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M.Sc.TE.(2 Yr), 4th Sem. May 15, 2024

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

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination — Summer Semester, A. Y. 2022-2023
Course No.: EEE 6499 — Time: 3 Hours
Course Title: Laser Theory and Optical Communication — Full Marks: 150

There are **8 (eight)** questions. Answer **any 6 (six)** questions. All questions carry equal marks. Marks in the margin indicate full marks. Programmable calculators are not allowed. Do not write on this question paper. All symbols bear their usual meaning. Assume reasonable values for missing data.

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1. a) Show the basic structure of a semiconductor laser and Fabry-Perot cavity associated with it. Explain optical feedback and threshold current in semiconductor laser. Mention how optical gain is achieved in stimulated emission. 3+4+4

   b) Show the gain and loss profiles in semiconductor lasers involving longitudinal modes and lasing modes. 6

   c) Find the refractive index of the gain medium for 30% facet reflectivity in a laser. Mention why epoxy is added in the etched well and the reason behind using gold stud in surface emitting LED. 3+5

2. a) Explain the carrier confinement problem of homojunction. How does double heterostructure geometry solve this problem? 3+6

   b) Explain radiative and non-radiative recombination of semiconductor materials. Make a comparison of direct and indirect-bandgap semiconductors in terms of internal quantum efficiency through their respective recombination times. 4+6

   c) Define and explain external and total quantum efficiency using power-current characteristics of LED. 6

3. a) State the differences between SRS and SBS. Find a measure of polarization mode dispersion. 8

   b) 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. 2+6

   c) Define optoelectronic integration for optical receiver. Compare between the main features and working principle of Raman and EDFA amplification. 9

4. a) Define spontaneous and stimulated emission. Explain radiative and non-radiative recombination of semiconductor materials. Define and explain the wall-plug efficiency and responsivity from the power-current characteristics of LED. 12

   b) Explain the carrier confinement problem of homojunction. Explain how a slightly smaller bandgap of active layer assists in the light confinement process of heterostructure. 8

   c) Explain population inversion and threshold current for semiconductor laser operation. 5

5. a) Define timing jitter and frequency chirping. Explain trade-off between bandwidth and responsivity of a photodetector. 4+6

b) Find the bandwidth of the photodetector while both transit time and RC time constant are 100 ps. Mention what you would do to increase the bit rate of the system to 7 Gb/s. 6

c) Mention the reason why external optical modulator is necessary for higher bit rates. State the main differences between DFB and DBR laser. 3+6

6. a) How is p-i-n diode advantageous over p-n diode as a photodetector? Briefly mention the basic principle behind avalanche photodiode. 6+4

b) Draw the diagram of a digital optical receiver showing various components. Define receiver sensitivity and extinction ratio of an optical receiver. 4+4

c) Show typical point to point fiber links with periodic loss compensation. Compare between the operation of an optoelectronic repeater and optical amplifier in point-to-point fiber links. 3+4

7. a) Define extinction ratio and reflection feedback noise. Briefly discuss star topology in optical local area network (LAN). 8

b) Explain how dispersion induced pulse broadening affects the receiver performance. State the sources of power penalty. Mention the purpose of system margin in power budget. 3+3+2

c) Calculate the bit rate of a loss-limited light-wave system at 1.5 μm wavelength for which transmission power is taken to be 1.1 mW, net loss is 0.28 dB/km and average number of photons/bit is found as 500. Consider maximum transmission distance as 20 km. 9

8. a) Name the suitable dopants of core and cladding for silica based optical fibers. Mention the two stages for fabrication of telecommunication-grade silica fibers. Explain depressed and raised cladding fibers with different index profile. 10

b) Explain when a mode reaches cutoff using p and q parameters from Helmholtz equation in cylindrical coordinates. How does dry fiber assist in reducing extrinsic absorption loss? 5+3

c) Compare between TDM based digital hierarchies used in North America-Japan and Europe. Name the SONET equivalent of STM-64 and mention its channel number along with bit rate. 7