Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSENAME	:	OPTICAL COMMUNICATION
COURSE CODE	:	BEJ 41303
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS
		2. THIS FINAL EXAMINATION IS A **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK.**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Identify **TREE (3)** technologies that have been adopted in the following fiber optic communication systems.

(i) Third generation

(3 marks)

(ii) Fourth generation

(3 marks)

(b) A graded-index fiber having a parabolic index profile ($\alpha = 2$), a 25 um core radius, core refractive index of 1.48 and cladding refractive index of 1.46. Analyze the number of modes propagate in this fiber if operate at wavelength of 820 nm and 1300 nm.

(10 marks)

(c) The typical optical fiber has high loss when operate at wavelength of 1390 nm. Briefly explain the reason for this phenomenon.

(4 marks)

Q2 (a) Describes an optical feedback mechanism in a laser structure with appropriate diagram.

(4 marks)

(b) Explain the importance of double-heterojunction (DH) structure of LED.

(6 marks)

(c) A double heterojunction InGaAsP LED emitting at a peak wavelength of 1310 nm has radiative and nonradiative recombination times of 25 and 90 ns, respectively. This LED operates at the drive current of 35 mA. Calculate the internal quantum efficiency of LED.

(3 marks)

(d) An LED has an optical output, P_o of 0.25 mW when supply with a constant dc drive current. Analyze the optical power output if the LED is modulated at frequencies range from 20 MHz to 100 MHz. Assume the injected minority carrier lifetime of LED is 5.5 ns. (Hint : plot P(f)/Po against frequency with 20 MHz increment).

(7 marks)

Q3 (a) List **TWO (2)** and describe the primary characteristics of a light detector.

(4 marks)

(b) You are required to design a receiver of 50 MHz optical fiber link based on plastic optical fiber (POF) for short distance application using wavelength of 650 nm. The receiver should be able to achieve signal-to-noise ratio (SNR) better than 25 dB when the received optical power is -25.4 dBm at a temperature of 20° C. The specification of components can be found in **Table Q3**.

(i) Draw and label the equivalent circuit of the designed receiver.

(4 marks)

(ii) Determine the maximum load resistance.

(12 marks)

Q4 (a) With the help of a diagram, explain briefly the operation of Fiber Bragg grating (FBG).

(5 marks)

(b) A fiber Bragg grating (FBG) is developed within a fiber core which has a refractive index of 1.46. Determine the grating period for it to reflect an optical signal with a wavelength of 1.55 μm.

(2 marks)

(c) You are required to characterize a biconical-tapered coupler of unknown specification as shown in **Figure Q4**. The power injected from the laser source into the coupler is 5 mW. The measured output power shows a reading of 0.7 mW, 2.8 mW and 1.5 µW for P_2, P_3 and P_4, respectively. Determine the:

(i) Coupling ratio
(ii) Insertion loss
(iii) Excess loss
(iv) Directivity

(8 marks)

(d) Due to the deployment of 7,800 km Asia optical fiber based link submarine cable express that connects Japan, Philippines, Singapore and Malaysia, the Malaysian government has taken a step further in realizing high speed broadband throughout the region. In your opinion, explain the impact of high speed internet access in societal and global context.

(5 marks)

Q5 An optical fiber communication link (point-to-point) need to be laid for new telecommunication company. The transmission distance is 50 km with 10 Gbps non return zero (NRZ) optical signal. The bit error rate (BER) is 10^{-9} and the minimum system margin is 5 dB. **Table Q5** shows the characteristics of the optical network.
As an engineer you are required to:

(i) Draw and label the optical network using suitable block diagram.
(ii) Determine the power as well as the bandwidth budget.
(iii) Comment on the outcome of the design.

(20 marks)

- END OF QUESTIONS -

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Table Q3

PIN photodiode
Quantum efficiency: 60 %
Dark current: 3 nA
Amplifier
Noise figure: 5 dB

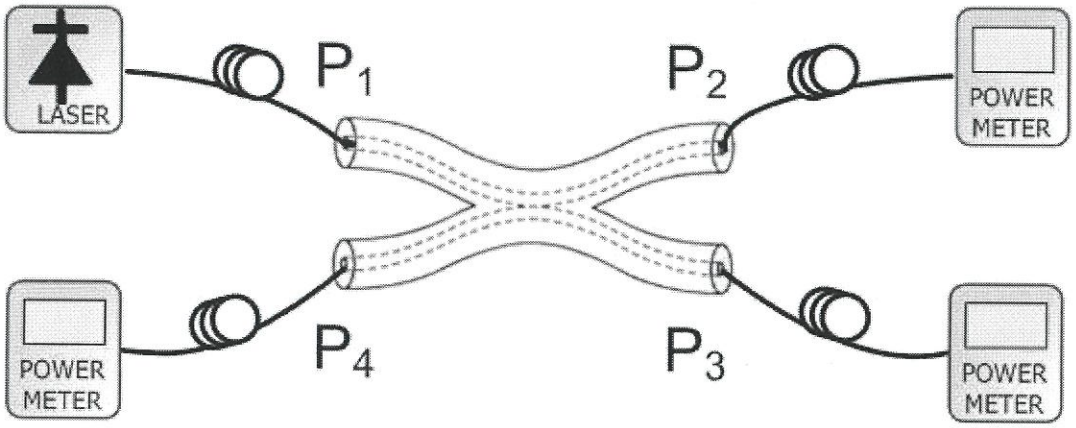

FIGURE Q4 : Biconical-tapered coupler

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Table Q5: Characteristic properties of the devices

Transmitter:	DFB laser λ=1580 nm, output power = 10 mW, rise time = 76 ps, spectral width = 0.7 pm, coupling loss to fiber = 7 dB.
Fiber:	Single mode fiber available lengths = 7 km, attenuation = 0.2 dB/km, dispersion = 20 ps/(km.nm)
Connectors:	Loss = 1 dB/connector (one at the transmitter and one at the receiver)
Splices:	Loss = 0.2 dB/splice
Detector:	InGaAs p-i-n RC- limited bandwidth = 4 GHz, coupling loss from the fiber = 1dB, receiver sensitivity = -25 dBm for BER= 10^{-9}