Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	FIBER OPTIC TECHNOLOGY
COURSE CODE	:	BNF 41102
PROGRAMME	:	BNF
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	2 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Discuss **THREE (3)** main reasons why optical fiber is a favored communication channel for long-haul communications as compared to copper channels.

(6 marks)

(b) As a consultant engineering technologist of company ABC, your customer needs to build up a new data link system at their new building. The customer required you to point out what fiber optic system is with the aid of a diagram. From your knowledge and experience, suggest to customer,

(i) Suggest the type of cable is suitable for their new building?

(2 marks)

(ii) Explain **TWO (2)** the characteristic of the cable list at **Q1(b)(i)**.

(4 marks)

(iii) Draw the diagram of basic communication system for the link as suggested for **Q1(b)**.

(4 marks)

(c) Differentiate (with the aid of a simple ray diagram) how an optical signal propagates inside:

(i) the single mode step index fiber
(ii) the multi-mode step index fiber
(iii) the multi-mode graded index fiber

Also, discuss the advantages and disadvantages of these types of fiber for the use as an optical communication system.

(9 marks)

Q2 (a) Light traveling in air strikes a glass plate at an angle $\theta_1 = 33°$, where θ_1 is measured between the incoming ray and the glass surface. Upon striking the glass, part of beam is reflected and part is refracted. If the refracted and reflected beams make an angle of 90° with each other, compute the followings. Given Snell's law: $n_i \sin\theta_i = n_r \sin\theta_r$.

(i) the refractive index of the glass

(5 marks)

(ii) the critical angle of the glass-air boundary

(4 marks)

(iii) the critical angle of glass-air boundary if $n_{air} = 1.2$ and $n_{glass} = 1.35$.

(3 marks)

(b) Referring to **Figure Q2 (b)**, a step-index fiber has a core index of refraction, $n_1 = 1.482$. The cut-off angle for light entering the fiber from air is found to be 7.86°. (Index of refraction air = 1, index of refraction water = 1.33).

(i) Determine the numerical aperture (NA) of the fiber.

(2 marks)

(ii) Determine the index of refraction of the cladding of this fiber, n_2.

(3 marks)

(iii) If the fiber were submersed in water, determine the new numerical aperture and cut-off angle.

(3 marks)

(c) A step index fiber has n_{core} = 1.45 and $n_{cladding}$ = 1.44 with diameter 50 μm, if the wavelength of the cable is 6.55 x 10^{-7}, estimate the number of propagating modes for the fiber. Given that $V = \frac{2\pi a}{\lambda}\sqrt{n_{core}^2 - n_{cladding}^2}$.

(5 marks)

Q3 (a) (i) Define responsivity and quantum efficiency of a photodiode.

(4 marks)

(ii) If a PIN photodiode has a quantum efficiency of 0.85 at 1550 nm, determine the responsivity. Given that, $R = \frac{\eta e \lambda}{hc}$ with e = 1.6x10^{-19}, h = 6.63x10^{-34} and c = 3x10^{8}.

(2 marks)

(b) A 2 x 2 fiber coupler has the input power of 200 μW, throughput power of 90 μW, coupled power of 85 μW and cross talk power of 6.3 μW. Compute the performance parameters of the fiber coupler in terms of

(i) coupling ratio,

(1 marks)

(ii) excess ratio,

(1 marks)

(iii) insertion loss, and

(2 marks)

(iv) cross talk.

(1 marks)

Given that;

$$Coupling\_ratio = \left(\frac{P_2}{P_1 + P_2}\right) \times 100,\ Excess\_ratio = 10\log\left(\frac{P_0}{P_1 + P_2}\right) dB,$$

$$Insertion\_loss = 10\log\left(\frac{P_0}{P_1}\right) dB, \text{ and } Cross\_talk = 10\log\left(\frac{P_3}{P_0}\right) dB.$$

(c) There are two splicing techniques used to join optical fiber, which are fusion splicing and mechanical splicing.

(i) Compare and discuss the difference between fusion splicing and mechanical splicing in terms of their loss, cost, performance, and time consumption.

