SHIRDI SAI ENGINEERING COLLEGE

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06EC72

Seventh Semester B.E. Degree Examination, Dec.2013/Jan.2014

Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Distinguish between:
i) Single mode versus multimode fibers
ii) Step index and graded index fibers. **(08 Marks)**

b. Derive the expressions for numerical aperture of a step index fiber in terms of acceptance angle, cone and cladding refracting indices and further in terms of the refractive index difference, with the help of a ray diagram. **(06 Marks)**

c. A step index fiber with core and cladding refractive indices of 1.44 and 1.42 respectively. Calculate acceptance angle for skew rays which change direction by 150^{o} at each reflection. **(06 Marks)**

2 a. Explain the material absorption losses by sketching the various loss mechanisms at different wavelengths. **(06 Marks)**

b. What is material dispersion? Starting from the expression for group delay, derive the expression for material dispersion. **(08 Marks)**

c. What is critical radius of curvature for a fiber? A multimode graded index fiber has a refractive index at core axis of 1.46 with a cladding refractive index of 1.45. The critical radius of curvature occur at 84 μm when the fiber is transmitting light of a particular wavelength. Determine the wavelength of transmitted light. **(06 Marks)**

3 a. Draw and explain the cross section of the Ga-Aℓ-As double hetero structure LED, energy band diagram and refractive index profile and explain. **(10 Marks)**

b. Derive the laser diode rate equation. **(06 Marks)**

c. Photons of energy are incident on a photo diode which has a responsivity of 0.75 A/W. If the optical power is 15 μW, what is the photocurrent generated? If the wavelength of light is 1300 nm, find the quantum efficiency.
$h = 6.625 \times 10^{-34}$ JS $q = 1.6 \times 10^{-19}$ C **(04 Marks)**

4 a. Explain the different mechanical splicing techniques. **(06 Marks)**

b. Name the requirements of a good connector design. Explain the different types of optical fiber connections used. **(08 Marks)**

c. An LED has a circular area of radius 35 μm and a Lambertian emission pattern with 150 W/(cm^2.sr) axial radiance at a given drive current. Compare the optical powers coupled into two step index fibers, one of which has a Core radius of 25 μm with NA = 0.20 and the other has a Core radius of 50 μm with NA = 0.20. **(06 Marks)**

PART – B

5 a. Explain the two types of front end amplifiers used in optical fiber receivers with associated diagrams. **(06 Marks)**

b. Explain Burst mode receivers. **(06 Marks)**

c. Explain fundamental concept of a coherent light wave system using coherent detection technique with the help of figure and expressions. **(08 Marks)**

6 a. Find the maximum transmission distance for an optical digital link with the following parameters:
Operating at 850 nm
Optical power launched is 0 dBm
Fiber attenuation is 3.5 dB/km
Connector loss is 1 dB/connector
APD sensitivity is –50 dBm
Assume system margin = 6 dBm. **(04 Marks)**

b. Explain the multi-channel AM modulation technique with the help of block diagram and relevant expression. **(06 Marks)**

c. Write short notes on: i) Chirping, ii) Radio over fiber link. **(10 Marks)**

7 a. Explain the operational principles of WDM with relevant diagram. **(06 Marks)**

b. Explain the design and operation of a polarization independent isolator. **(06 Marks)**

c. What are tunable optical filters? Explain how the wavelength can be adjusted in a tunable filter. **(08 Marks)**

8 a. Explain the amplification mechanism of an EOFA amplifier with the help of energy band diagrams. **(08 Marks)**

b. Explain the basic structure of STS-1 Sonet frame. **(06 Marks)**

c. Explain the architecture of ROADM based on the use of wavelength blocker with relevant diagram. **(06 Marks)**

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10EC/TE72

Seventh Semester B.E. Degree Examination, Dec.2013/Jan.2014
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

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PART – A

1 a. Describe block diagram of an optical fiber transmission link and explain the function of each element in link. **(08 Marks)**

b. Explain what is meant by graded index optical fiber using simple ray theory concept indicate the major advantages of this type of fiber with regard to multimode propagation. **(06 Marks)**

c. A Graded index fiber with parabolic refractive index has $n_1 = 1.48$ and $n_2 = 1.46$ if core radius is 20 μm. Find the number of modes at 1300nm and 1550 nm. **(06 Marks)**

2 a. Describe Rayleigh Scattering in optical fiber. **(06 Marks)**

b. Briefly explain intramodal and intermodal dispersion. **(06 Marks)**

c. Glass fiber exhibits material dispersion given by, $\lambda^2\left(\frac{d^2n_1}{d\lambda_2}\right)$ of 0.025. Determine material dispersion parameter at a wavelength of 0.85 μm and estimate rms pulse broadening / km for good LED source with an rms spectral width of 20 nm at this wavelength. **(08 Marks)**

3 a. Sketch and explain Fabry perot resonator cavity of laser. **(07 Marks)**

b. Discuss the operation of silicon RAPD with neat diagram. **(07 Marks)**

c. Consider a photodiode with quantum efficiency 75%, when photon of energy 1.6×10^{-19} J, are incident on the surface then calculate operating wavelength and if 2.6 μA photo current through detector corresponding, determine incident optical power when detector is operated at same wavelength. **(06 Marks)**

4 a. Describe with aid of suitable diagram, three common technique used for mechanical splicing of optical fibers. **(06 Marks)**

b. With aid of simple sketches, outline major categories of fiber couplers. **(06 Marks)**

c. A GaAs optical source that has a refractive index of 3.6 is closely coupled to step index fiber which has a core refractive index of 1.465, if the source size is smaller than fiber core, and small gap between source and fiber is filled with a gel that has a refractive index of 1.305. What is the power loss in decibels from source into fiber? **(08 Marks)**

PART – B

5 a. Briefly discuss the possible sources of noise in optical fiber receivers. **(06 Marks)**

b. Discuss how the eye diagram is powerful measurement tool for assessing the data handling capability in digital transmission system. **(08 Marks)**

c. Write a note on analog receivers. **(06 Marks)**

6 a. Explain the multi AM techniques employed in broadband analog application. **(08 Marks)**

b. Explain : (i) Microwave photonics (ii) RF over fiber. **(06 Marks)**

c. Explain in brief : (i) Short wavelength band (ii) Chirping. **(06 Marks)**

7 a. Explain the design and operation of polarization independent isolator. How it is different from polarization dependent isolator. **(06 Marks)**

b. Write a note on MEMS technology. **(06 Marks)**

c. Explain operational principle and implementation of WDM with diagrams. **(08 Marks)**

8 a. Write basic applications and types of optical amplifiers. **(08 Marks)**

b. Explain with the aid of neat diagram, three possible EDFA configurations. **(06 Marks)**

c. Describe SONET / SDH frame formals
SONET / SDH frame rings. **(06 Marks)**

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2002 SCHEME

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EC/TC82

VII

Eighth Semester B.E. Degree Examination, Dec.2013/Jan.2014
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
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1 a. Using ray optics representation and assuming wave representation in a dielectric slab waveguide derive the condition for wave propagation in dielectric slab waveguide. **(08 Marks)**

b. What is core size and cladding index for manufacturing silica core, step index fiber with V = 70 and NA = 0.25 to be used with LED of 820 nm if core RI is 1.458. **(04 Marks)**

c. Explain how optical fibers are manufactured. Briefly highlight only the below given points:
i) Mention perform making methods.
ii) Material used.
iii) Oxides addition to control RI.
iv) Fiber drawing apparatus. **(08 Marks)**

