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

(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 gradded 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 μm and a relative refractive index difference of 1·5% is operating at a wavelength of 0·85 μm. 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 Rayliegh and Mie scattering ? 5

3. *(a)* When the mean optical power launched into an $8km$ length of fiber is $120\mu W$, the mean optical power at the fiber output is $3\mu W$. 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 $10km$ optical link using the same fiber with splices at $1km$ intervals each giving an attenuation of $1dB$

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

(b) A long single-mode optical fiber has an attenuation of $0{\cdot}5\,dB\,km^{-1}$ when operating at a wavelength of $1{\cdot}3\,\mu m$. The fiber core diameter is $6\mu m$ and the laser source bandwidth is $600MHz$. 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 1·55μm.

(ii) A core refractive index the same as (i) but a relative refractive index difference of 3% and an operating wavelength of 0·82μm. 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 $3\times10''$ photons each with a wavelength of $0{\cdot}85\mu m$ are incident on a photodiode, on average $1{\cdot}2\times10''$ electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at $0{\cdot}85\mu m$. 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.
