Jordan University of Science and Technology
Department of Electrical Engineering
Optical Fiber Communication Systems (EE555) Final Exam

Dr. Mansour Abbadi

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Q1

a- What are the three main fiber types? What is the effect of the following parameters on fiber dispersion (increasing or decreasing): core diameter, numerical aperture, and refractive index difference?

b- What are the three main characteristics of laser light? Mention one advantages and one disadvantage for LED and LD?

c- An InGaAsP LD has a bandgap energy of 0.8, an internal quantum efficieny of 0.9, and an external efficiency of 1 percent. The drive current is 20 mA. Find the emitted wavelength, and the external optical power emitted.

Q2

a- Draw a circuit diagram for a photodiode receiver and draw its equivalent circuit.

b- Mention two advantages and one disadvantage of pin and APD? What is the dominant noise generated by each of them?

c- An APD photodiode has a band-gap energy E_g = 0.75 eV, a quantum efficiency η = 0.9 and a multiplication ratio of M = 50. Calculate the generated photocurrent if the incident optical power is - 30 dBm at 1550 nm. For which wavelength windows this APD can be used?

Q3

a- What are the three key system requirements needed to design a point-to-point fiber optic link?

b- Mention three main characteristics (specifications) needed to carry out the design of a fiber optic link for the following components: optical source, optical fiber, and photodetector.

c- Choose an appropriate light source, fiber, and photodetector for the following two optical links: 1) 100 Km and 2.5 Gb/s link, 2) 10 Km and 5 Mb/s link.

Q4

A fiber link has the following components: A 1550 nm laser diode with a launched power of 1 mW, a spectral linewidth of σ_λ = 0.5 nm, and a rise time of t_{tx} = 100 ps. A 60 km multimode graded-index fiber cable with α_f = 0.5 dB/km including splice loss, a dispersion factor of D= 5 ps/(nm.km), a bandwidth-distance product B_o = 20 GHz.km (q = 0.7) and a connector loss of 1.5 dB. An APD–based receiver with a sensitivity of - 40 dBm and bandwidth B_{rx} = 2 GHz.

a) Show whether or not this fiber link fulfills the power budget and the rise- time budget for a 1000 Mb/s RZ data stream.

b) Suggest two solutions if one or both of the budgets are not fulfilled and recalculate the unfulfilled budget.

$$\lambda(\mu m) = \frac{1.24}{E_g(eV)}, \quad P_{int} = \eta_{int}\frac{hcI}{q\lambda}, \quad P_{ext} = \eta_{ext}P_{int}, \quad q = 1.6\times10^{-19}$$

$$h = 6.625\times10^{-34}, \quad c = 3\times10^{8}\ m/s$$

$$R_{pin} = \frac{\eta q\lambda}{hc}, \quad R_{APD} = M R_{pin}, \quad I_p = R_{pin}P_r, \quad I_M = MI_p$$

$$P_T = P_S - P_R \geq 2\alpha_c + \alpha_f L + 6\ dB\ \text{noise margin}$$

$$t_{sys} = \left[t_{tx}^2 + \left(\frac{440}{B_o}\right)^2 + (D\sigma_\lambda L)^2 + \left(\frac{350}{B_{rx}}\right)^2\right]^{\frac{1}{2}}, \quad t_{sys} \leq \begin{cases} 0.7\,T_b & \text{for NRZ} \\ 0.35\,T_b & \text{for RZ} \end{cases}$$