UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

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

THIS PAPER CONSISTS OF EIGHT PAGES

PART A

Q1 (a) One technique for impedance matching is stub matching. Discuss briefly with the help of a proper figure.

(5 marks)

(b) If $\Gamma = 0.5\angle -60°$ and $\lambda = 24\,\text{cm}$, find the locations of the voltage maximum and minimum nearest to the load. Use calculation method.

(3 marks)

Q2 (a) Design a rectangular waveguide with an aspect ratio of 3 to 1 for use in the K-band (18 - 26.5 GHz). Assume that the waveguide is air filled.

(4 marks)

(b) A standard air filled rectangular waveguide with dimensions $a = 8.636\,\text{cm}$, $b = 4.318\,\text{cm}$ is fed by a 4 GHz carrier from a coaxial cable.

(i) Determine if a TE_{10} mode will be propagated. Justify your answer.
(ii) Calculate phase velocity, u_{ph}

(4 marks)

Q3 (a) Calculate the power gain both in absolute and dB for a half-wave dipole with efficiency of 0.90.

(4 marks)

(b) Analyze briefly the voltage and current distribution along a half-wave dipole supported with an appropriate figure.

(4 marks)

Q4 (a) Explain the difference between 'attenuation' and 'absorption' in radio wave propagation.

(4 marks)

(b) For a semi-rough surface to act like a smooth/specular surface, explain the condition that it must fulfill.

(2 marks)

(c) Differentiate between Line-of-Sight and Non-Line-of-Sight.

(2 marks)

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

(3 marks)

(b) Distinguish the interference between mobile phone and digital computer signal transmission situations to a source, coupling path and receptor. Explain briefly the situation.

(5 marks)

PART B

Q6 (a) A stub length of 0.12λ is used to match a $60\,\Omega$ lossless line to a load. If the shorted-stub is located at 0.3λ from the load, calculate:

(i) the load impedance, Z_L
(ii) the length of an alternative stub and its location from the load.
(iii) the standing wave ratio between the stub and the load, S

(15 marks)

(b) A $50\,\Omega$ lossless transmission line uses an insulating material with $\varepsilon_r = 2.25$. When terminated in an open circuit, how long should the line be for its input impedance, Z_{in} to be equivalent to a 10 pF capacitor at 50 MHz?

(5 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) Distinguish between TE mode and TM mode.

(4 marks)

(c) In air filled rectangular waveguide, the cutoff frequency of a TE_{10} mode is 5 GHz, whereas that TE_{01} mode is 7.5 GHz.

(i) Determine the dimensions of the waveguide. (4 marks)

(ii) Calculate the number of modes that the waveguide supports if the operating used is 7.8 GHz .

(2 marks)

(iii) Suggest TWO (2) steps that can be taken in such a way that the waveguide support single mode only.

(4 marks)

(iv) Over what frequency range will the guide support the propagation of a single dominant mode?

(2 marks)

Q8 (a) Describe the major lobe, side lobes, back lobes and nulls for an antenna.

(4 marks)

(b) Design a five-element Yagi-Uda array from the basic dipole for a frequency of 200 MHz. Illustrate your design by indicating the length and spacing for driven and parasitic elements.

(6 marks)

(c) A probe measured 2μV/m of field strength 100 km away from a parabolic antenna with directive gain of 1000 and efficiency of 0.85. Calculate

(i) The power gain

(ii) The EIRP of the parabolic antenna.

(iii) The radiated power, P_{rad} and input power, P_{in}

(iv) The distance of the probe if an isotropic antenna is used for the same amount of field strength.

(10 marks)

Q9 A communication link between the headquarters in city A to a subsidiary outlet in city B which is 60 kilometres away is going to be set up. The communication link will utilize the newly acquired 4 GHz spectrum for transmission and a 20 dBW transmitter and 15 dBi gain antennas for both transmitter and receiver station. During the site survey, a knife edge hill with height of 40 metres from sea level is found located at the middle of the proposed communication path.

(a) Find the height of the proposed transmitter and receiver tower so that the diffraction loss can be negligible. Assume the same transmitter and receiver height.

(7 marks)

(b) If both the transmitting and receiving tower is only 15 metres in height from sea level, calculate the loss due to the obstacle.

(5 marks)

(c) Calculate the free space loss in between the communication link.

(2 marks)

(d) Find the effective isotropic radiated power (EIRP) of the transmitter in dBW and Watt.

(3 marks)

(e) Find the received power, P_R, at the receiver in dBW and Watt. Assume there are no other losses in the system.

(3 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 facilities below:

(i) Open Area Test Site

(ii) GTEM Cell

(iii) Anechoic Chamber

(6 marks)

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FORMULAS

IMPORTANT EQUATIONS FOR TM AND TE MODES

TM Modes	TE Modes
$Exs = -\frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$Exs = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$Eys = -\frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$Eys = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$Ezs = E_o \sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$Ezs = 0$
$Hxs = \frac{j\omega\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$Hxs = \frac{j\beta}{h^2}\left(\frac{m\pi}{a}\right)H_o \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$Hys = -\frac{j\omega\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$	$Hys = \frac{j\beta}{h^2}\left(\frac{n\pi}{b}\right)H_o \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$Hzs = 0$	$Hzs = H_o \cos\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma z}$
$\eta = \eta'\sqrt{1-\left(\frac{f_c}{f}\right)^2}$	$\eta = \frac{\eta'}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$

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:

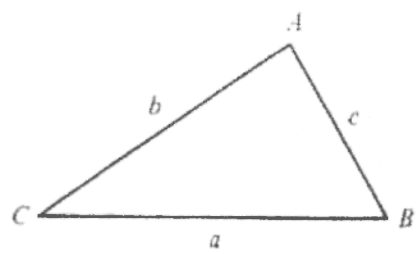
$$\alpha_d = \frac{\sigma\eta'}{2\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

Trigonometric Identities

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

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

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 open circuit line,

$$Z_{in}^{oc} = -jZ_o \cot \beta \ell$$

The Complete Smith Chart

Black Magic Design