Name : ……………………………………………………………

Roll No. : ……………………………………………………………

Invigilator's Signature : ……………………………………

CS/M.TECH (ECE)/SEM-2/MEC-2001/2010
2010
PHOTONICS AND OPTICAL COMMUNICATION

Time Allotted : 3 Hours   Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer Question No. 1 which is compulsory and any *four* from the rest.

1. Indicate the correct choice of each of the following questions with a brief justification of the choice.   5 × 2 = 10

    a) A step-index fibre with fused silica core (n_1 = 1·458) and cladding (n_2 = 1·457) has a core diameter of 20 μm. At λ = 1·3 μm, the fibre behaves like (*A*) single mode, or *(B)* multi-mode. At λ = 0·82 μm, the same fibre behaves like *(C)* multi-mode or *(D)* single-mode. Indicate the correct combination from the following :

        i)   *(A)* and *(C)*

        ii)   *(B)* and *(D)*

        iii) *(C)* and *(B)*

        iv)   *(A)* and *(D)* .

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b) In a multi-mode step-index optical fibre, the higher modes propagate within the fibre with

  i) lower group velocity than the lower order modes

  ii) higher group velocity than the lower order modes

  iii) same group velocity as that of lower order modes

  iv) Random group velocity.

c) Which of the following fibres are suitable for wavelength-division multiplexing of optical signals ?

  i) Dispersion-optimized

  ii) Dispersion-shifted

  iii) Dispersion-flattened

  iv) Dispersion-compensated.

d) An LED with an external quantum efficiency of $0 \cdot 012$ is coupled to an optical fibre of $NA = 0 \cdot 15$ [with air in between them]. The overall source-fibre coupling efficiency is

  i) $1 \cdot 8 \times 10^{-4}$

  ii) $2 \cdot 7 \times 10^{-4}$

  iii) $3 \cdot 2 \times 10^{-4}$

  iv) $7 \cdot 8 \times 10^{-3}$.

e) The material more suitable for making a p-n junction diode is

  i) a direct band gap semiconductor

  ii) an indirect band gap semiconductor

  iii) a good conductor

  iv) a good dielectric.

2. a) Mention and discuss in detail the various mechanisms of attenuation creation in an optical fibre. 5

b) With a neat sketch, show the variation of attenuation with signal wavelength. Explain the significance of the diagram in the design of an optical fibre. 2 + 3

c) A certain optical fibre of length 3·5 dB/km is operating at 850 nm. If 0·5 mW of optical power is initially launched into fibre, find the level of power in mW and dBm available at the output end of the fibre at a distance of 4 km. 5

3. a) Establish, in terms of relevant parameters, the relation between the V-number and the total number of propagating modes within a graded-index optical fibre. For single-mode propagation, obtain the limiting value of the normalized frequency for the fibre. 8

b) A graded-index fibre having a parabolic profile supports 700 propagating modes. The relative refractive index difference of the fibre is 2%. The core is made up of a material with a refractive index of 1·45 and the core has a diameter of 75 μm. Find the operating wavelength of the signal. 7

4. a) Define and explain what is meant by chromatic dispersion in a single-mode optical fibre. Spell out the factors affecting the value of the chromatic dispersion. Discuss how it depends on the wavelength. 3 + 3 + 2

b) A step-index single-mode fibre exhibits waveguide dispersion of 6 ps nm^{-1} km^{-1} at the operating wavelength of 1·55 μm. Find the value of $| d^2 n/d\lambda^2 |$ of the fibre material, if the zero dispersion is made to occur right at the operating wavelength. 7

5. a) Explain what is meant by birefringence and beat length of a single-mode fibre. 5

    b) Elucidate the effects of modal birefringence on light-pulse propagation in a single-mode fibre. 5

    c) The modal birefringence of a typical single-mode fibre is in the range of 10^{-6} – 10^{-5}. Obtain (i) the range of $\delta\beta$, when the fibre is operating at $\lambda = 1\cdot3$ μm and (ii) the range of the corresponding beat lengths. 5

6. a) Explain, with the help of a neat diagram, the process of modulation using directional couplers considering co-directional and contra-directional cases. 8

    b) The major requirements for a source in optical fibre communication system are normally fulfilled by ILDs and LEDs. Discuss. 7

7. a) The avalanche photodiode and the photo-conducting detector both provide gain. Compare their merits for use in optical communication applications. 7

    b) An APD has quantum efficiency of 50% at $1\cdot3$ μm. When illuminated with optical power of $0\cdot4$ μW at this wavelength, it produces an output photocurrent of 8 μA, after avalanche gain. Calculate the multiplication factor of the diode. 8

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