2 a. Discuss loss or signal attenuation in an optical fiber with respect to following phenomena, absorption reasons scattering losses, bending losses, core and cladding losses, high lighting on formulas and graphs if any. **(11 Marks)**

b. Derive an expression for material dispersion. Explain how material dispersion can be reduced by choosing sources with narrower spectral output widths or by operating at longer wavelengths with graph if required. **(06 Marks)**

c. Consider an optical link of 6 km long step index fiber with core index n1 = 1.48 and relative index difference $\Delta = 1.5\%$. Find the delay difference between the slowest and fastest modes. **(03 Marks)**

3 a. Write a note on Fabry Perot resonator cavity laser diode. **(06 Marks)**

b. Explain how photo current is generated in pin photo detection with circuit and energy band diagram. **(06 Marks)**

c. Derive an expression for optical power that can be coupled into a fiber using non-imaging microscope. **(08 Marks)**

4 a. Explain fiber splicing techniques with neat diagrams. **(06 Marks)**

b. An LED with a circular emitting area of radius 28 μm has a lambertian emission pattern with a 120 W/cm^2.sr axial radiance at a 100 mA drive current. How much optical power can be coupled into a step index fiber having a 100 μm core diameter and NA = 0.22? How much optical power can be coupled from this source into a 50 μm core diameter graded index fiber with $\alpha = 2.0$, $n_1 = 1.5$ and $\Delta = 0.015$. **(06 Marks)**

c. Explain how losses occur due to mechanical misalignments in fiber joints with figures and expressions. **(08 Marks)**

5 a. Derive an expression for BER of a digital bit stream. **(08 Marks)**

b. Explain the working of high impedance FET amplifier with a neat circuit diagram. **(06 Marks)**

c. Write a note on analog receivers. **(06 Marks)**

6 a. Briefly explain about multichannel transmission techniques used in optical fiber communication. **(10 Marks)**

b. What are the system considerations and analysis required in point to point links of optical fiber communication design. **(10 Marks)**

7 a. In a fiber optic communication link we have LED with power 1 mW (0 dBm) as source with rise time 20 nsec, spectral width 20 nm. At the receiver end pin diode is used which has rise time of 1 nsec and sensitivity of -25 dBm. A step index multimode fiber is used with core refractive index = 1.48 NA = 0.2 optical fiber cables are available in the lengths of 1 km each. Source coupling loss is 2 dB, detector coupling loss is 1.5 dB, system margin is 4 dB, splice loss is 0.15 dB per splice and attenuation is 0.15 dB per kilometer at an operating wavelength of 850 nm. What is the maximum permissible link length and data rate? **(10 Marks)**

b. Discuss noise effects on optical fiber communication system performance with relevant expressions and graphs. **(10 Marks)**

8 a. What is operational principle of WDM. Explain how a WDM network is implemented with neat diagram. **(10 Marks)**

b. What is stimulated RAMAN scattering. How it affect the network performance? **(10 Marks)**

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06EC72

Seventh Semester B.E. Degree Examination, June/July 2013
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
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PART – A

1 a. Discuss the advantages and disadvantages of OFC. **(06 Marks)**

b. Explain Mode Field Diameter (MFD) of a single mode fiber. **(06 Marks)**

c. Differentiate between glass fiber and plastic fibers. In case of glass fiber, how RI can be varied? **(04 Marks)**

d. A SI multimode fiber with a NA of 0.20 supports approximately 1000 modes at an 850nm wavelength.
   i) What is the diameter of its core?
   ii) How many modes does the fiber support at 1320 nm?
   iii) How many modes does the fiber support at 1550 nm? **(04 Marks)**

2 a. Explain the "pulse dispersion" with suitable diagram and differentiate MMSIF, MMGIF and SMF by their information carrying capacity with reason. **(06 Marks)**

b. Discuss the following for optical fibers:
   i) Extrinsic absorption.
   ii) Material dispersion. **(08 Marks)**

c. Optical power launched into fiber at transmitter end is 150µw. The power at the end of 10km length of the link working in first window is -38.2 dBm. Another s/m of same length working in second window is 47.5 µw. Same length s/m working in third window has 50% of launched power. Calculate fiber attenuation for each case and mention wavelength of operation. **(06 Marks)**

3 a. A double-hetero junction "InGaAsP" LED emitting at a peak wavelength of 1310 nm has radiative and non radiative recombination times of 25 ns and 90 ns respectively. The drive current is 35 mA.
   i) Find the internal quantum efficiency and the internal power.
   ii) If the RI of the light source material is n = 3.5. Find the power emitted from the device. **(06 Marks)**

b. Describe the following terms relating to LASER:
   i) External quantum efficiency.
   ii) Wavelength spacing. **(06 Marks)**

c. Explain the three factors which affects the response time of a photodiode. **(08 Marks)**

4 a. Discuss the different lensing scheme used to improve the source-to-fiber coupling efficiency, with the necessary sketches. **(06 Marks)**

b. For a surface emitting LED has radiance of 150W/(cm^2.sr) and radius of emitting area is 35µm. Calculate the optical power coupled to the fibers with
   a_1 = 25µm and NA = 0.20, step index
   a_2 = 50µm and NA = 0.20, step index. **(06 Marks)**

c. Define fiber splicing. Explain different types of splicing with neat sketches. **(08 Marks)**

PART – B

5 a. Explain the different types of front-end amplifiers in optical receiver. **(06 Marks)**

b. With a neat sketch, explain how system performance information can be obtained from the eye diagram. **(08 Marks)**

c. Write a short note on burst-mode receivers. **(06 Marks)**

6 a. Following are the parameters of a point-to-point optical link:

i)	Optical power launched	: +3dBm
ii)	Sensitivity of detector	: -32dBm
iii)	Source/detector connector loss	: 1dB
iv)	Length of optical cable	: 60 km
v)	Cable attenuation	: 0.3dB/km
vi)	Jumper cable loss	: 3dB
vii)	Connector loss at each fiber joint (two at each transmitter and receiver end because of the jumper cables)	: 1dB

Compute the power margin of the link using spread sheet method. **(06 Marks)**

b. Explain the basic elements of analog link with different noise contribution. **(09 Marks)**

c. What is sub carrier multiplexing? Explain. **(05 Marks)**

7 a. Explain the need of isolator in optical network. Give its principle of operation also. **(06 Marks)**

b. Explain the operational principle and implementation of WDM. **(08 Marks)**

c. Briefly discuss dielectric thin-film filters. **(06 Marks)**

8 a. Explain the three main optical amplifier types. **(06 Marks)**

b. Describe:

i) SONET/SDH rings.

ii) SONET/SDH networks.

iii) Frame format of STS-1 SONET. **(10 Marks)**

c. An EDFA amplifier produces $P_{s,out} = 27dBm$ for an input $P_{s,in} = 2dBm$ at 1542 nm.

i) Find the amplifier gain, G.

ii) What is the minimum pump power required. **(04 Marks)**

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06EC72

Seventh Semester B.E. Degree Examination, December 2012
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
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PART – A

1 a. List the disadvantages of copper wire at the optical frequency range. **(06 Marks)**

b. Explain the ray theory of the optical fiber, with the help of a neat sketch. **(08 Marks)**

c. A silica glass fiber has a core refractive index of 1.5 and the cladding refractive index of 1.45. Calculate (i) critical angle for the core-cladding interface, (ii) the NA of the fiber and (iii) percentage of light collected by the fiber. **(06 Marks)**

2 a. Describe the attenuation mechanisms in an optical fiber. **(10 Marks)**

b. Derive the equation for material dispersion in the optical fiber. **(06 Marks)**

c. An optical signal at a specific wavelength has lost 55% of its power, after traversing 7 km of fiber .What is the attenuation in dB/km of this fiber. **(04 Marks)**

