MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 529: FIBER-OPTIC COMMUNICATION

DATE: 21/10/2020 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS)

a) Fiber optic communication system has emerged as a key communication system medium. Compared to traditional system media, highlight the circumstances under which fiber optic would be preferable (2 marks)

b) Draw the basic block diagram of optical fiber communication system. (3 marks)

c) What are the disadvantages of using a fiber optic cable as a transmission medium? Discuss any four. (4 marks)

d) Calculate the Numerical Aperture, acceptance angle and critical angle of the fiber having n_1 (Core refractive index) = 1.50 and refractive index of cladding n_2= 1.45. (6 marks)

e) You need to transmit data over an optical link of 100 km with fiber loss of 0.2 dB/km. The link has five splices with 0.05 dB loss per splice and two connectors with 0.2 dB per connector. The receiver sensitivity is 20 µW. Express the minimum transmitter power in both mW and dBm. (6 marks)

f) Consider an optical fiber of 50 µm diameter, core index n_1 = 1:5, and cladding index n_2 = 1:49

g) for operation at wavelength of 1:31m.

i. How many modes does this fiber support?

ii. What would be the pulse spread due to modal dispersion over a distance of 10 km?

iii. What would the maximum fiber diameter need to be for the fiber to operate with a single mode? (9 marks)

QUESTION TWO (20 MARKS)

a) Define critical angle. Derive an expression for the critical angle in terms of two refractive indices. (5 marks)

b) A fiber of 100-m length has P_{in} = 10 μW and P_{out} = 9 μW. Find the loss in dB/km. (3 marks)

c) A 3-km fiber optic system has an input power of 2 mW and a loss characteristic of 2 dB/km. Determine the output power of the fiber optic system. (5 marks)

d) A 2-km-length multimode fiber has a modal dispersion of 1 ns/km and a chromatic dispersion of 100 ps/km • nm. If it is used with an LED of linewidth 40 nm;

i. what is the total dispersion?

ii. Calculate the bandwidth (BW) of the fiber. (4 marks)

e) What is waveguide dispersion and what is its cause? (3 marks)

QUESTION THREE (20 MARKS)

a) Explain total internal reflection is using appropriate diagrams to illustrate. (3 marks)

b) Differentiate between microbending and macrobending losses. (3 marks)

c) A GRIN fiber with parabolic refractive index profile core has a refractive index at the core axis of 1.5 and relative index difference at 1%. Calculate maximum possible core diameter that allows single mode operations at $\lambda = 1.3$ μm. (5 marks)

d) Estimate cut-off wavelength for step index fiber in single mode operation. The core refractive index is 1.46 and core radius is 4.5 μm. The relative index difference is 0.25 %. (4 marks)

e) When mean optical power launched into an 8 km length of fiber is 120 μW, the mean optical power at the fiber output is 3 μW. Determine –

i. Overall signal attenuation in dB. (2 marks)

ii. The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB. (3 marks)

QUESTION FOUR (20 MARKS)

a) Briefly discuss the classification of optic fibers based on modes and the refractive index profile. (6 marks)

b) What is the pulse spreading when a laser diode having a 2 nm spectral width is used? Find the material-dispersion-induced pulse spreading at 1550 nm for an LED with a 75 nm spectral width. Take $\left|\lambda^2 . \frac{d^2 n}{d\lambda^2}\right|$ to be 0.03 for the laser diode and 0.025 for the LED. (4 marks)

c) The radiative and non radiative recombination life times of minority carriers in the active region of a double heterojunction 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. (4 marks)

d) Discuss the merits and demerits of using the LED as an optical source? (3 marks)

e) Discuss the merits and demerits of using the laser diode as an optical source? (3 marks)

QUESTION FIVE (20 MARKS)

a) A step-index fibre with a pure silica core has a core refractive index of 1.5000, a cladding refractive index of 1.4967, and is used to transmit light at 1.55 μm. The core radius is 5 μm.

i. How many modes can propagate in the fibre?

ii. Which are the two main causes of dispersion in this fibre?

iii. Determine the dispersion due to these two mechanisms

For waveguide dispersion, make the (realistic) assumption that the material dispersion can be neglected ($dn/d\omega=0$). (6 marks)

b) For an optical communications system, the transmitter and receiver operate at 2.5 Gb/sec NRZ (BNRZ) at a central wavelength of 1550 nm, using a laser with a spectral line width of $\Delta\lambda = 0.05$ nm. The fiber has a dispersion parameter of $M = -20$ ps/nm·km.

i. Calculate the pulse spread per unit distance (ps/km). (2 marks)

ii. What is the maximum length of fiber that allows the stated system bit rate? (3 marks)

iii. If the system were to operate at 10 Gb/sec NRZ, then what would be the required optical bandwidth $f_{3dB,optical}$? Hint: you don't need fiber length or $\Delta\lambda$ for this calculation. (4 marks)

c) Given the optical bandwidth of part c), then what would be the optical frequency spread in terms of $\Delta\lambda$? What would be the maximum fiber length? (5 marks)