# BETCE Examination, 2018
## (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) Explain the propagation of optical signal through a graded index optical fiber with parabolic refractive index profile.
   b) For a step index optical fiber having core refractive index 1.5 and cladding refractive index 1.45. Calculate critical angle and acceptance angle.

(6+4)

### Group-A

2. a) Write the advantages and disadvantages of a LASER over LED as an optical source.
   b) Calculate the source to fiber coupling efficiency considering a Lambertian source and step index optical fiber.
   c) The light output from a GaAs LED is coupled into a step index fiber having numerical aperture of 0.22 and core refractive index of 1.42. Calculate coupling efficiency and optical power loss in dB.

(5+6+4)

3. a) Describe the working principle of an Erbium-doped fiber amplifier (EDFA).
   b) Derive the expression for power conversion efficiency and gain of an EDFA.
   c) A semiconductor optical amplifier has an active area width 3μm, thickness 0.3 μm, length 500 μm, confinement factor 0.3, time constant 1ns, gain coefficient $2\times10^{-20}$ $m^2$, threshold carrier density $1.0\times10^{24}$ $m^{-3}$. Find
      i) Pumping rate for the semiconductor optical amplifier
      ii) Zero signal gain

(4+6+5)

4. a) Derive an expression for numerical aperture for a step index fiber using ray diagram.
   b) Estimate the maximum core diameter for an optical fiber with refractive index difference 1.6% and core refractive index of 1.48, in order to make it suitable for single mode operation for an operating wavelength 900 nm and V number 2.405.
   c) With a neat diagram explain the working principle of an optical isolator

(6+4+5)

## Group-B

5. a) Explain two different types of nonlinear scattering losses in an optical fiber.
   b) What do you mean by self phase modulation? How it is employed in optical solitons?
   c) A multimode graded index fiber exhibits total pulse broadening of 0.1μs over a distance of 15 km. Estimate
      i) The maximum possible bandwidth on the link assuming no inter-symbol interference.
      ii) Bandwidth length product for the fiber.

(6+6+3)

6. a) What do you mean by intramodal dispersion?
   b) Derive an expression for material dispersion.
   c) A step index single mode fiber exhibits material dispersion of 6 ps/nm-km at an operating wavelength of 1550 nm. If core refractive index is 1.45 and refractive index difference is 0.5%, then calculate the core diameter of the fiber to make total dispersion zero at operating wavelength.

(3+6+6)

7. a) Describe the loss due to bending in an optical fiber.
   b) Calculate the critical radius of curvature at which large bending losses occur in a multimode fiber with core refractive index of 1.5, relative refractive index difference of 3% and an operating wavelength of 820 nm.
   c) Explain the basic principle of polarization mode dispersion.

(7+4+4)

## Group-C

8. a) Derive an analytical expression for dispersion equalization penalty for a Gaussian shaped pulse.
   b) Write the expression for power budget of an optical fiber link and also explain each term.
   c) Calculate the maximum possible link length with and without dispersion equalization for a long haul single mode optical fiber system operating at a wavelength of 1300 nm. Specifications of the link are as follows.

   Mean power launched from the laser transmitter is -3dBm, Cable fiber loss is 0.4 dB/km, Splice loss 0.1 dB/km, Connector loss at the transmitter and receiver is 1 dB each, Mean power required at APD receiver when operating at 400 Mbps with BER $10^{-9}$ is -44 dBm, Required safety margin is 7 dB, Dispersion equalization penalty is 1.5dB.

(4+4+7)

9. a) Draw a block schematic for an analog optical fiber system employing direct intensity modulation and explain its operation.
   b) Explain three types of noises in an optical receiver. Calculate r.m.s. value of signal to noise ratio for a system mentioned above with an APD receiver.

(7+8)

10. a) With a neat block schematic explain the operation of a WDM system.
    b) Write the differences between CWDM and DWDM.
    c) A digital optical fiber communication system operating at a wavelength of 1000 nm requires a maximum bit error rate of $10^{-9}$. Determine
       i) The theoretical quantum limit at the receiver in terms of quantum efficiency of the detector and the energy of an incident photon.
       ii) The minimum incident optical power in dBm is required at an ideal detector in order to achieve same performance when system is employing ideal binary signaling at 10 Mbps.

(5+3+7)