3 a. What are the characteristic requirements of an optical source? With the help of diagram, describe the operation of surface emitting LED. **(10 Marks)**

b. Which are the noise types affecting the optical detector. **(03 Marks)**

c. Describe the PIN diode performance, using the diagram. **(07 Marks)**

4 a. Derive an equation for power coupling to the step index fiber and graded index fiber. **(10 Marks)**

b. What is equilibrium numerical aperture of a fiber? With the help of diagrams, explain the lensing schemes for coupling improvement. **(10 Marks)**

PART – B

5 a. Discuss the error sources in the optical signal detection. **(07 Marks)**

b. Derive an equation for optical receiver sensitivity. **(10 Marks)**

c. Calculate the PIN diode receiver sensitivity, if the gain of the photo detector is 1, its noise figure is 1 and bandwidth of the receiver is assumed to be half of the bit rate. Note the BER is 10^{-12} and data rate is 100 Mb/s. **(03 Marks)**

6 a. Write the diagram and explain the radio over fiber links. **(10 Marks)**

b. What is link power budget? With an example, explain the link power budget calculation. **(10 Marks)**

7 a. With the help of neat diagram, explain the operation of WDM. **(08 Marks)**

b. Describe the principles of working of isolators, circulator and ADM using suitable diagrams. **(12 Marks)**

8 a. What are the optical amplifiers? Describe with the help of a sketch the semiconductor laser amplifier. **(10 Marks)**

b. Describe the SONET optical network working with reference to suitable diagram. **(10 Marks)**

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06EC72

Seventh Semester B.E. Degree Examination, June 2012

Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
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PART – A

1 a. What are the advantages of optical fiber communication? Explain in detail. **(06 Marks)**

b. Explain briefly the fiber materials. **(07 Marks)**

c. With a neat diagram, explain the photonic crystal fibers, in optical fiber communication. **(07 Marks)**

2 a. Explain the macro bending loss in optical fiber. **(06 Marks)**

b. Explain the material dispersion with relevant expressions. **(07 Marks)**

c. Explain the following terms in optical communication :
   i) Attenuation
   ii) Absorption
   iii) Scattering losses
   (Note : Mathematical expressions and graphs may be given wherever necessary) **(07 Marks)**

3 a. Give comparison between laser diode and light emitting diode, considering the various parameters. **(06 Marks)**

b. A double heterojunction InGaAsp LED emitting at a peak wavelength of 1310 nm has radiative and non-radiative recombination times of 30 and 100 ns respectively. The drive current is 40 mA. Calculate the :
   i) Bulk recombination lifetime
   ii) Internal quantum efficiency
   iii) Internal power level. **(07 Marks)**

c. Explain the operation of avalanche photo diode with schematic diagram and separate absorption and multiplication (SAM) APD configuration. **(07 Marks)**

4 a. Explain the examples of possible Lensing schemes used to improve optical source to fiber coupling efficiency. **(06 Marks)**

b. What is fiber splicing? Explain the fusion splicing of optical fibers with relevant diagram. **(07 Marks)**

c. What are the principal requirements of a good connector? Explain the alignment scheme used in tapered-sleeve fiber-optic connector with relevant diagram. **(07 Marks)**

PART – B

5 a. Explain the receiver sensitivity of an optical receiver. Derive an expression for receiver sensitivity. **(06 Marks)**

b. Explain the general configuration of an eye diagram showing the definitions of fundamental measurement parameters. And also explain noise margin and timing jitter parameters. **(07 Marks)**

c. Explain the operation of Burst mode receiver with received data pattern and signal level variations in pulses. **(07 Marks)**

6 a. Explain the operation of multi-channel amplitude modulation standard technique for frequency division multiplexing of N independent information bearing signals. **(07 Marks)**

b. Explain the radio-over-fiber links with a concept of a broadband wireless access network for interconnecting antenna base stations with the central controlling office. **(06 Marks)**

c. Explain the link power budget, with a relevant diagram. **(07 Marks)**

7 a. Explain the wavelength division multiplexing network containing various types of optical amplifiers. **(07 Marks)**

b. Explain the optical Isolator with a design and operation of a polarization independent isolator mode of three miniature optical components. **(06 Marks)**

c. Explain the operation of optical Add/Drop multiplexers, with a relevant diagram. **(07 Marks)**

8 a. Explain the configuration of SONET/SDH rings, with relevant diagrams. **(10 Marks)**

b. Write notes on the following :

i) Optical amplifier

ii) High speed light wave links. **(10 Marks)**

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EC82

Eighth Semester B.E. Degree Examination, June 2012
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer any FIVE full questions.*
2. *Missing data may be suitably assumed.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. With the help of ray diagram compare single mode SIF and multimode GRIN fiber in the form of a table. **(08 Marks)**
b. Write important advantages and disadvantages of fiber. **(06 Marks)**
c. Briefly explain the structure of fiber optic cables. **(06 Marks)**

2 a. Explain briefly absorption losses in fibers. **(06 Marks)**
b. Find Raleigh scattering coefficient at 630 nm if $\eta = 1.46$, Fictive temperature is 1400°K Isothermal compressibility is 7×0^{-11} m^2/N and photoelastic constant is 0.286. **(06 Marks)**
c. Define the following terms: (i) Mode filed diameter; ii) Cut off wavelength; (iii) Dispersion shifted fiber; (iv) Dispersion flattened fiber. **(08 Marks)**

3 a. With the help of a neat diagram explain the working a DFB laser diode. Write equations for lasing threshold. **(08 Marks)**
b. A double heterojunction In Ga ASP LED operating at 1310 nm has $\tilde{c}r = 25$ n sec and $\tilde{c}nr = 90$ n sec. If drive current is 30 mA, find internal quantum efficiency and internal power generated. **(06 Marks)**
c. A photodiode has quantum efficiency of 65% when photons of energy 1.5×10^{-19} joules is incident upon it; (i) At what wave length is the photodiode operating? (ii) Calculate the incident optical power required to obtain a photo current of 2.5μA when photodiode is operating as described above. **(06 Marks)**

4 a. Derive the equation for the power coupled from LED to a SIF. **(09 Marks)**
b. With the help of diagram explain different types of fiber splicing techniques. **(06 Marks)**
c. A Ga As optical source with R.I 3.6 is coupled to silica fiber that has R.I of 1.48. If the fiber end and source are in close contact, find power loss due to coupling. **(05 Marks)**

5 a. With the help of a neat schematic, explain optical power loss model for point to print link. **(08 Marks)**
b. Starting from fundamentals derive the equation for CNR of a single channel AM system. **(12 Marks)**

6 a. Briefly explain different system features of WDM. **(08 Marks)**
b. How 8×8 star coupler can be realized by using 2×2 coupler? Explain with the help of neat diagram. **(06 Marks)**
c. A 2×2 biconical tapered fiber coupler has an input optical power of 300μw. Power out put at the other three ports are P_1= 100μw, P_2= 90μw and P_3= 8.2 nm. Find coupling ratio, excess loss, insertion loss(port 0 to port 2) and cross talk. **(06 Marks)**

7 a. With the help of a neat diagram, explain the basic structure of a STS–1 SONET frame. **(06 Marks)**
b. Two star N/Ws have 10 and 50 stations respectively. Each station is located 500 m from star coupler and fiber alternation is 0.4 dB/km. If excess loss is 0.75dB for 10 stations n/w and 1.25 dB for 50 stations n/w with connector loss of 1 dB, find power margin between transmitter and receiver for the n/w. **(08 Marks)**
c. What are the NL effects on N/w performance? Explain. **(06 Marks)**

