index difference of 1.5% is operating at a wavelength of $0.85\mu\text{m}$. If the core refractive index is 1.48, estimate —

- (i) the normalized frequency of the fiber
- (ii) the number of guided modes. 4

(d) What are Rayleigh and Mie scattering? 5



3. (a) When the mean optical power launched into an 8 km length of fiber is $120\mu\text{W}$, the mean optical power at the fiber output is $3\mu\text{W}$. Determine —

(i) the overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices

(ii) the signal attenuation per km . for the fiber

(iii) the overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km intervals each giving an attenuation of 1 dB

(iv) the numerical input/output power ratio in (iii). 8

(b) A long single-mode optical fiber has an attenuation of 0.5 dB km^{-1} when operating at a wavelength of $1.3\mu\text{m}$. The fiber core diameter is $6\mu\text{m}$ and the laser source bandwidth is 600 MHz . Compare the threshold optical powers for stimulated Brillouin and Raman scattering within the fiber at the wavelength specified. 4

- (c) Two-step indexed fiber has the following characteristics :
- (i) A core refractive index of 1.5 with a relative refractive index difference of 0.2% and an operating wavelength of $1.55\mu\text{m}$.
 - (ii) A core refractive index the same as (i) but a relative refractive index difference of 3% and an operating wavelength of $0.82\mu\text{m}$. Estimate the critical radius of curvature for both. 4+4=8
4. (a) Explain the working principle of LASER. 5
- (b) Obtain the Einstein relation of stimulated and spontaneous emission rate. 10
- (c) How three-level and four-level Laser works? Show with Energy level diagrams. 5
5. (a) What are the advantages of LED as a source for optical fiber communication system? 6
- (b) What are quantum efficiency and responsivity of an optical detector? Derive the expression for responsivity of optical detector. 2+2+6=10

- (c) When 3×10^{11} photons each with a wavelength of $0.85 \mu\text{m}$ are incident on a photodiode, on average 1.2×10^{11} electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at $0.85 \mu\text{m}$. 4

6. (a) How can optical fibers be used for the measurement of fluid level and displacement? Explain with neat diagram. 5+5=10

- (b) How is a polarization sensor used for current measurement? Explain. 10

7. (a) What is Holography? How can holograms be generated and reconstructed? 10

- (b) Write short notes on: **(any two)** 5×2=10

(i) Fiber splices

(ii) Avalanche photodiode

(iii) Population inversion.