UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2008/2009

SUBJECT NAME	:	APPLIED ELECTROMAGNETICS
SUBJECT CODE	:	BEE 3223
COURSE	:	3 BEE / 3 BEI
DATE OF EXAM	:	APRIL 2009
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS IN PART A. ANSWER ANY THREE (3) QUESTIONS ONLY IN PART B.

THIS QUESTION BOOKLET CONSISTS OF TEN (10) PRINTED PAGES

SOALAN DALAM BAHASA INGGERIS

PART A – COMPULSORY QUESTION (ANSWER ALL)

Q1 (a) Transmission lines are not suitable to be employed at high frequency applications. Discuss this drawback of transmission lines as compared to waveguides.

(2 marks)

(b) A 50-Ω lossless transmission line is connected to a load composed of a 75-Ω resistor in series with an inductor of unknown inductance as shown in Figure Q1(b). If at 10MHz, the voltage standing wave ratio on the line was measured to be 3, determine the inductance, *L*. Use calculation method.

(6 marks)

Q2 (a) An air-filled cubical cavity operates at a resonant frequency of 12.6 GHz when excited at TE_{101} mode.

(i) Design the dimensions of the cavity (i.e height, width and length of cavity)

(ii) Calculate the cavity bandwidth at the resonant frequency of 12.6 GHz if the Quality Factor of the cavity is 9, 512.

(8 marks)

Q3 (a) Determine the efficiency and power gain, G_p for an antenna with radiation resistance, R_{rad} = 18.8 Ω, effective resistance R_e = 0.4 Ω and directive gain, G_d = 200.

(4 marks)

(b) Differentiate between driven and parasitic elements in antenna array.

(4 marks)

Q4 (a) Using a suitable diagram, explain Snell's Law for refraction.

(4 marks)

(b) A radio wave moves from air (ε_r = 1) to glass (ε_r = 7.8) with angle of incidence 30°. Determine the angle of refraction.

(2 marks)

(c) For a dielectric ratio $\sqrt{\varepsilon_{r2} / \varepsilon_{r1}} = 0.4$ and an angle of incident is 18°, determine the critical angle.

(2 marks)

Q5 (a) Identify THREE (3) criteria for the system to be considered as electromagnetically compatible.

(3 marks)

(b) Discriminate the interference between unintended radar transmitter and digital computer signal transmission situations to a source, coupling path and receptor.

(5 marks)

PART B – ANSWER THREE (3) QUESTIONS FROM THIS PART

Q6 (a) Given a 50Ω transmission line with a load impedance of $60 - j50\,\Omega$. Design a 50Ω short circuit stub that will achieve the match. i.e.: Find the length of the line and how far it is from the load. Use Smith Chart.

(12 marks)

(b) Illustrate the concept of quarter-wavelength transformer matching technique with the help of a proper figure and formula.

(4 marks)

(c) If $\Gamma = 0.7\angle -80^\circ$ and $\lambda = 10\,\text{cm}$, find the locations of the first and second voltage maximum together with location of voltage minimum nearest to the load. Use calculation method.

(4 marks)

Q7 a) With the aid of diagram, explain why single mode propagation in the waveguide is highly desirable in microwave system.

(4 marks)

b) Differentiate between TE mode and TM mode.

(4 marks)

c) Given a hollow rectangular waveguide with width, $a = 3\,cm$ and height, $b = 2\,cm$

(i) Determine the cutoff frequencies for all modes, up to 7.8 GHz
(ii) Calculate the number of modes that the waveguide supports if the operating used is 7.8 GHz
(iii) Suggest TWO (2) steps that can be taken in such a way that the waveguide support single mode only
(iv) Over what frequency range will the waveguide support the propagation of a single mode?

(12 marks)

Q8 (a) Determine how much transmitted power for the half wavelength dipole if a magnetic field strength of 3 μA/m is required at a point on θ =π/2, which is 4 km from an antenna in air.

$$\text{Half-wavelength dipole, } |H\phi s| = \frac{I_o \cos\left(\frac{\pi}{2}\cos\theta\right)}{2\pi r \sin\theta}$$

(4 marks)

(b) The effective area of parabolic dish antenna is approximately equal to its physical aperture. If the directivity of a dish antenna is 30 dB at 10 GHz;

(i) Calculate its effective area, A_e.

(ii) Analyze the wavelength and directivity in absolute value and in dB if the frequency is increased to 30 GHz.

(6 marks)

(c) Construct using dipole antenna to produce the radiation pattern as described below. Explain for both antenna arrangement.

(i) Broad side

(ii) End fire

(10 marks)

Q9 A The Royal Armed Forces wishes to set up a line of sight communication between Kuala Lumpur and Kuantan. The distance between the two cities is around 250km. They plan to use antennas with power gain of 13 dB for the link for both transmitting and receiving station. The transmitting antenna will be fed with 5W of power at carrier frequency of 300MHz. After conducting a site survey, a knife edge hill with height of 800 meter is found located 125km from the transmitter in Kuala Lumpur. It will become a major obstruction to the line of sight that already planned.

(a) Determine the free space loss

(2 marks)

(b) Determine the Knife edge loss, L_{ke} cause by the hill if both transmitter and receiver are 30 meters above sea level.