8 Write explanatory notes on: (i) Material dispersion on fibers; (ii) Rise time budget; (iii) Surface emitting LED; (iv) EDFA architecture. **(20 Marks)**

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SHIRDI SAI ENGG COLLEGE

06EC72

Seventh Semester B.E. Degree Examination, December 2011
Optical Fiber Communication

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PART – A

1 a. Enlist the advantages of optical fibers, compared to the usage of a copper cables in the communication. **(06 Marks)**

b. With relevant diagrams, explain the different types of optical fibers, considering the number of the modes and material composition of the core. **(08 Marks)**

c. Light traveling in air strikes a glass plate at an angle $\theta_1 = 33^\circ$, where θ_1 is measured between the incoming ray and glass surface. If the refracted and reflected beams make an angle of 90° with each other, what is the refractive index of the glass? What is the critical angle? **(06 Marks)**

2 a. Explain the mechanisms which cause absorption in the optical fibers. Mention the measures which can reduce this type of signal degradation. **(06 Marks)**

b. Prove that, delay difference between the axial ray and extreme meridional ray is $\delta T_s \cong \frac{Ln_1\Delta}{c}$. **(08 Marks)**

c. A 6 Km optical link consists of multimode step–index fiber, with a core RI of 1.5 and relative index difference of 1%. Estimate, **(06 Marks)**

i) Delay difference between slowest and fastest modes at the fiber output
ii) rms pulse broadening due to intermodal dispersion on the link
iii) Maximum bit rate that may be obtained without substantial errors on the link assuming only intermodal dispersion.

3 a. Draw and explain the cross – sectional view of a typical GaAlAs double heterostructure LED, along with the energy band diagrams and variations in RI profile. **(10 Marks)**

b. What is quantum efficiency? How are the 'responsivity' and 'quantum efficiency' related? **(04 Marks)**

c. A given silicon avalanche photodiode has a quantum efficiency of 65% at a wavelength of 900nm. Suppose 0.5μW of optical power produces a multiplied photocurrent of 10μA, find the primary photocurrent and the multiplication factor. **(06 Marks)**

4 a. List and sketch the different types of splicing techniques and connectors. **(08 Marks)**

b. What are the principal requirements of a good connector design? **(06 Marks)**

c. A single mode fiber has a normalized frequency V = 2.40, a core RI $n_1 = 1.47$, a cladding RI of $n_2 = 1.465$ and a core diameter of 9μm. Find the insertion loss of a fiber joint, if the lateral offset is 1μm. Also find the loss, if there is an angular misalignment of 1° at a 1300nm wavelength. **(06 Marks)**

PART – B

5 a. Explain with a neat diagram, the basic sections and operations of an optical receiver. **(06 Marks)**

b. Briefly explain the 'quantum limit'. **(04 Marks)**

c. Derive the equation for the performance fidelity of an analog receiver. Substantiate that for large optical signals, SNR represents the quantum limit for receiver sensitivity. **(10 Marks)**

6 a. With a relevant diagram, discuss the subcarrier multiplexing technique. **(06 Marks)**

b. Discuss the various parameters involved in optical link power budget, with the relevant equations. **(06 Marks)**

c. Write short notes on:

i) Mode – partition noise

ii) Chirping. **(08 Marks)**

7 a. Describe the operational principles of WDM, depicting the implementation of a typical WDM network containing various types of optical amplifiers. **(08 Marks)**

b. Explain briefly the working of thin – film resonant cavity filter. What is the application? **(06 Marks)**

c. What is MEMS technology? With an example, explain a MEMS actuation method. **(06 Marks)**

8 a. With relevant schematic diagrams, explain the three possible configurations of a EDFA. **(06 Marks)**

b. Discuss the physical layer aspects of SONET, explaining the basic structure of an STS–L SONET frame. **(06 Marks)**

c. What is the difference between fixed OADM and ROADM? List the features of ROADM. **(08 Marks)**

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06EC72

SHIRDI SAI ENGG COLLEGE

Seventh Semester B.E. Degree Examination, June/July 2011

Optical Fibre Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

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PART – A

1 a. Discuss briefly the inherent advantages of optical fibers over conventional copper systems. **(06 Marks)**

b. Describe the different types of optical fiber waveguide structures, using ray theory with neat diagrams. Explain the light propagation. **(08 Marks)**

c. Briefly discuss modified chemical vapor deposition (MCVD) process of fabrication of optical fiber, with neat diagrams. **(06 Marks)**

2 a. Describe the different types of attenuation mechanism for an optical fiber. **(08 Marks)**

b. Derive an equation for material dispersion and waveguide dispersion in an optical fiber. **(08 Marks)**

c. A 30 km long optical fiber has an attenuation of 0.4 dB/km at 1310 nm, with input decibel power level referred to 1 mW. Find out the optical power output, if 200 μW of optical power is launched into the fiber. **(04 Marks)**

3 a. With a neat diagram, explain the working of an edge-emitting double-heterojuction LED structure. **(08 Marks)**

b. Discuss the different types of noise which occur in photo detectors. **(08 Marks)**

c. An InGaAs pin-photodiode has the following parameters at a wavelength of 1300 nm.

i) Quantum efficiency = 0.90

ii) Plank's constant = 6.625×10^{-34} J.S.

iii) Electron charge = 1.6×10^{-9} C. (Assume velocity = 3×10^{8} m/sec)

Assume surface leakage current negligible. Find out the primary photo detector current. **(04 Marks)**

4 a. Explain the different types of fiber splicing techniques, with neat diagrams. **(06 Marks)**

b. With the principal requirements of a good connector design, explain basic coupling mechanism used in Butt-Joint and expanded-beam connectors. **(10 Marks)**

c. A GaAs optical source with refractive index of 3.6 is coupled to a silica fiber that has a R.I. of 1.48. If the fiber end and the source are in close physical contact, find out the Fresnel reflection (R) and power loss in dB. **(04 Marks)**

PART – B

5 a. With a neat diagram, explain the working of optical receiver. **(08 Marks)**

b. Discuss briefly, how the eye diagram is powerful measurement tool for assessing the data-handling ability in a digital transmission system. **(08 Marks)**

c. Differentiate between Heterodyne and Homodyne coherent detection schemes, with respect to probability of error function of a BER. **(04 Marks)**

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6 a. Discuss the basic elements of an analog link and the major noise contributors of an analog link, with a neat diagram. **(08 Marks)**

b. With a simplex point-to-point link, explain the key system requirements which are needed in analyzing a link and how to fulfill these requirements. **(08 Marks)**

c. Explain the polarization mode dispersion penalty in power penalties of a digital link. **(04 Marks)**

7 a. With a neat diagram, explain the working of dielectric thin film filters. **(08 Marks)**

b. With basic operational principles of WDM, explain the working of typical WDM network and mention WDM standards. **(08 Marks)**

c. Explain MEMS technology, with a simple diagram. **(04 Marks)**

8 Write short notes on:

a. Optical amplifiers **(10 Marks)**

b. SONET/SDH **(10 Marks)**

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2002 SCHEME

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EC82

Eighth Semester B.E. Degree Examination, June/July 2011
Optical Fiber Communications

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions.***
2. ***Write symbols according to the prescribed text.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Sketch the R.I. profile and meridional rays inside a single mode step index fiber and multimode GRIN fiber. Compare the differences between single mode and multimode fibers in the form of a table. **(10 Marks)**

b. Define the terms : i) NA of a SIF ii) V – number of an optical fiber. **(04 Marks)**

c. A multimode SIF supports 75 nodes, having NA = 0.3, $n_1 = 1.458$, operating at 820nm. Find core radius, R.I of cladding and fractional change in R.I. **(06 Marks)**

