Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 1

1. Light travels from air (n=1.00) to water (n = 1.33) at an incident angle of 40 degree. Calculate the refracted angle.
2. Given the speed of light in following types of glass, calculate the index of refraction for each one: -

   Barium flint: 1.89 X 10^8 m/s
   Spectacle crown: - 1.97 X 10^8 m/s
   Fused Quartz: - 2.06 X 10^8 m/s

3. Given electromagnetic waves in vacuum, determine wavelength for the following frequencies: 150Ghz, 225 Mhz , 14Thz.
4 A typical relative refractive difference for an optical fiber designed for long distance transmission is 1%. Estimate the NA and solid acceptance angle in air for the fiber, when the core index is 1.46. Further calculate the critical angle at the core cladding interface within the fiber.
5. A multimode step index fiber has a relative refractive index difference of 1%, and a core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3um is 1100. Estimate the diameter of fiber core.
6. A graded index fiber with a parabolic refractive index profile has a core refractive index of 1.5 and relative refractive index difference of 1%. Estimate the maximum core diameter, which allows single mode operation at a wavelength of 1.3m.
7. A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.50 and a cladding refractive index of 1.47.determine
(a) The critical angle at the core cladding interface;
(b) The NA for the fiber;
(c) The acceptance angle for the fiber.

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 2

1. An optical fiber in air has an NA of 0.4. Compare the acceptance angle for meridional rays with that for skew rays which change direction by 100 degree at each reflection.
2. The velocity of light in the core of a step index fiber is 2.01 X 10^8 m/s and the critical angle at the core cladding interface is 180 degree. Determine the numerical aperture 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 a vacuum is 2.998 X 10^3 m/s.
3. A step index fiber has a solid acceptance angle in air of 0.115 radians and a relative refractive index difference of 0.9%. Estimate the speed of light in the fiber core.
4. A step index fiber in air has a NA of 0.16, a core refractive index of 1.45 and a core diameter of 60 micrometer. Determine the normalized frequency for the fiber when light at a wavelength of o.9 micrometer is transmitted further, Estimate the number of guided modes propagating in the fiber.
5. A multimode graded index fiber has an acceptance angle in air of 8 degree. Estimate the relative refractive index difference between the core axis and the cladding when the refractive index at the core axis is 1.52.
6. A graded index fiber with the parabolic index profile supports the propagation of 742 guided modes. The fiber has a NA in air of 0.3 and a core diameter of 70 micrometer. Determine the wavelength of the light propagating in the fiber. Further estimate the maximum diameter of the fiber which gives single mode operation at the same wavelength.

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 3

1. Two step index fibers exhibit the following parameters:
a) A multimode fiber with a core refractive index of 1.5, a relative refractive index difference of 3% and an operating wavelength of 0.82 µm.
b) An 8um core diameter single mode fiber with a core refractive index same as (a), a relative refractive index difference of 0.3% and an operating wavelength of 1.55µm.. Estimate the critical bending radius of curvature at which large bending losses occur in both cases.
2. A multimode graded index fiber exhibits total pulse broadening of 0.1µm over a distance of 15 Km. Estimate:
a) Maximum possible bandwidth on the link assuming no intersymbol interference;
b) The pulse dispersion per unit length.
c) bandwidth-length product for the fiber.
3. Two polarization maintaining fibers operating at a wavelength of 1.3µm. have beat lengths of 0.7mm and 80m.Determine the modal birefringence in each case and comment on the results.
4. The difference between the propagation constants for the two orthogonal modes in a single mode fiber is 250. It is illuminated with light of peak wavelength 1.55µm. from an injection laser source with a spectral linewidth of 0.8nm. Estimate the coherence length within the fiber.
5. The mean optical power launched into an optical fiber link is 1.5mW and the fiber has an attenuation of 0.5dB/Km. Determine the maximum possible link length without repeaters when minimum mean optical power level required at the detector is 2µW.
6. Given below the following parameters for silica:
Fictive temperature =1400K
Isothermal compressibility = $7 \times 10^{11} m^{2} N^{-1}$
Refractive index = 1.46
Photo elastic coefficient = 0.286
Boltzman constant = $1.381 \times 10^{-23} Jk^{-1}$
Determine attenuation due to fundamental Rayleigh scattering in decibels per kilometer at a wavelength of 0.63ms.
7. A 6 Km optical link consists of multimode step index fiber with a core refractive index of 1.5 and a relative refractive index difference of 1%.Estimate:
(a) The delay difference between the slowest and fastest modes at the fiber output;
(b) The rms pulse broadening due to intermodal dispersion on the link;
(c) The maximum bit rate that may be obtained without substantial errors on the link assuming only intermodal dispersion.
(d) The bandwidth length product corresponding to (c).

