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

Date: May 4, 2023 (Morning)

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

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination
Course No.: EEE 6499
Course Title: Laser Theory and Optical Communication

Summer Semester, A. Y. 2021-2022
Time: 3 Hours
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) How is optical gain achieved in stimulated emission? Explain optical feedback and threshold current in semiconductor laser. Show the basic structure of a semiconductor laser and Fabry-Perot cavity associated with it. 3+4+4

   b) What are the deficiencies from which broad area semiconductor lasers suffer? How does gain guided semiconductor laser solve this problem? 6

   c) What will be the refractive index of the gain medium for 28% facet reflectivity in a laser? What is the use of gold stud in surface emitting LED and why is epoxy added in the etched well? 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 main difference between DFB and DBR laser and show their respective structures. 7

   b) What makes optical amplifier a better solution for WDM lightwave systems? Explain three possible applications of optical amplifiers in lightwave system. 2+6

   c) Compare between the main features and working principle of Raman and EDFA amplification. 5+5

4. a) Which are the suitable dopants of core and cladding for silica based optical fibers? Explain depressed and raised cladding fibers with different index profile. Mention the two stages for fabrication of telecommunication-grade silica fibers. 2+5+3

   b) Mention some applications of graded index fibers. Explain four wave mixing (FWM) in optical fiber. 3+7

   c) Compare between TDM based digital hierarchies used in North America-Japan and Europe. 5

5. a) Explain mean time to failure (MTTF) of an optical transmitter. Why should t_F exceed 10^5 hours for the optical source? 5

b) Describe the operating principles of two types of external modulators. 9

c) Why is external optical modulator necessary for higher bit rates? What makes packaging an important issue in the design of reliable optical transmitters? 6

d) Define optoelectronic integration. What is the functionality of photonic integrated circuit? 5

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) Briefly discuss ring and star topologies in optical local area network (LAN). 3+5

b) How does dispersion induced pulse broadening affect the receiver performance? What are the sources of power penalty? What is the purpose of system margin in power budget? 3+3+2

c) Find out the bit-rate of a loss-limited light-wave system at 1.3 μm wavelength for which transmission power is taken to be 1 mW, net loss is 0.4 dB/km and average number of photons/bit is found as 450. Consider maximum transmission distance as 15 km. 9

8. a) What is burn-in or accelerated aging? Briefly explain the issue of coupling stability in the design of reliable optical transmitters. 5

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. 6+3

c) Explain trade-off between bandwidth and responsivity of a photodetector. 5

d) What will be the bandwidth of the photodetector while both transit time and RC time constant being 10 ps? If the bit rate suddenly drops to 10 Gb/s for a drift velocity of 10^5 m/s, find out the depletion region width. 2+4