2 a. Starting from the equation for group delay, derive the equation for rms pulse broadening due to material dispersion in an optical fiber. **(06 Marks)**

b. Define the following terms :
i) Mode field diameter ii) Cut off wave length iii) Dispersion shifted fiber iv) Dispersion flattened fiber. **(08 Marks)**

c. Find Rayleigh scattering attenuation coefficient at 630nm if R.I of medium is 1.46, Fictive temperature is 1400^0K, isothermal compressibility is 7×10^{-11} m^2/N and photo elastic constant is 0.286. **(06 Marks)**

3 a. With the help of a neat diagram, explain the working of a high radiance surface emitting LED. **(06 Marks)**

b. What are the different types of noise sources that affects the performance of photodiode? Explain. **(08 Marks)**

c. A photo diode has a quantum efficiency of 65%, when photons of energy 1.5×10^{-19} Joules are incident upon it. i) At what wave length is the detector operating? ii) Calculate the incident of optical power required to obtain a photo current of 2.5μA, when photodiode is operating as described above. **(06 Marks)**

4 a. A double heterogenic InGaAs LED operating at 1310nm has radiative recombination time 25nsecs and non radiative recombination time 90nsecs. Drive current is 30mA. Find internal quantum efficiency and internal power generated. **(06 Marks)**

b. Explain different possible lensing schemes used to improve optical source to fiber coupling efficiency. **(08 Marks)**

c. A digital fiber optic link operating at 850nm requires a maximum BER of 10^{-9}. i) Find quantum limit in terms of quantum efficiency and energy of incident photons ii) Find the minimum incident optical power (Po) that must fall on the photodiode to achieve 10^{-9} BER at a data rate of 10Mbps. (Assume equal number of 0^s and 1^s pulses in the stream) and quantum efficiency is 1. **(06 Marks)**

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5 a. Starting from the fundamentals, derive the equation for CNR of a single channel AM optical fiber system. **(12 Marks)**

b. With the help of a neat schematic diagram, explain the optical power loss model for a point to point link. **(08 Marks)**

6 a. Briefly explain the different system features of WDM. **(08 Marks)**

b. A 2 × 2 biconical tapered fiber coupler has an input optical power of 300μw, The power output at other three ports are $P_1 = 100\mu w$, $P_2 = 90\mu w$ and $P_3 = 8.2nw$. Find coupling or splitting ratio, excess loss, insertion loss (Port 0 to Port 2) and cross talk. **(07 Marks)**

c. How 8 × 8 star coupler can be realized by using 2 × 2 couplers? Explain with the help of neat schematic diagram. **(05 Marks)**

7 a. Two star networks have 10 and 50 stations respectively. Each station is located 500m from star coupler and fiber attenuation is 0.4dB / km. The excess loss is 0.75dB for 10 station n/w and 1.25 dB for 50 station n/w and connector loss is 1dB. Find power margin between transmitter and receiver of the two n/ws. **(06 Marks)**

b. Explain the basic structure of a STS – 1 SONET frame, with the help of a neat diagram. **(08 Marks)**

c. Write an explanatory note on architecture of 4 fiber bidirectional line switched ring. **(06 Marks)**

8 Write explanatory notes on the following :

a. Fiber optic cables. **(05 Marks)**

b. Fiber splicing techniques. **(09 Marks)**

c. EDFA architecture. **(06 Marks)**

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06EC72

Seventh Semester B.E. Degree Examination, December 2010

Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. What are the advantages of optical fiber communication? **(06 Marks)**

b. Explain the structure of single mode and multimode step index and graded-index optical fibers with cross section and ray path. **(07 Marks)**

c. What are the different fiber materials used in optical communication? Explain briefly. **(07 Marks)**

2 a. Explain the different types of bending losses in optical fiber. **(08 Marks)**

b. Explain the material dispersion in optical waveguides. **(06 Marks)**

c. Explain the following parameters on optical fiber:
   i) Absorption
   ii) Scattering loss **(06 Marks)**

3 a. With schematic of an edge-emitting double heterojunction LED, explain the operation. **(06 Marks)**

b. Give comparison between LED and laser diode considering the different parameters. **(06 Marks)**

c. A given APD has a quantum efficiency of 65% at wavelength of 900 nm. If 0.5 microwatt of optical power produces a multiplied photocurrent of 10 micro Amps, find the multiplication factor M. **(08 Marks)**

4 a. Explain the mechanical misalignment between two fibers. **(06 Marks)**

b. An optical source has refractive index of 3.6 and is coupled to a fiber of 1.48 refractive index. Consider the medium between fiber and source has similar index as that of fiber. Calculate Fresnel reflection and loss of power in dBs. **(06 Marks)**

c. Explain the following briefly:
   i) Fiber splices
   ii) Fiber connectors. **(08 Marks)**

PART – B

5 a. With a neat diagram, explain the operation of transimpedance preamplifier equivalent circuit. **(06 Marks)**

b. An In GaAs PIN photodiode has the following parameters at a wavelength of 1300 nm : $I_D = 4$ nA, $\eta = 0.9$, $R_L = 1000\ \Omega$ and the surface leakage current is negligible. The incident optical power is 300 nw (-35 dBm) and the receiver bandwidth is 20 MHz. Find the various noise terms of the receiver. **(08 Marks)**

c. Explain the analog receiver briefly. **(06 Marks)**

6 a. With a diagram, explain the operation of multichannel AM briefly. **(06 Marks)**

b. Explain the radio over fiber concept of a broadband wireless access network for interconnecting antenna base stations with the central controlling office. **(07 Marks)**

c. What is rise time budget? Explain. Derive an expression for total rise time or total system rise time (t_{sys}). **(07 Marks)**

7 a. Explain the implementation of a typical WDM network containing various types of optical amplifiers. **(06 Marks)**

b. Explain the operation of a polarization-independent isolator made of three miniature optical components. **(07 Marks)**

c. Explain the operation of optical adding and dropping wavelengths with a 4 × 4 OADM device that uses miniature switching mirrors. **(07 Marks)**

8 Write short notes on the following: **(20 Marks)**

a. Optical amplifier

b. Semiconductor optical amplifier

c. SONET / SDH network services

d. Optical interface.

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2002 SCHEME

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EC82

Eighth Semester B.E. Degree Examination, December 2010
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. What are the advantages of optical fiber communication system? **(06 Marks)**

b. Explain with necessary diagrams, the different types of fiber structures. **(08 Marks)**

c. A lightwave is traveling in a semiconductor medium (GaAs) of refractive index 3.6. It is incident on a different semiconductor medium (ALGaAs) of refractive index 3.4 and the angle of incidence is 80°. Will this result in total internal reflection? Comment on this result. **(06 Marks)**

2 a. Discuss the following parameters for optical fibers:
i) Absorption ii) Waveguide dispersion iii) Material dispersion iv) Bending loss. **(12 Marks)**

b. Explain the term mode coupling in optical fiber. **(04 Marks)**

c. Find the radius of curvature R at which the number of modes decreases by 50 percent in a graded index fiber. For this fiber $\alpha = 2$, $n_2 = 1.5$, $\Delta = 0.01$, $a = 25\ \mu m$ and wavelength of guided light is $1.3\ \mu m$. **(04 Marks)**

