Registration No : | | | | | | | | | | |

Total Number of Pages : 03 **B.Tech**

PET7J008

7th Semester Regular Examination 2018-19
OPTICAL COMMUNICATION NETWORKING
BRANCH : ECE, ETC
Time : 3 Hours
Max Marks : 100
Q.CODE : E177

Answer Question No.1 (Part-1) which is compulsory, any EIGHT from Part-II and any TWO from Part-III.
The figures in the right hand margin indicate marks.

Part- I

Q1 **Short Answer Type Questions (Answer All-10)** **(2 x 10)**

a) Why silicon is not used to fabricate LED or laser diode?

b) A beat length of 15 cm is observed in a typical single mode fiber, when light of 1 μm is launched into it. Calculate the modal birefringence.

c) Define MFD.? How it is related to V parameter?

d) What is Rayleigh scattering? Mention the factors that cause Scattering losses.

e) A step index single mode fiber has a core index of 1.48,relative refractive index difference of 0.27%, and a core radius of 4.5 μm. Estimate the waveguide dispersion for this fiber at λ=1.31μm.

f) Two compatible multimode fibers are jointed with small air gap. The fiber axes and end faces are perfectly aligned. Determine the refractive index of the fiber core if the joint is showing a loss of 0.47 dB.

g) Compare and contrast between surface and edge emitting LEDs.

h) A p-n photodiode has quantum efficiency of 50 % at λ=0.92μm.Calculate the responsivity at this wavelength.

i) A digital fiber optic link operating at 1420 nm, requires a maximum BER of 10^{-8}.Calculate the required averaged photons per pulse.

j) Write the fundamental difference between attenuation and dispersion. What are the methods for the measurement of attenuation of fiber?

Part- II

Q2 **Focused-Short Answer Type Questions- (Answer Any EIGHT out of TWELVE)** **(6 x 8)**

a) How skew rays differ from meridional rays? Explain TIR, acceptance cone with respect to skew rays. Deduce an expression for the numerical aperture for a skew ray.

b) Derive the expression for the wave equation of an electromagnetic wave propagating through optical fiber using Maxwell's equation.

c) Define the normalized frequency for an optical fiber and explain its use in the determination of the number of guided modes propagating within a step index fiber.
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 50 μm. Determine the normalized frequency for the fiber when light at a wavelength of 0.95 μm is transmitted. Further, estimate the number of guided modes propagating in the fiber.

d) Compare stimulated Brillouin and stimulated Raman scattering in optical fibers, and indicate the way in which they may be avoided in optical fiber communications.

The threshold optical powers for stimulated Brillouin and Raman scattering in a single-mode fiber with a long 8 μm core diameter are found to be 190 mW and 1.70 W, respectively, when using an injection laser source with a bandwidth of 1 GHz. Calculate the operating wavelength of the laser and the attenuation in decibels per kilometer of the fiber at this wavelength.

e) A 10 km optical link consists of multimode step index fiber with a core refractive index of 1.48 and a relative refractive index difference of 1%. Estimate,

i. The delay difference between the slowest and fastest modes at the fiber output;
ii. The rms pulse broadening due to intermodal dispersion on the link;
iii. The maximum bit rate that may be obtained without substantial errors on the link assuming only intermodal dispersion;
iv. The bandwidth–length product corresponding to (c).

f) The measured optical output powers from ports 3 and 4 of a multimode fiber FBT coupler are 45.0 μW and 50.0 μW respectively. If the excess loss specified for the device is 0.6 dB, calculate the amount of optical power that is launched into port 1 in order to obtain these output power levels. Hence, determine the insertion losses between the input and two output ports, as well as the split ratio for the device. When the specified crosstalk for the coupler is −45 dB, calculate the optical output power level that would be measured at port 2 when the above input power level is maintained.

g) With suitable schematic diagram explain the distributed feedback laser in comparison with the Fabry–Pérot laser.

h) Explain the concept of quantum-dot and quantum wire lasers and describe their operation in comparison with conventional injection laser diodes.

i) Derive expressions for the SNR of both PIN and APD considering all noise sources.

j) A digital optical fiber communication system operating at a wavelength of 1 μm requires a maximum bit-error-rate of 10^{-10}. Determine:

i. The theoretical quantum limit at the receiver in terms of the quantum efficiency of the detector and the energy of an incident photon;
ii. The minimum incident optical power required at the detector in order to achieve the above bit-error-rate when the system is employing ideal binary signaling at 10 Mbit s^{-1}, and assuming the detector is ideal.

k) A silicon p–i–n photodiode has a quantum efficiency of 65% at a wavelength of 0.8 μm. Determine:

i. The mean photocurrent when the detector is illuminated at a wavelength of 0.8 μm with 5 μW of optical power
ii. The rms quantum noise current in a post-detection bandwidth of 20 MHz
iii. The SNR in dB, when the mean photocurrent is the signal.

l) Discuss with the aid of suitable diagrams the measurement of dispersion in optical fibers. Consider both time and frequency domain measurement techniques. Pulse dispersion measurements are taken on a multimode graded index fiber in the time domain. The 3 dB width of the optical output pulses from a 950 m fiber length is 827 ps. When the fiber is cut back to a 2 m length the 3 dB width of the optical output pulses becomes 234 ps. Determine the optical bandwidth for a kilometer length of the fiber assuming Gaussian pulse shapes

Part-III
Long Answer Type Questions (Answer Any TWO out of FOUR)

Q3 **a)** Explain the concept of electromagnetic modes in relation to a planar optical waveguide. Discuss the modifications that may be made to electromagnetic mode theory in a planar waveguide in order to describe optical propagation in a cylindrical fiber. **(8)**

b) Describe single mode fiber and their mode field diameter. What are the propagation modes in them? **(8)**

Q4 Explain in detail attenuation mechanism in optical fiber communication using relevant schematic diagram. **(16)**

Q5 With suitable diagram explain the structure of surface and edge emitter LED. **(16)**

Q6 Describe the optical receiver operation and its performance using appropriate diagram. **(16)**