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 4

1. A multimode step index fiber has a NA of 0.3 and a core refractive index of 1.45. The material dispersion parameter for the fiber is 250 ps /nm/Km which makes material dispersion the totally dominating intramodal dispersion mechanism. Estimate:
(a) The total rms pulse broadening per Km when the fiber is used with an LED source of rms spectral width 50 nanometer and
(b) The corresponding bandwidth length product for the fiber.
2. The beat length in a single mode optical fiber is 9 cm when light from an injection LASER with a spectral line width of 1 nm and a peak wavelength of 0.9 micrometer is launched into it. Determine the model birefringence and Estimate the coherence length in this situation. In addition calculate the Difference between the propagation constants for the two orthogonal modes and check the result.
3. The polarization mode dispersion in a uniformly birefringent single mode fiber is 300 ps /nm/Km. calculate the maximum bit rate that may be obtained on a 20 Km repeater less link assuming only polarization mode dispersion to occur.
4. A multimode graded index fiber has a refractive index at the core axis of 1.46 with the cladding refractive index of 1.45. The critical radius of curvature which allows large bending losses to occur is 84 micrometer when the fiber is transmitting light of a particular wavelength. Determine the wavelength of the transmitted light.

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 5

1. A planer LED is fabricated from gallium arsenide, which has a refractive index of 3.6.
a) Calculate the optical power emitted into air as a percentage of internal optical power for the device when the transmission factor at the crystal-air interface is 0.68.
b) When the optical power generated internally is 50% of the electrical power supplied, determine the external power efficiency.
2. The radiative and nonradiative recombination lifetimes of minority carriers in the active region of double hetrojunction LED are 60ns and 100ns respectively. Determine the total carrier recombination lifetime and the power internally generated within the device when the peak emission wavelength is 0.87um at a drive current of 40mA.
3. Calculate the ratio of the stimulated emission rate to the spontaneous emission rate for an incandescent lamp operating at a temperature of 1000K. It may be assumed that the average operating wavelength is 0.5 micrometer.
4. A ruby LASER contains a crystal length 4 cm with a refractive index of 1.78. The peak emission wavelength from the device is 0.55micrometer. Determine the number of longitudinal modes and their frequency separation.
5. Compare the approximate radiative minority carrier lifetimes in Gallium arsenide and Silicon when the minority carriers are electrons injected into the p-type region which has a hole concentration of 10^{18} cm^{-3}. The injected electron density is small compared with majority carrier density.

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 6

1. An LED operating at 1300 nm injects 25uW of optical power into a fiber. If the attenuation between the LED and photodetector is 40dB and photo detection quantum efficiency is 0.65, what is the probability that less electron-hole pairs are generated at detection in a 1 ns interval?
2. What do you mean by Bit Error Rate (BER)? What are its typical values? Derive expression for BER for typical optical receiver.
3. In a 100-ns pulse, 6×10^{6} photons at a wavelength of 1300nm fall on an InGaAs photo detector. On the average 5.4×10^{6} electron-hole pairs are generated. Find the quantum efficiency.
4. Photons of energy 1.53×10^{-19} J are incident on a photodiode which has responsivity of 0.65A/W. If the optical power level is 10uW, then find the generated photocurrent. For the wavelength range 1300nm < λ < 1600nm, the quantum efficiency for InGaAs is around 90%. Find the responsivity in this wavelength range.
5. A given silicon Avalanche photodiode has a quantum efficiency of 65% at a wavelength of 900nm. Suppose 0.5uW of optical power produces a multiplied photocurrent of 10uA.Find multiplication factor M. 124. If the photodiode capacitance is 3pF, the amplifier capacitance is 4pF, the load resistor is 1KΩ, the amplifier input resistance is 1MΩ, CT=7pF and RT=1KΩ, find the circuit bandwidth.

Department of Electronics and Communication

Subject: Optical Fiber Communication (TEC-701)
Branch: 4th Year

TUTORIAL 7

1. What do you mean by preamplifier? What are its various types? What are advantages and disadvantages of each type of preamplifier?
2. Discuss and draw optical transmitter Circuit. Explain the signal gets modulated and launched in the optical fiber.
3. What are sources of noise in optical receiver? Also write S/N ratio for typical optical receiver.
4. What are parameters considered for designing an optical receiver? Explain their importance.
5. What are various modulation techniques used in optical communication System? Explain any one in detail.
5. Write short notes:
a) Power budgeting
b) Mode theory
c) Optical transmitter circuit
7. What is meant by intensity modulation of an optical source? Give reasons for the major present use of direct intensity modulation of semiconductor optical sources and comment on possible alternatives.