3 a. Explain the operation of an edge-emitting double-heterojunction LED, with neat schematic diagram. **(06 Marks)**

b. Derive an expression for internal quantum efficiency of LED and also an expression for optical power generated internally in LED. **(06 Marks)**

c. A GaAs laser operating at 850 nm has a 500μm length and a refractive index n = 3.7. What are the frequency and wavelength spacing? **(04 Marks)**

d. Give comparison between PIN diode and Avalanche photodiode. **(04 Marks)**

4 a. Show that P_{LED}, Step $= P_s (NA)^2$ for $r_s \leq a$. **(10 Marks)**

b. Describe the different types of mechanical misalignment between the two joined fibers. **(06 Marks)**

c. The end faces of two optical fibers with core refractive indices of 1.50 are perfectly aligned and have a small gap between them. This gap is filled with a gel having a refractive index of 1.30. Find the optical loss in decibels at this joint. **(04 Marks)**

5 a. With a schematic diagram, explain the working of optical receiver. **(08 Marks)**

b. Discuss the possible sources of noise in optical receiver. **(06 Marks)**

c. Discuss the different types of pre-amplifiers in optical receiver. **(06 Marks)**

6 a. Explain the basic elements of an analog link with different noise contribution. **(08 Marks)**

b. What is subcarrier multiplexing? Explain briefly. **(04 Marks)**

c. Explain link power budget and system rise time budget analysis. **(08 Marks)**

7 a. For a multimode fiber link following parameters are recorded:

i) LED with drive circuit has rise time of 15 ns.
ii) LED spectral width = 40 nm
iii) Material dispersion related rise time degradation = 21 ns over 6 km link.
iv) Receiver bandwidth = 25 MHz.
v) Modal dispersion rise time = 3.9 nsec.

Calculate the system rise time. **(06 Marks)**

b. Discuss the different types of line codes optical fiber communication. **(06 Marks)**

c. With a diagram, explain the structure of 2×2 fiber coupler. Also, discuss the construction of 8×8 star coupler formed by interconnecting twelve 2×2 couplers. **(08 Marks)**

8 a. A 32×32 star coupler is formed by interconnecting 2×2 couplers. If 5 percent of power is lost in each coupler element, determine the total loss in the coupler. **(05 Marks)**

b. Write short notes on the following :

i) Wavelength division multiplexing
ii) Optical amplifiers
iii) Photonic switching. **(15 Marks)**

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SHIRDI SAI ENGG COLLEGE

VII (6) a. Prabhu Set

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2002 SCHEME

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EC82

Eighth Semester B.E. Degree Examination, May/June 2010
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Explain the advantages of optical fiber as compared to copper conductor. **(06 Marks)**

b. Differentiate between a 'ray congruence' and modes. Give two examples for linearly polarized modes. **(08 Marks)**

c. A multimode fiber has a core dia of 70μm and the relative refractive index difference of 1.5 percent. It operates at the wavelength of 0.85 μm. The refractive index of the fibre is 1.46. Calculate i) The refractive index of the cladding.
ii) Normalized frequency V-number of the fiber.
iii) The total number of guided modes in the fiber. **(06 Marks)**

2 a. Explain the following with related equations in the case of optical fibers:
i) Scattering losses
ii) Dispersion
iii) Group delay. **(12 Marks)**

b. A single mode S.I. fiber is operating in the guided mode. The core refractive index and radius are 1.46 μm and 5 μm respectively. The refractive index difference between the core and cladding is 0.25 percent. Calculate the cut-off wavelength of the fiber. **(08 Marks)**

3 a. Derive the equations for internal quantum efficiency, optical power and external quantum efficiency of LED. **(08 Marks)**

b. Explain a photo-detector receiver with a related diagram and equations for related photo-detector noise current and Johnson noise current. **(12 Marks)**

4 a. Explain what is meant by the following:
i) Power coupled from a surface emitting LED.
ii) Mode coupling in a multimode fiber.
iii) Lencing arrangement for coupling improvement.
Explain with related diagrams and equations. **(12 Marks)**

b. Differentiate between splicing and connecting in optical fibres. **(08 Marks)**

5 a. A p-i-n photo-diode has a capacitance of 5 pF. Calculate the maximum value of load resistance R_L which will make the post-detection bandwidth of 10MHz and estimate the decrease in bandwidth with the same load resistance when the following amplifier has a input capacitance of 5 pF. **(06 Marks)**

b. Define the following terms with related equations:
i) Receiver sensitivity of a photo-diode
ii) Quantum limit
iii) Minimum energy (E) at wavelength (λ).
Specify the parameters used. **(09 Marks)**

c. Draw an 'eye pattern' and mark the fundamental measurement parameters. **(05 Marks)**

6 a. Explain the following terms:
   i) Relative intensity noise (RIN)
   ii) Multi channel frequency modulation with related graphs and equations. **(10 Marks)**

b. An optical fiber-link designed to operate at a maximum bitrate of 50 Mbps employs an LED transmitter and PIN photo-detector diode as a receiver. The link requires 6 dB power budget and 3 dB safety margin. The receiver draws 1.5 μA of current and the LED draws 100 mA. Calculate, i) Operating power required by the PIN diode.
   ii) The total power budget.
Assume PIN sensitivity of 0.5 A/W. **(10 Marks)**

7 a. Explain the following with related diagrams:
   i) Reflection noise in a fiber-link
   ii) ARQ error-correction scheme. **(10 Marks)**

b. Explain the concept of (2×2) fiber coupler with related diagram and equations. Specify the coupling coefficient, splitting ratio and the losses. **(10 Marks)**

8 a. Draw and explain a STS-N sonent and SDS-NSDH frames. Specify their basic data rates. **(10 Marks)**

b. What are the types of optical non-linearities? Explain their effects. **(06 Marks)**

c. What is optical switching? Specify its uses. **(04 Marks)**

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SHIRDI SAI ENGG COLLEGE

06EC72

Seventh Semester B.E. Degree Examination, Dec.09/Jan.10
Optical Fibre Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. What are the advantages, applications and disadvantages of optical fibre as compared to copper cables? **(08 Marks)**

b. Derive the numerical aperture of a step index fiber (SIF) from Snell's law. **(06 Marks)**

c. A multimode SIF has V number of 75, NA = 0.3, R.I. of core is 1.458 and operates at 820nm. Find core radius, R.I. of cladding, fractional change in R.I. and number of modes gets propagated. **(06 Marks)**

2 a. A 30 km long fiber at 1300 nm has an attenuation of 0.8 dB/km. If 200 μw power is launched into the fiber, find the output power in dBm and in watts. **(06 Marks)**

b. Briefly explain, different mechanisms which cause absorption losses in optical fibers. **(06 Marks)**

c. Derive an expression for pulse spreading and dispersion, which is a function of wavelength, using time delay. **(08 Marks)**

3 a. Draw the diagram of a typical GaAlAs double hetero structure LED, along with energy band diagram and refractive index profile and explain. **(08 Marks)**

b. Sketch and explain the Fabry-Perot resonator cavity of laser. **(06 Marks)**

c. A photodiode has a quantum efficiency of 65%, when photons of energy 1.5×10^{-19} Joules are incident upon it.

i) At what wavelength is the photodiode operating?

ii) Calculate the incident optical power required, to obtain a photocurrent of 2.5μA. **(06 Marks)**

