B.E. Electronics and Telecommunication Engineering Examination-2019
(4th Year 2nd Semester)
Optical Fiber Communication

Time: 3 Hours **Full Marks: 100**

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

1. a) Describe the construction of a fiber optic cable.
   b) Explain the propagation of optical signal through a step index multi-mode optical fiber using simple ray theory concept.
   c) How attenuation and dispersion affect the communication through an optical fiber?

(3+3+4)

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) Derive an expression for threshold current density for stimulated emission in a semiconductor LASER.
   d) 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.

(4+2+5+4)

3. a) Write the basic principle of a semiconductor optical amplifier.
   b) Describe common applications of optical amplifiers with neat sketches.
   c) 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.

(4+8+3)

4. a) Explain the working principle of optoelectronic wavelength converter.
   b) Describe the principle of fused fiber coupler with a neat sketch.

[Turn over

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)

d) Write the basic principle of an optical multiplexer.

(4+5+4+2)

Group-B

5. a) Explain different types of dispersion in brief.
   b) Derive an expression for waveguide dispersion in a step index single mode fiber.
   c) 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.

(4+7+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.
   c) Explain the chirping effect due to self phase modulation.

(7+4+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. How many modes will be supported in the fiber? 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?
   c) Briefly explain the linear scattering losses in an optical fiber.

(6+5+4)

Group-C

8. a) Derive an expression for total system rise time of an optical fiber link.
   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) How electrical bandwidth and optical bandwidth are related?

(8+5+2)

9. a) Describe different architectures in fiber optic systems.
   b) Write the steps for designing an optical fiber communication link from system requirements.
   c) 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+5)

10. a) What do you mean by quantum noise? Explain the effect of quantum noise in digital optical link.
    b) With a neat block schematic explain the operation of a DWDM system.
    c) What do you mean by direct modulation?
    d) Describe the working principle of a modulator for long-haul and high speed optical communication link.

(5+4+2+4)