2023

UIE603: Optical Fiber and Optoelectronics

Full Marks: 100

Time: Three hours

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

*Answer **any five** questions.*

1. a) Match the Column A with Column B   5

   Column A   **Column B**

   i) Bragg wavelength is dependent on   a) a few hundreds of micrometers

   ii) FBGs have the spatial period of the modulation   b) about 10 meters

   iii) LPGs have spatial periods of refractive index modulation of   c) grating period and effective refractive index

   iv) Doppler anemometers, noncontact vibration measurement, and pressure sensors   d) about half a micrometer

   v) LiFi Coverage distance   e) extrinsic sensors

   b) Fill in the blanks with the correct answer: 5

   i) The loss of optical power as light travels along a fiber is called_____ (*dispersion/scattering/attenuation/absorption*)

   ii) The most common two types of optical detectors are_____ (*LEDs and APDs/ PIN diodes and APDs/ APDs and laser diodes/ Laser diodes and PIN diodes*)

   iii) System performance is affected most by _____ of the fiber properties. (*Core diameter and cladding/ Attenuation and dispersion/ Core diameter and NA/ NA and delta*)

   iv) The speed of light in the fiber is _____compared to the speed of light in the air. (*slower/ same/ faster*)

   v) The refractive index vary_____in Graded Index fiber. (*Tangentially/ Radially/ Longitudinally/ Transversely*)

c) Mention any five advantages of fiber optic sensors. 5

d) A step index fiber in air has a numerical aperture of 0.16, a core refractive index of 1.45 and a core diameter of 60 μm. Determine the normalized frequency for the fiber when light at a wavelength of 0.9 μm is transmitted. Further, estimate the number of guided modes propagating in the fiber. 5

2. a) Outline the benefits and drawbacks of laser surgery. 5

b) List a variety LIDAR applications. 5

c) How can fluid velocity be measured using a LASER Doppler Velocimetry (LDV)? Explain. 6

d) Compare the differences between LIDAR and RADAR. 4

3. a) Evaluate the distinctions between photography and holography. 5

b) Transmission holograms and reflection holograms; describe the distinctions that exist between them. 6

c) What exactly are surface plasmons (SP)? Describe a typical Surface Plasmon Resonance (SPR) sensor arrangement using fiber optics. 7

d) What distinguishes a PIN from an APD? 2

4. a) List the analytes that can be measured using evanescent field absorption sensors. 4

b) An FBG sensor reflects signals with a wavelength of 1562 nm. If the core of the fiber has a mean value index of refraction n = 1.500, what is the periodic spacing (Λ) of the spatial variation in the index of refraction of this FBG? 3

c) A fiber optic current sensor is having 30 turns of fiber wound around a current-carrying conductor, for a current of 10 A determine the angle of rotation of the plane of polarization. (Given the Verdet constant value (for silica) is 2.64× 10 −4 degree/A. 4

d) Using a schematic illustration, explain how the Fibre Mach-Zehnder interferometer (MZI) enables fiber-optic sensing applications for measurements of temperature, stress, and strain. 9

5. a) In a multimode parabolic index fiber having a core radius of 50 μm, and Δ = 0.2. Now calculate the periodic spacing (Λ) required for maximum coupling in the fiber due to micro bending. 3

b) When the mean optical power launched into an 8 km length of fiber is 120 μW, the mean optical power at the fiber output is 3 μW. **5**

Determine:

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

(b) The signal attenuation per kilometre for the fiber.

c) A light source with a bandwidth of 100 GHz is injected into a 3-km fiber. If the pulse injected has a width of 20 ms and the bandwidth length product of the fiber is 100 kHz-km, what is the pulse width at the exit end of the fiber? **3**

d) What operational characteristics of optical sources would affect the dispersion loss in an optical fiber? **2**

e) List the terms that might be used to describe the noise and sensitivity of a detector. **5**

f) If you had to choose a detector for a computer network (short distance communications), which detector would you choose? Why? **2**

6. a) Explain why a 4-level laser is more efficient than a 3-level laser. **5**

b) A four port coupler has 60μw optical power launched into port-1. The measured output powers at ports 2, 3 and 4 are 0.004, 26.0 and 27.5 μw respectively. Determine the excess loss, the insertion losses between the input and output ports, the crosstalk and the split ration of the device. **4**

c) Reflection is categorized into three types: Fresnel, specular, and diffuse. Define each of them. **3**

d) Calculate the difference in time per meter between a long mode and a short mode in a fiber (10 m long) with a V number of 23 and a core index of 1.46. **3**

e) Make a comparison between Step Index and Graded Index Fibres **5**

7. Write short notes on *any four* of the following **5x4=20**

a) FBG sensor

b) LASER Distance Meter

c) Reagent mediated fiber optic sensor

d) Fiber optic rotation sensor/fiber optic gyroscope

e) Micro-bend hydrocarbon sensor