53 (IE 703) FOLI

2019

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)* What does index of refraction measure? 1

(b) How is a skew ray different from a meridional ray? 3

(c) Define Numerical Aperture of a fiber. On what factors it depends? 3

(d) Define the relative refractive index difference for an optical fiber and show how it may be related to the numerical aperture. 3

Contd.

(e) What are the photon energies in electron volts (eV) of light at wavelengths 0·88, 1·3 and 1·55μm? 3

(f) Calculate the transmission distance over which the optical power will attenuate by a factor of 10 for fiber with loss of 20dB/km. 3

(g) How would you classify optical fiber based on the variations in the composition of core material? 4

2. (a) Define the terms : Phase and Group velocity. 3

(b) State the merits and demerits of single-mode fiber. 3

(c) Name the *five* different types of intrinsic losses that appear in a fiber joint. 5

(d) Explain the mechanism that causes distortion of pulses in an optical fiber. 3

(e) A fiber optic link of length 50km has a rated 0·2dB/km loss. The maximum power required to run the photodector is 20nW. What power must be supplied by a source? 3

(f) A p-n photodiode has a quantum efficiency of 70% for photons of energy $1{\cdot}52\times10^{-19}J$.
Calculate :

(i) The wavelength at which the diode is operating

(ii) The responsivity of the photodiode. 3

3. (a) Define normalized frequency of an optical fiber and explain its use in the determination of the no. of guided modes propagation along a fiber. 3

(b) What can be done to minimize bending loss in optical fiber? 2

(c) State the different categories of reflection with suitable examples. 3

(d) An SI fiber has an NA of 0·18 and a cladding RI of 1·46. Determine :

(i) The acceptance angle of the fiber when it is placed in water (RI_{water} = 1·33)

(ii) The critical angle at core cladding interface. 4

(e) What is the difference in mode travel times for a fiber with a core index of 1·5 and *V*-number of 120? 3

(f) State the differences between a splice and a connector. 3

(g) What is the function of the intrinsic layer in a PIN? 2

4. (a) State and describe the basic components of a Laser. 6

(b) What are the differences in characteristics between a PIN and APD detector? 4

(c) Differentiate between spontaneous and stimulated emission with neat diagrams. 5

(d) The data for two LEDs are given below and if one from these has to be chosen as a source for a fiber optic system with the given requirements, which LED would be your choice? 5

LED characteristics

Parameter	LED1	LED2
O/P power	1*mW*	2*mW*
Rise time	1*ns*	10*ns*
NA	1·10	1·70
Supply voltage	2·3V	3V
Forward currents	10*mA*	50*mA*

System requirements

*Bandwidth = 20*MHz*

* O/P power of 10μW after 1·5*km* (loss of 3*dB/km*)

* Electric power : 1 Watt

* Fiber NA : 1·2

5. (a) Describe the main components of a LIDAR system. Also make a comparison between LIDAR and RADAR. 4+4=8

(b) State the differences between intrinsic and extrinsic fiber optic sensors with suitable examples. 5

(c) List out the properties of LASER compared to ordinary light. 4

(d) Why we prefer 4-level LASER over 3-level LASER? 3

6. *(a)* A 4-port directional coupler has 4 : 1 splitting ratio and excess loss equals to 18*dB*, directionality equals to 12*dB*. 5

(i) What fraction of input power goes to each of the port ?

(ii) Compute the loss due to radiation and scattering.

(b) With suitable diagram, explain the operation of *He-Ne* LASER. 5

(c) State few applications of directional coupler. 3

(d) List out the features of Nd : YAG laser compared to ruby laser. 5

(e) Define the term : Dark current noise. 2

7. *(a)* What is Sagnac effect ? Explain the working principle of Fiber optic gyroscope. 6

(b) List out the differences between a Photograph and a Hologram. Explain the process of recording and reconstruction of a transmission hologram. 4+6=10

(c) With the help of a neat diagram, explain how the Laser Doppler Velocimeter (LDV) can be used for measurement of fluid velocities. 4

8. Write short notes on : ***(any four)*** 5×4=20

- Ruby Laser
- Mode locking
- Fiber optic current sensor
- Quantum efficiency
- Population inversion.