25 G TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Outline the advantages of optical fiber communication system and it's applications. Explain the evolution of the Optical Communication technology. [2+2+3]
   b) What are the different types of Optical fiber used in the communication system? [4]
2. a) Explain Goos Haenchen Shift. Derivation and explain the significance of the wave equation for a Dielectric slab waveguide of infinite depth consisting of a slab of dielectric material of width 'd' of refractive index, η_1 embedded in a material having refractive index, η_2. [2+6]
   b) Calculate the normalized frequency at 820 nm for a step-index fibre having 25 μm core radius, n_1 equal to 1.48 and n_2 equal to 1.46.
   (i) How many modes propagate in this fibre at 820 nm?
   (ii) How many modes propagate in this fibre at 1320 nm?
   (iii)What percentage of this optical power flows in the cladding in each case? [3]
3. a) What is the significance of profile parameter in graded index fiber? [2]
   b) Derive and explain the relation between bandwidth and numerical aperture in a Multi mode step index fiber due to dispersion. [4]
4. a) What is optical modulation? Compare D-IM and Subcarrier IM. [2+4]
   b) Estimate the external power efficiency of a GaAs planar LED when the transmission factor of the GaAs-air interface is 0.68 and the internally generated optical power is 30% of the electric power supplied. The refractive index of GaAs may be taken as 3.6. [4]
5. a) Explain Optical Couplers and it's types? How FBT Technology is used to manufacture Star Coupler? [3+3]
   b) A step index fiber with a 200μm core diameter is butt jointed. The joint which is index matched has a lateral offset of 10μm but no longitudinal or angular misalignment. Determine the loss due to this type of misalignment. [3]
   c) What are the performance parameters of a good optical detectors. [3]
6. a) For Silica the fictive tempersature (T_f) is 1400K, the isothermal compressibility (β_T) is $6.8*10^{-11} m^2/N$, and the photo-elastic coefficient is 0.286. Estimate the scattering loss at 1.3μm wavelength where n = 1.45. [3]
   b) What is Optical Amplifiers? Explain the working principle of EDFA. Using energy level diagram explain the significance of metastable level. [2+5]

7. a) Explain the working principal of Distributed feedback Laser. Why it is preferred by the telecom companies? [3+2]

   b) Explain the importance of link budget analysis in optical communication system. Define Dispersion penalty. [2+2]

8. a) Find the total system loss and excess margin where 9 splices and 2 connectors are used.

Fiber Cable Loss	Splice Loss	Connector Loss	Safety Margin
3-dB/km	0.3 dB/ splice	1 dB/connector	7 dB

   A typical operating power budget over 8-km of multimode graded index fiber at wavelength of 0.85-μm, mean power launched from laser transmitter is -4.5dB and APD receiver sensitivity is -48 dBm. [6]

   b) Explain different components of FTTH network. What are the different standards of Passive Optical Network? [3+2]

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INSTITUTE OF ENGINEERING
Examination Control Division
2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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1. a) Explain different components of optical fiber communication system with block diagram and list the advantages of optical fiber communication. [2+2]
   b) Explain in detail about cutoff wavelength and normalized frequency? Also write the significance of each. [2+2]
2. a) What is the difference between phase velocity and group velocity? Elaborate with examples. [4]
   b) Find the maximum diameter of a signal mode fiber designed to carry a signal of wavelength 1.3 μ m if the index of refraction of the core of the fiber is 1.55 and the index of refraction of the cladding of the fiber is 1.52. [3]
3. a) Describe the major causes of attenuation in optical fiber. Illustrate the transparent windows in optical fiber with major peak transparent wavelength in fiber. Describe its impact in transmission systems. [3+2+2]
   b) Compare meridional rays and skew rays with necessary sketch. [4]
4. a) Explain Modulation bandwidth in terms of electrical and optical bandwidth. [4]
   b) Explain quantum efficiency and responsively along with their mathematical relationship. [6]
5. a) What are the property of light which are used in optical modulation? Explain in detail about direct intensity modulation. [2+5]
   b) Explain in detail about the procedure of fusion splicing? What are the advantages and disadvantages associated with fusion splicing? [4+2]
6. a) Write the difference between linear and non-linear scattering. Also explain its type. [5]
   b) A glass fiber has the material dispersion parameter value 98.1 $psnm^{-1}km^{-1}$. Estimate the pulse broadening per kilometer for the fiber operating at 0.85 μm wave length given that relative spectral width of injection laser ($6\lambda/\lambda$) is 0.0012. [4]
7. a) Explain in detail about Dense Wave Division Multiplexing technology. Write the advantages. [6]
   b) A 15 km optical fiber link uses fiber with a loss of 1.5dB km^{-1}. The fiber is jointed every kilometer with connectors which give an attenuation of 0.8dB each. Determine the minimum mean optical power which must be launched into the fiber in order to maintain a mean optical power level of 0.3μw at detector. [4]
8. An optical fiber system is to operate at 622 Mbps over a distance of 65 km without repeaters. Fiber with a loss of 0.23 dB/km and a dispersion of 5.5 ps/km is available in maximum lengths of 1 km. The fusion spice loss is 0.035dB/splice and repair power margin is 5 dB. If the receiver sensitivity is -28 dBm and the transmitter output power is +1dBm, determine the maximum allowable attenuation which can be tolerated during installation. If a system upgrade to operation at 1.2 Gbits/sec is required, is the fiber link acceptable? [12]

