(16)

B.Sc. Engg. (EEE), 6th Sem. May 14, 2024 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination
Course No.: EEE 4671
Course Title: Optoelectronics

Summer Semester, A. Y. 2022-2023
Time: 3 Hours
Full Marks: 150

There are **6 (six)** questions. Answer all of them. All questions carry equal marks. Marks of each question and corresponding COs and POs have been written in the brackets on the right margin. Programmable calculators are not allowed. Do not write on this question paper. All symbols bear their usual meaning. Assume reasonable values for missing data.

---

1. a) Discuss the deficiencies from which broad area semiconductor lasers suffer. Explain how gain guided semiconductor laser solves this problem. (7) (CO1) (PO1)

   b) State the use of gold stud in surface emitting LED along with the reason why epoxy is added in the etched well. (6) (CO1) (PO1)

   c) Explain how optical gain is achieved in stimulated emission. Describe optical feedback and threshold current in semiconductor laser. Show the basic structure of a semiconductor laser and Fabry-Perot cavity associated with it. (12) (CO1) (PO1)

2. a) Name some suitable dopants of core and cladding for silica based optical fibers. Explain depressed and raised cladding fibers with different index profiles. State the two stages for fabrication of telecommunication-grade silica fibers. (9) (CO1) (PO1)

   b) Explain four-wave mixing (FWM) in optical fiber. (5) (CO1) (PO1)

   c) State why external optical modulator is necessary for higher bit rates. Describe the operating principles of two types of external modulators. (11) (CO1) (PO1)

3. a) Determine the maximum achievable data rate for a loss-limited optical communication system operating at a wavelength of 1.3 μm. Given a transmission power of 1 mW, a net loss of 0.4 dB/km, an average number of photons per bit of 450, and a maximum transmission distance of 15 km. (9) (CO2) (PO2)

   b) Determine the bandwidth of a photodetector considering both transit time and RC time constant are 10 ps. Subsequently, with a sudden drop in bit rate to 10 Gb/s and a drift velocity of 10^5 m/s, calculate the depletion region width of the photodetector. (6) (CO2) (PO2)

   c) Show that the responsivity of LED, $R_{LED} = \eta_{tot} V_o$; where V_o is the voltage drop across the device. Find out the typical values of internal quantum efficiency for both direct and indirect bandgap semiconductors from their respective recombination times. (10) (CO2) (PO2)

4. a) Derive the expression of quantum efficiency of a photodetector in terms of absorption coefficient and slab width. Define cut-off wavelength from the wavelength dependence of the absorption coefficient. (10) (CO1) (PO1)

b) Explain the trade-off between bandwidth and responsivity of a photodetector. (6) (CO1) (PO1)

c) Explain how dispersion induced pulse broadening affects the receiver performance. Name the sources of power penalty. State the purpose of system margin in power budget. (9) (CO1) (PO1)

5. a) State the main difference between DFB and DBR laser and show their respective structures. (6) (CO1) (PO1)

b) State the reason what makes optical amplifier a better solution for WDM lightwave systems. Explain three possible applications of optical amplifiers in lightwave system. (8) (CO1) (PO1)

c) Explain - "Indeed, an optical amplifier is nothing but a laser without feedback". Compare between the main features and working principle of Raman and EDFA amplification. (11) (CO1) (PO1)

6. a) Compare the performance of a typical bus topology and passive star topology in a lightwave communication system by analyzing their respective subscriber capacity. Given an insertion loss of $\delta = 0.05$ and a fraction of power coupled at each tap $C = 0.05$, along with a transmitter power of 1 mW and available power at the Nth tap or user of 0.1 μW, determine the maximum number of subscribers that can be supported in each topology. (8) (CO2) (PO2)

b) Determine the refractive index of the gain medium required to achieve a facet reflectivity of 28% in a semiconductor laser. Then, calculate the responsivity of a p-i-n photodiode at both 1.3 μm and 1.55 μm wavelengths, given a quantum efficiency of 80%. Additionally, explain the underlying physical mechanisms responsible for the increased responsivity of the photodiode at 1.55 μm compared to 1.3 μm. Consider factors such as bandgap energy, absorption coefficient, and material properties in your analysis to provide a comprehensive understanding of the phenomenon. (7) (CO2) (PO2)

c) In a long-haul optical communication system operating at a wavelength of 1.3 μm with a targeted data rate of 1.5 Gb/s, an average power of 1 mW is coupled into the fiber. The system faces a fiber cable loss of 0.5 dB/km, inclusive of splice losses, with connectors at each end incurring 1 dB losses. Employing an InGaAs p–i–n receiver with a sensitivity of 250 nW, perform a comprehensive power budget analysis to account for various sources of losses and gains along the transmission path. Subsequently, estimate the optimal repeater spacing required to maintain signal integrity over the entire distance, considering factors such as amplifier noise, dispersion, and nonlinear effects. (10) (CO2) (PO2)