(4 marks)

(c) Calculate the total path loss due to free space loss and knife-edge loss.

(2 marks)

(d) Calculate power received, P_R at the receiving antenna. Compared this value with the theoretical free space received power if an obstruction did not exist.

(5 marks)

(c) A general design rule for microwave links is 55% clearance of the first Fresnel zone.

(i) Find the maximum first Fresnel zone radius
(ii) Find the Fresnel zone clearance that required for this system
(iii) Propose the suitable height of the transmitter and receiver tower, so that the diffraction loss due to knife-edge effect can be negligible. Assume same transmitter and receiver height.

(7 marks)

Q10 (a) One of the reasons to consider electromagnetic compatibility is to achieve the desired functional performance of a digital circuitry system. Recommend the control techniques of electromagnetic interference while designing the system. Draw the appropriate figures to explain the techniques.

(10 marks)

(b) Draw the block diagrams to illustrate FOUR (4) basic of EMC subproblems.

(4 marks)

(c) Propose radiated emission measurement setup using ONE (1) of the following measurement facilites below

(i) Open Area Test Site
(ii) GTEM Cell
(iii) Anechoic Chamber

(6 marks)

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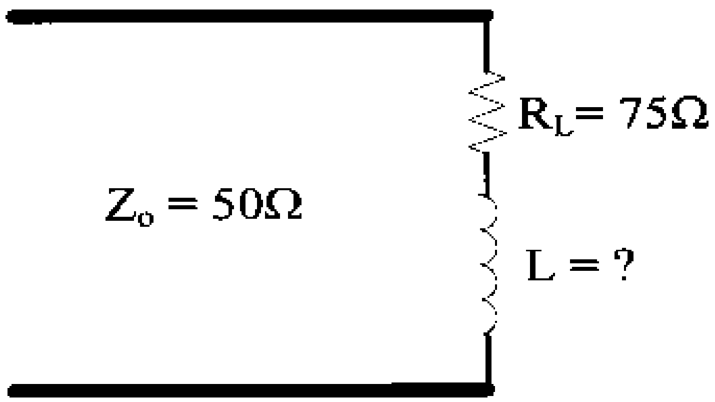

FIGURE Q1(b)

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FORMULAS

IMPORTANT EQUATIONS FOR TM AND TE MODES

TM Modes	TE Modes
$E_{xs} = -\frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$E_{xs} = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$E_{ys} = -\frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$E_{ys} = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$E_{zs} = E_o \sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$E_{zs} = 0$
$H_{xs} = \frac{j\omega\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$H_{xs} = \frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$H_{ys} = -\frac{j\omega\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$H_{ys} = \frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$H_{zs} = 0$	$H_{zs} = H_o \cos\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$\eta = \eta'\sqrt{1-\left(\frac{f_c}{f}\right)^2}$	$\eta = \frac{\eta'}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$

α_c for TE_{mn} modes where $n \neq 0$:

$$\alpha_c|_{TE} = \frac{2R_s}{b\eta'\sqrt{1-\left[\frac{f_c}{f}\right]^2}}\left[\left(1+\frac{b}{a}\right)\left[\frac{f_c}{f}\right]^2 + \frac{\frac{b}{a}\left(\frac{b}{a}m^2+n^2\right)}{\frac{b^2}{a^2}m^2+n^2}\left(1-\left[\frac{f_c}{f}\right]^2\right)\right]$$

α_c for TE_{10} mode:

$$\alpha_c|_{TE_{10}} = \frac{2R_s}{b\eta'\sqrt{1-\left[\frac{f_c}{f}\right]^2}}\left(\frac{1}{2}+\frac{b}{a}\left[\frac{f_c}{f}\right]^2\right)$$

α_c for TM modes:

$$\alpha_c|_{TM} = \frac{2R_s}{b\eta'\sqrt{1-\left[\frac{f_c}{f}\right]^2}}\frac{(b/a)^3m^2+n^2}{(b/a)^2m^2+n^2}$$

α_d for both TE and TM modes:

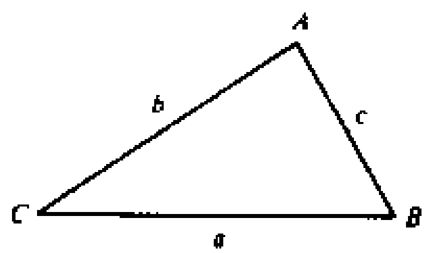
$$\alpha_d = \frac{\sigma\eta'}{2\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}[\cos(A-B) - \cos(A+B)]$$

$$\cos A \cos B = \frac{1}{2}[\cos(A-B) + \cos(A-B)]$$

For any plane triangle ABC:



$$c^2 = a^2 + b^2 - 2ab(\cos C) \quad \text{(Cosine Law)}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \quad \text{(Sine Law)}$$

For a lossless line,

$$Z_{in} = Z_o\left[\frac{Z_L + jZ_o \tan\beta\ell}{Z_o + jZ_L \tan\beta\ell}\right]$$

The Complete Smith Chart

Black Magic Design

STUDENT NAME :
MATRIC NO :