4 a. A silica multimode step index fiber has a core refractive index of 1.46. Determine the optical loss in decibels due to Fresnel reflection at a fiber joint with:
i) A small air gap, ii) an index matching epoxy which has a refractive index of 1.40.
It may be assumed that the fiber axes and end faces are perfectly aligned at the joint. **(06 Marks)**

b. Explain different types of fiber splicing techniques. **(06 Marks)**

c. Briefly describe the principle of operation of the following:

i) Expanded beam connectors

ii) Fiber fused biconical taper coupler. **(08 Marks)**

PART – B

5 a. With a schematic diagram, explain the working of an optical receiver. **(06 Marks)**

b. What are the noise sources and disturbances that arise in optical pulse detection mechanism? Explain. **(08 Marks)**

c. Write a note on Burst-mode receivers. **(06 Marks)**

SHIRDI SAI ENGG COLLEGE

6 a. Explain multichannel A.M. technique employed in broadband analog applications. **(05 Marks)**

b. What is RF-over-fiber technique? Explain. **(05 Marks)**

c. What is rise time budget analysis? Derive an expression for the total system rise time budget in terms of transmitter fiber and receiver rise time. **(10 Marks)**

7 a. What is WDM? How is it implemented? **(05 Marks)**

b. Explain the design and operation of a polarization independent isolator. **(05 Marks)**

c. Explain the importance of the following active components used in WDM based on MEMS.
   i) Variable optical attenuators
   ii) Tunable optical filters. **(10 Marks)**

8 a. What are the applications of optical amplifiers? **(04 Marks)**

b. An EDFA is pumping 28mw of pump power at 970nm. If the gain at 1570 nm is 30 dB, determine maximum input and output signal power and also determine power conversion efficiency. **(06 Marks)**

c. Describe
   i) SONET/SDH frame formats
   ii) SONET/SDH Rings **(10 Marks)**

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2002 SCHEME

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EC82

Eighth Semester B.E. Degree Examination, Dec.09/Jan.10
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

Important Note: 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and/or equations written eg, 42+8=50, will be treated as malpractice.

1 a. What are the advantages of optical fiber communication? **(06 Marks)**

b. Calculate the number of modes of an optical fiber having diameter of 50μm, $n_1 = 1.48$, $n_2 = 1.46$ and $\lambda = 1.82\mu m$ **(06 Marks)**

c. With diagrams explain the following cable structures.
i) Two fiber cable.
ii) Six fiber cable. **(08 Marks)**

2 a. Derive an expression for pulse spreading and dispersion, which is a function of wavelength using time delay. **(08 Marks)**

b. For a single mode fiber $n_2 = 1.48$ and $\Delta = 0.2\%$ operating at $\lambda = 1320nm$, compute the waveguide dispersion if $V.\frac{d^2(V_b)}{dv^2} = 0.26$. **(04 Marks)**

c. Explain the design optimization of single mode fibers with respect to refractive index profile.
i) 1300nm – optimized fibers
ii) Dispersion – shifted fibers
iii) Dispersion flattened fibers. **(08 Marks)**

3 a. With the help of a neat diagram, explain the working of an edge emitting LED. Mention its special features and usage. **(06 Marks)**

b. A double hetero junction InGaAsP LED operating at 1310nm has radiative and non radiative recombination times of 30ns and 100ns respectively. The current injected is 40 mA. Calculate
i) Bulk recombination life time
ii) Internal quantum efficiency
iii) Internal power level. **(08 Marks)**

c. With schematic diagram explain the operation of avalanche photodiode, and explain the variation of E – field across diode. **(06 Marks)**

4 a. Show that the optical power coupled into a step index fiber due to an LED with Lambartian distribution is given by $P = P_S(NA)^2$ for $r_s \leq a$ with usual notations. **(08 Marks)**

b. For an optical source having refractive index of 3.6 coupled to a fiber of 1.48 refractive index. Considering the medium between fiber and source has similar index as that of fiber. Calculate Fresnel reflection and loss of power in dBs. **(04 Marks)**

c. With a neat diagram, explain the working of a straight sleeve connector. **(04 Marks)**

d. Explain the process of fiber-end-face preparation using controlled fracture technique with the help of a diagram. **(04 Marks)**

5 a. With the help of a schematic diagram explain the working of optical receiver. **(08 Marks)**

b. Discuss the possible sources of noise in optical receiver. **(06 Marks)**

c. Discuss the different types of preamplifiers in optical receiver. **(06 Marks)**

EC82

6 a. What is rise time budget? Explain its significance. Derive an expression for the total system rise time budget in terms of transmitter, fiber and receiver rise time. **(12 Marks)**

b. A transmitter has an output power of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6 dB/km and length 0.5 km. The link contains two connectors of 2dB average loss. The receiver has a minimum acceptable power (sensitivity) of -35dBm. The designer has allowed a 4 dB margin. Calculate the link power budget. **(08 Marks)**

7 a. With the help of a block diagram, explain the operation of optical amplifier. **(05 Marks)**

b. Explain 8 × 8 star coupler with neat diagram. **(05 Marks)**

c. A 32 × 32 star coupler is formed by interconnecting 2 × 2 couplers. If 5% of power is lost in each coupler element, calculate total loss in the coupler. **(04 Marks)**

d. Explain photonic switching with relevant diagram. **(06 Marks)**

8 Write short notes on :

a. Multichannel Amplitude Modulation

b. Sub-Carrier Multiplexing (SCM)

c. Wave length Division Multiplexing(WDM)

d. SONET /SD4 networks. **(20 Marks)**

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2002 SCHEME

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EC82

Eighth Semester B.E. Degree Examination, June-July 2009
Optical Fiber Communication

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions.*

1 a. Distinguish between
   i) Step-index and graded index fibers and
   ii) Single-mode and multimode fibers. **(06 Marks)**

   b. Show with neat diagrams the ray optics representation for the skew rays and meridional rays in a Step-index fiber and hence, derive an expression for numerical aperture of step-index fiber in terms of refractive index and maximum ray entrance angle. **(10 Marks)**

   c. 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 60 μm. Determine the normalized frequency for the fiber when the light at a wavelength of 0.9 μm is transmitted. Further, estimate the number of guided modes propagating in the fiber. **(04 Marks)**

2 a. Explain briefly the halide glass, active glass and chalgenide glass fibers. **(06 Marks)**

   b. With neat sketch, describe the vapour phase axial deposition method of drawing optical fibers. **(08 Marks)**

   c. Explain the three main mechanisms, which cause absorption of optical energy in fibers. **(06 Marks)**

3 a. What do you mean by material dispersion and waveguide dispersion? Describe briefly. **(06 Marks)**

   b. Write a note on mode-coupling in optical fibers. **(06 Marks)**

   c. Two step index fibers exhibit the following parameters
   i) A multimode fiber with a core refractive index of 1.50, a relative refractive index difference of 3% and an operating wavelength of 0.82 μm.
   ii) An 8 μm core diameter single mode fiber with a core refractive index the same as (i), a relative refractive index difference of 0.3% and an operating wavelength of 1.55 μm.
   Estimate the critical radius of curvature at which large-bending losses occur in both cases. **(08 Marks)**

4 a. Draw the cross-section diagram of GaAl As double-hetero-structure LED and energy band diagram and explain. **(06 Marks)**

   b. Show that the optical power emitted from the LED is $P = \frac{P\,int}{n(n+1)^2}$ where P_{int} is the internally generated optical power, n is the refractive index of LED material. **(08 Marks)**

   c. The radiative and non-radiative recombination lifetimes of the minority carriers in the active region of a double hetero junction LED are 60ns and 100ns respectively. Determine the total recombination lifetime and the power internally generated within the device when peak emission wavelength is 0.87 μm at a drive current of 40mA. **(06 Marks)**

5 a. Sketch the diagram of fabry-Perot resonator cavity for laser diode and describe. **(06 Marks)**

   b. For laser diode, prove that the number of photons per unit volume is

$$\phi_s = \frac{\tau_{ph}}{qd}(J - J_{th}) + \tau_{ph} R_{sp}$$ with the usual notations. **(08 Marks)**

c. Assuming exponential dependence of threshold current density on temperature, compare the ratio of the threshold current densities at 20°C and 80°C for a AlGaAs injection laser with T_o = 160K and the similar ratio for an I_n GaAsP device with T_o = 55K. **(06 Marks)**