35 G TRIBHUVAN UNIVERSITY
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Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCT, BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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1. Explain different components of an optical fiber communication system with a block diagram. [3]
2. What is a material absorption loss? What are the causes of absorption of light in optical fiber? [1+2]
3. Explain Goos-Haenchen shift. For a TE mode wave propagation, derive the wave equation for a Dielectric slab waveguide of infinite depth consisting of a slab of dielectric material of width 'd' of refractive index, η_1 embedded in a material having refractive index, η_2. [2+7]
4. A multimode step index fiber with a core diameter of 80 μm and a relative index difference of 1.5% is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48. Determine [2]
   a) The normalized frequency for the fiber
   b) The number of guided modes
5. With a suitable example explain the effect of dispersion during optical signal propagation and how it can be reduced? [6]
6. Derive the expression of Numerical Aperture of meridional-ray in terms of refractive index of core and cladding. [4]
7. Explain a subcarrier intensity modulation. [5]
8. What is a Misalignment Loss? Explain the causes of misalignment loss. [1+2]
9. In which condition mode LED act as laser? Explain it. [3]
10. What are the types of LED? Which types of LED used in optical fiber communication? Explain it briefly. [4]
11. Explain about benefit and drawback of an avalanche photodiode. [3]
12. A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it.
    a) At what wavelength is the photodiode operating? [2]
    b) Calculate the incident optical power required to obtain a photo current of 2.5μA when the photo diode is operating as described above. [2]
13. Explain the causes of the insertion loss. What are the problems associated with fusion splicing? [3+2]

14. An optical fiber has a core refractive index of 1.5. Two lengths of the fiber with smooth and perpendicular (to the core axes) end faces are butted together. Assuming the fiber axes are perfectly aligned, calculate the optical loss in dB at the joint (due to Fresnel reflection) when there is a small air gap between the fiber end faces. [3]

15. The LED in a silica optical fiber link has arise time of 8ns and a spectral width of 40nm at an operating wavelength of 840nm. The PIN photo detector has a rise time of 10ns. For silica D = 95.2 ps/(nm.km). For a 2.5 Km link, the intermodal dispersion of graded index fiber is 3.5 ns/Km. Calculate the system rise time and data rate that the system can support for NRZ coding and RZ coding.
Also Calculate data rate for NRZ and RZ coding when Single mode fiber with D = 95.2 ps/(nm.km) and LASER having spectral width 1 nm and a rise time of 8ns is used in the same system. [4+3]

16. Explain the amplification process based on stimulated emission. What are the advantages of Erbium Doped Fiber Amplifier? [3+2]

17. Three clients traffic: STM-16 from SDH equipment, 10 Gbps internet traffic from router and 1 Gbps voice traffic from MSC needs to be carried from Kathmandu to Biratnagar. Only one pair of optical fiber is available between these cities. Explain how the traffic can be carried in the given scenario using DWDM technology with necessary block diagram. Assume the channel value having channel spacing of 100 GHz. [7]

18. What are the advantages and enhanced management capabilities of Synchronous Digital Hierarchy? [4]

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1. What are the advantage of optical fiber communication over other medium? [4]
2. The velocity of the light in the core of step index fiber is 2.01×10^8 ms^{-1} and the critical angle at the core- cladding interface is 80°. Determine the NA and the acceptance angle for the fiber in air, assuming it has a core diameter suitable for consideration by ray analysis. The velocity of light in vacuum is $2.998 \times 10^3 ms^{-1}$. [4]
3. State Maxwell's equation for optical propagation. [2]
4. What is Evanescent Field in optical fiber communication? [2]
5. A multimode step index fiber has a relative refractive index difference of 1% and core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3 μm is 1100. Estimate the diameter of the fiber core. [5]
6. What is a fiber dispersion? Explain it. [4]
7. A multimode graded index fiber has a refractive index at the core axis of 1.46 with a cladding refractive index of 1.45. The critical radius of curvature which allows large bending losses to occur is 84 μm when the fiber is transmitted light of a particular wavelength. Determine the wavelength of the transmitted light. [5]
8. Explain an internal Quantum efficiency and external Quantum efficiency of LED along with necessary mathematical expressions. [4]
9. The power generated internally within a double hetero junction LED is 28.4-m W at a drive current of 60-mA. Determine the peak emission wavelength from the device when the radiative and non radiative recombination lifetimes of the minority carriers in the active region are equal. [3]
10. Explain the optical detection principle of p-n photodiode. [4]
11. A given silicon avalanche photodiode has a quantum efficiency of 65% at a wavelength of 900 nm. If 0.5μW of optical power produces a multiplied photocurrent of 10μA. Find the multiplication factor. [3]
12. Briefly explain a Direct-Intensity modulation (D-IM). [5]
13. Compare between an optical splice and connector. [5]
14. Briefly explain structure and principle of operation for the fiber fused biconical taper coupler. [6]
15. Explain with principle of different types of optoelectronic integration. [7]

16. Explain with principle and neat diagram of digital fiber optic transmission. [8]

17. A D-IM analog optical fiber link of length 2 km employs an LED which launches mean optical power of -10 dBm in to multimode optical fiber. The fiber cable exhibits a loss of 3.5 db km^{-1} with splice losses calculated at 0.7 db km^{-1}. In addition there is a connector loss at the receiver of 1.6 db. The p-i-n photodiode receiver has a sensitivity of -25 dBm for an SNR of 50 dB and with a modulation index of 0.5. Estimated that a safety margin of 4dB is required. Assuming there is no dispersion equalization penalty.

a) Perform an optical power budget for the system operating under the above conditions and as certain its velocity.

b) Estimate any possible increase in link length which may be achieved using an injection laser source which launches mean optical power of 0 dBm in to the fiber cable. In this case the safety margin must be increased to 7 dB. [9]

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