(4 marks)

(ii) Discuss the possible application using each method in the optical field.

(2 marks)

(d) Several channels in a WDM system are indicated in **Figure Q3 (d)** in terms of their wavelength and their frequency spacing. The system is operating at 1550 nm. Given that $\frac{\Delta\lambda}{\lambda} = \frac{\Delta f}{f}$ and $f = c/\lambda$. Determine the wavelength spacing $\Delta\lambda$ and the number of channels that can be fit into the C-band if the frequency channel spacing Δf specified by the equipment manufacturer is

(i) 25 GHz
(ii) 50 GHz
(iii) 100 GHz
(iv) 200 GHz

(8 marks)

Q4 (a) UniFi is a broadband service by Telekom Malaysia (TM) that uses fiber optics to deliver high speed internet, phone, and internet protocol TB (IPTV) services to customers' home. From your understanding, illustrate the network configuration design from the central office to the in-home networks. Please also specify the type of lasers, fibers, number of users and the technology that is suitable to describe the UniFi systems.

(10 marks)

(b) A fiber system operates at the wavelength of 1300 nm, where the fiber loss is 0.5 dB/km. The LED light source emits 1.59 mW and couples into the fiber with a 16 dB loss. Connectors and splices in the system contributes a total loss of 6 dB. The receiver sensitivity is given as – 30 dBm. A 4 dB margin is specified to account for system degradations (such as aging of the LED). Conduct power budget analysis on the system and determine the maximum fiber length that can be used.

(5 marks)

(c) A transmitter has an output power of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6 dB/km and length 0.5 km. The link contains two connectors of 2 dB average loss. The receiver has a minimum acceptable power (sensitivity) of – 35 dBm. The designer has allowed a 4 dB margin. Conduct link power budget and determine whether the system can operate adequately.

(6 marks)

(d) **Table Q4 (d)** listed the parameters and specifications of a fiber optic link. Compute the system rise time and bandwidth. Given that $t_{sys} = \sqrt{\sum_{i=1}^{N} tr_i^2}$ and $BW = \frac{0.35}{t_{sys}}$.

(4 marks)

Table Q4 (d) Fiber link parameters

Component	**Bandwidth (MHz)**	**Rise time, *tr* (ns)**
Transmitter	200	1.75
LED (850 nm)	100	3.50
Fiber cable	90	3.89
PIN detector	350	1.00
Receiver	180	1.94

- **END OF QUESTION** -

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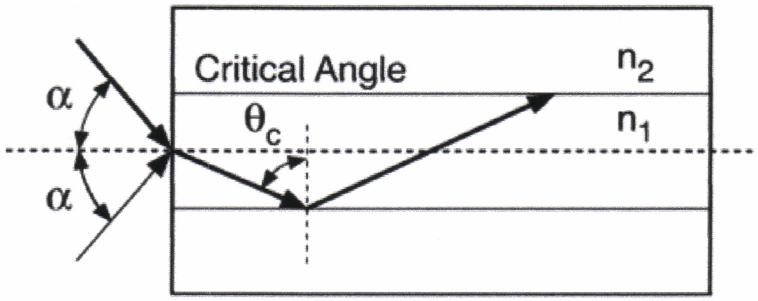

$$NA = n_0 sin\alpha = \sqrt{n_1^2 - n_2^2}$$

Full Acceptance Angle = 2α

Figure Q2 (b)

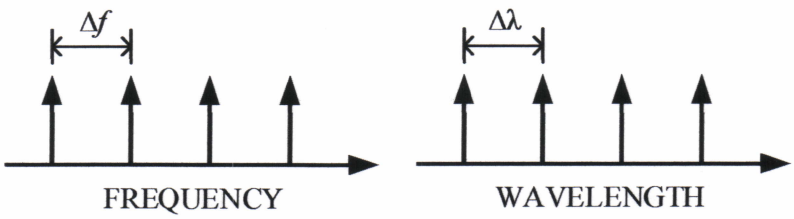

Figure Q3 (d)