6 a. Discuss the different lensing schemes used to improve the source-to-fiber coupling efficiency, with the necessary sketches. **(06 Marks)**

b. Describe the different aspects of fiber-to-fiber joints. **(06 Marks)**

c. With the schematic representation and energy band diagram explain the working of a pin photo diode. **(08 Marks)**

7 a. A silicon avalanche photo diode has a quantum efficiency of 65 percent at a wavelength of 900 nm. If 0.5 μw of optical power produces multiplied photo current of 10 μA, calculate the primary photo current and the multiplication for the camers generated in diode. **(04 Marks)**

b. Derive an expression for the total mean-square noise carriers in a photo detector. **(10 Marks)**

c. With the necessary block diagram, explain the digital signal transmission through an optical data link. **(06 Marks)**

8 a. Discuss the aspects of link-power budget and system rise time budget of optical communication system, with neat sketches. **(10 Marks)**

b. With neat sketches, explain the UPSR and BLSR architectures of SONET and SDH networks. **(10 Marks)**

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EC82

Eighth Semester B.E. Degree Examination, May / June 08
Optical Fiber Communications

Time: 3 hrs. Max. Marks:100

Note : ***Answer any FIVE full questions.***

1 a. Compare and contrast : i) Single mode v/s Multimode fibers. ii) Step – index v/s Graded index fibers. **(06 Marks)**

b. Discuss the necessary mathematical condition that the angle of incidence θ must satisfy for the optical rays to propagate in a dielectric slab wave-guide. **(08 Marks)**

c. A multimode step – index fiber with a core diameter of 80μm and a refractive index difference of 1.5% is operating at a wave length of 0.85μm. If the core refractive index is 1.48, estimate the normalized frequency for the fiber and the number of guided modes. **(06 Marks)**

2 a. Explain the three different mechanisms that cause absorption of optical energy in optical fibers. **(06 Marks)**

b. Explain the contributions of microscopic and macroscopic fiber bends towards the bending losses in optical fibers. **(06 Marks)**

c. Describe the material dispersion and wave guide dispersion. **(08 Marks)**

3 a. Draw the diagram of a typical GaAlAs double hetero-structure light emitter along with energy band diagram and refractive index profile and explain. **(10 Marks)**

b. Sketch and explain the Fabry – Perot resonator cavity of laser. **(10 Marks)**

4 a. An LED has a circular emitting area of radius 35μm and a Lambersian pattern with 1.50 W/cm^2 steradian of axial brightness for a given drive current. Out of two step index fibers used, one has core radius 25μm and NA = 0.20 and the other has core radius 50μm and NA = 0.20. Calculate the power coupled to each fiber from the LED and compare. **(06 Marks)**

b. Explain with the diagrams, the different lensing schemes used to improve source – to – fiber coupling efficiency. **(06 Marks)**

c. Explain any five design requirements of a good optical fiber connector and highlight its alignment schemes used during connection. **(08 Marks)**

5 a. Discuss with a neat diagram, how digital signal transmission takes place in a fiber transmission link. **(12 Marks)**

b. What are the noise sources and disturbances that arise in optical pulse detection mechanism? Describe. **(08 Marks)**

6 a. In order to design a simplex point-to-point link, what are all the choices available with regard to the components and their associated characteristics? Discuss. **(10 Marks)**

b. Draw the optical power loss model diagram for a point-to-point link and explain the concept of link power budget. **(06 Marks)**

c. Explain briefly the NRZ codes and RZ codes used in line coding. **(04 Marks)**

7 a. Draw the block diagram of basic elements of an analog link and explain. **(10 Marks)**

b. How is frequency division multiplexing adopted for multi channel amplitude modulation? Discuss with the help of a diagram. **(10 Marks)**

8 a. Write the frame structure of SDH. How do you get a basic data rate of 155.54 mbps for STM – 1? What is PDH? **(10 Marks)**

b. Draw the diagram of a passive linear – bus coupler and discuss the losses encountered. **(10 Marks)**

EC/TC-82

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NEW SCHEME

Eighth Semester B.E. Degree Examination, May / June 2006
EC / TC
Optical Fiber Communication

Time: 3 hrs.] [Max. Marks:100

Note: 1. ***Answer any FIVE full questions.***

1 a. List out limitations of optimal fiber communication systems. **(06 Marks)**

b. What is numerical aperture? Derive an expression for numerical aperture and maximum acceptance angle in the case of a step index optical fiber in terms of refractive indices of core and cladding material. **(08 Marks)**

c. A silica tube with inside and outside diameter of 6 mm and 8 mm respectively, is to have a certain thickness of glass deposited on the inner surface. What should the thickness of this glass deposition be if a fiber having a core diameter of 50 μm and an outer cladding diameter of 125 μm is to be drawn from this preform? **(06 Marks)**

2 a. Differentiate between intrinsic and extrinsic absorption. **(04 Marks)**

b. Derive an expression for the pulse spread due to material dispersion using group delay concept. **(10 Marks)**

c. The input power to an optical fiber is 2 mw while the power measured at the output end is 2 μw. If the fiber attenuation is 0.5 dB/km, calculate the length of the fiber. **(06 Marks)**

3 a. Using rate equations for photons and carriers (electrons), show that laser is a threshold device. **(08 Marks)**

b. With a neat diagram, explain the working of an edge emitting LED. Also mention its special features and usage. **(06 Marks)**

c. The radiative and non radiative recombination life times of minority carriers in the active region of a double hetero junction LED are 60 nsec and 90 nsec respectively. Determine the total carrier recombination life time and optical power generated internally if the peak emission wavelength is 870 nm and the drive current is 40 mA. **(06 Marks)**

4 a. Show that the optical power coupled into a step index fiber due to an LED with Lambartian distribution is given by: $P = P_s(NA)^2$ for $r_s \leq a$ with usual notations. **(08 Marks)**

b. An LED has a circular area of emission radius 35 μm and Lambartian emission pattern with axial radiance of 150 w/cm^2.sr. Compute the optical power coupled into an optical fiber having a core radius of 50 μm and NA = 0.20. **(06 Marks)**

c. Explain fusion splicing method with a neat sketch. **(06 Marks)**

5 a. Derive an expression for the carrier to noise ratio (CNR) of an analog optical communication system under limiting conditions of noise sources involved. **(12 Marks)**

b. Draw the optical path through a digital link with relevant components and optical/electrical wave forms at every stage. **(08 Marks)**

6 a. What is rise time budget? Explain its significance. Derive an expression for the total system rise time budget in terms of transmitter, fiber and receiver rise time. **(12 Marks)**

b. Following are the parameters of a point to point optical link:

i. Optical power launched : + 3 dBm
ii. Sensitivity of detector : -32 dBm
iii. Source / detector connector loss : 1 dB
iv. Length of optical cable : 60 km
v. Cable attenuation : 0.3 dB/km
vi. Jumper cable loss : 3 dB
vii. Connector loss at each fiber joint : 1 dB

Assume two jumper cables and two cable joints. Compute the power margin of the link using spread sheet method. **(08 Marks)**

7 a. Draw the basic structure of an STS-1 SONET frame. Bring out relations among STS, OC and STM frames. **(10 Marks)**

b. Explain the features of WDM and give an example of WDM component. **(10 Marks)**

8 Write short notes on :

a. Optical fiber cables
b. Fiber end preparation
c. PE line coding
d. Sub carrier multiplexing. **(20 Marks)**