Total number of printed pages–7

53 (IE 703) FOLI

2021

(Held in 2022)

FIBRE 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 an Optical fibre system. 5

   (b) Define the terms — acceptance angle and numerical aperture. 3

   (c) A silica optical fibre 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) the NA for the fibre

(iii) the acceptance angle in air for the fibre. 6

(d) A typical relative refractive index difference for an optical fibre designed for long distance transmission is 1%. Estimate the NA and the solid acceptance angle in air for the fibre when the core index is 1.46. Further calculate the critical at the core-cladding interface within the fibre. 6

2. (a) What are step index and graded index fibres ? Draw their refractive index profiles. 2+4=6

(b) State the advantages of multimode fibre over single-mode fibre. 3

(c) A multimode step index fibre 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 for the fibre

(ii) the number of guided modes. 4

(d) When the mean optical power launched into an 8km length of fibre is 120 μW, the mean optical power at the fibre output is 3 μW.

Determine —

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

(ii) the signal attenuation per *km* for the fibre

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

(iv) the numerical input/output power ratios in *(iii)*. 7

3. *(a)* Silica has an estimated fictive temperature of $1400K$ with an isothermal compressibility of 7×10^{-11} m^2N^{-1}. The refractive index and the photoelastic coefficient for silica are 1.46 and 0.286 respectively. Determine the theoretical attenuation in decibels per *km* due to the fundamental Rayleigh scattering in silica at optical wavelengths of 0.63, 1.00 and 1.30 μm. Boltzmann's constant is 1.381×10^{23} JK^{-1}. 8

(b) A long single-mode optical fibre has an attenuation of 1.3 μm. The fibre core diameter is 6 μm and the laser source bandwidth is 600 *MHz*. Compare the threshold optical powers for stimulated Brillouin and Raman scattering within the fibre at 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) Derive the Einstein's relation for stimulated emission rate and spontaneous emission rate. 10

(b) State the advantages of LED as source for optical fibre system. 6

(c) The radiative and non-radiative recombination lifetimes of the minority carriers in the active region of a double heterojunction LED are 60ns and 100ns respectively. Determine the total carrier recombination lifetime and the power internally generated within the device when the peak emission wavelength is 0.87 μm at a drive current of 40 mA. 4

5. (a) Derive the expression for responsivity of a photodiode. 8

(b) When 3×10^{11} photons each with a wavelength of 0.85 μm are incident on a photodiode, an 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 μm. 6

(c) A photodiode has a quantum efficiency of 65% when photons of energy $1.5 \times 10^{-19} J$ are incident upon it.

(i) At what wavelength is the photodiode operating ?

(ii) Calculate the incident optical power required to obtain a photocurrent of $2.5 \mu A$ when the photodiode is operating as described above. 6

6. (a) Explain the measurement technique for water level and displacement using optical fibres. 10

(b) What are polarization sensor ? How can current be measured by optical fibre using the technique modulation of polarization ? 10

7. Write short notes on : 10×2=20

(a) Holography

(b) Fibre splices.
