B.E. Electronics and Telecommunication Engineering Examination-2022
(4th Year 2nd Semester)
Optical Fiber Communication

Time: 4 Hours **Full Marks: 70**

Answer Question no. 1 and any two from each group
Answer all the parts of a question in the same place

1. Choose the correct answer (10×1)

i) The common windows used in fiber-optic communications are centered on wavelengths of
   a) 850 nm, 1500 nm and 1300 nm
   b) 1310 nm, 1550 nm and 850 nm
   c) 1350 nm, 1500 nm and 810 nm
   d) 800 nm, 1300 nm and 1500 nm

ii) Which type of fiber cable offers lowest dispersion?
   a) Single-mode step index
   b) Multi-mode step index
   c) Multi-mode graded index
   d) None of these

iii) Which type of detector has internal gain mechanism?
   a) pn-photodiode
   b) PIN-photodiode
   c) Avalanche photodiode
   d) Photovoltaic detector

iv) A single-mode fiber has material dispersion of 20 ps/nm-km and waveguide dispersion of -15 ps/nm-km at a specific wavelength. Then the amount total chromatic dispersion is
   a) 35 ps/nm-km
   b) -35 ps/nm-km
   c) 5 ps/nm-km
   d) -5 ps/nm-km

v) In single-mode fibers, how does the fraction of energy traveling through bound mode appear in the cladding?
   a) As a crescent wave
   b) As a gibbous wave
   c) As an evanescent wave
   d) All of the above

vi) In Kerr effect, refractive index changes in proportion to
   a) Square of electric field
   b) Cube of electric field
   c) Cube root of electric field
   d) One-fourth power of electric field

vii) Which kind of dispersion phenomenon gives rise to pulse spreading in single mode fibers?
   a) Intramodal
   b) Intermodal
   c) Material
   d) Group Velocity

viii) Optical solitons are pulses which propagate through the fiber without showing any variation in
   a) Amplitude
   b) Velocity
   c) Shape
   d) All of the above

ix) In stimulated emission, which among the following parameters of generated photons is/are similar to the incident photon
   a) Phase
   b) Frequency
   c) Polarization
   d) All of the above

x) In a LASER structure, the existence of standing wave is possible at frequencies for which the distance between mirrors is an integral number of
   a) $\lambda/4$
   b) $\lambda/2$
   c) λ
   d) 2λ

Group-A

2. a) Write the desirable characteristics of an optical source.
   b) Why three and four levels LASER are preferable compared to two level LASER?
   c) A GaAs injection LASER has an optical cavity of length 250 μm and width 100 μm. At normal operating temperature the gain factor is 21×10^{-3} A/cm^3 and loss coefficient per cm is 10. Determine the threshold current density and hence threshold current for the device. It may be assumed that cleaved mirrors are uncoated and the current is restricted to the optical cavity. The refractive index of GaAs may be taken as 3.6.

(2+3+5)

3. a) Explain the working principle of an Erbium doped fiber amplifier (EDFA) and derive an expression for power conversion efficiency and gain of an EDFA.
   b) For an erbium-doped fiber amplifier what should be the minimum pump power required to obtain 12 dBm output at 1540 nm, if the amplifier input is 0 dBm and pump wavelength is 980 nm.

(8+2)

4. a) What do you mean by active optical component and polarization independent optical component? Give an example for each case.
   b) Describe the working principle of fused fiber coupler with a neat sketch.
   c) A (2×2) biconical tapered fiber coupler has an input optical power level of $P_0 = 200$ μW. The output power at the other three ports are $P_1 = 90$ μW, $P_2 = 85$ μW and $P_3 = 6.3$ nW. Find i) Coupling ratio ii) insertion losses (in dB) and iii) return loss (in dB)

(3+4+3)

Group-B

5. a) Derive an expression for waveguide dispersion in a step index single mode fiber.
   b) A step index single mode fiber has a core refractive index of 1.45, relative refractive index difference of 0.3% and core diameter of 8.2 μm. Calculate the waveguide dispersion for the given fiber at wavelength (λ) = 1300 nm.

(6+4)

6. a) Derive an expression for the rms pulse broadening at the fiber output due to intermodal dispersion of a multimode step index fiber.
   b) A 6 km optical link consists of multimode step index fiber with core refractive index of 1.5 and a relative refractive index difference of 1%. Estimate the delay difference between the slowest and fastest modes at the fiber output. Also calculate the rms pulse broadening due to intermodal dispersion in the link.

(6+4)

7. a) What do you mean by cross phase modulation? Explain the working principle of four wave mixing.
   b) A step-index fiber has a core radius of 8 μm, core and cladding refractive indices are 1.458 and 1.44 respectively. Calculate the V-number if the operating wavelength is 1300 nm. What must be the radius of the fiber, if the fiber must be operated as a single mode fiber at 1500 nm with same refractive indices?

(6+4)

Group-C

8. a) How electrical bandwidth and optical bandwidth are related?
   b) Considering following specifications, calculate the system rise time and maximum allowable bit rate when data is encoded into NRZ format.
      i) LED source with drive circuit has a rise time 15 ns
      ii) Material dispersion related rise time degradation of 21 ns over 6 km link
      iii) Receiver has a 25 MHz electrical bandwidth
      iv) Fiber has 400 MHz.km bandwidth-distance product with q = 0.7
   c) Write the difference between direct and indirect modulation.

(1+6+3)

9. a) Write the steps for designing an optical fiber communication link from system requirements.
   b) Calculate the maximum transmission distance for a 1300 nm light wave system operating at 100 Mb/s and using an LED for launching 0.1 mW of average power into the fiber. Assume 1 dB/km loss, 0.2 dB splice at every 2 km, 1 dB connector loss at each end of the fiber link, 100 nW receiver sensitivity and 6 dB system margin.

(5+5)

10. a) What do you mean by quantum noise? Explain the effect of quantum noise in digital optical link.
    b) Draw a neat block schematic of a DWDM system.
    c) Write the importance of MEMS technology in optical fiber communication.

(5+3+2)