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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	APPLIED ELECTROMAGNETICS
COURSE CODE	:	BEB30603
PROGRAMME	:	3 BEJ
EXAMINATION DATE	:	DECEMBER 2014/JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) A 140 Ω lossless transmission line is terminated with a load impedence of $Z_L = 280 + j182\ \Omega$. If the operating wavelength $\lambda = 72$ cm, find

(i) the reflection coefficient,

(2 marks)

(ii) the voltage standing wave ratio,

(2 marks)

(iii) the location of the first voltage maximum, and

(2 marks)

(iv) the location of the first voltage minimum.

(2 marks)

(b) It is given that the voltage standing wave ratio S=3 exists on a 50 Ω transmission line, that the first voltage minimum occurs at 5 cm from the load, and that the distance between successive minima is 20 cm. Using the Smith chart, find the load impedence.

(8 marks)

(c) Standing waves are sinusoidal patterns that are caused by the interference between the incident and reflected waves. Draw and discuss voltage standing wave patterns for

(i) a matched load,

(3 marks)

(ii) a short-circuited line, and

(3 marks)

(iii) an open-circuited line.

(3 marks)

Q2 (a) Outline the differences between transmission lines and waveguides in terms of propagation modes, losses at microwave frequencies and operating frequencies.

(6 marks)

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

(i) Show that a TE_{10} mode will propagate in the waveguide.

(3 marks)

(iii) Calculate both the phase velocity and the group velocity for the TE_{10} mode. Then, draw a conclusion regarding all types of velocity that exist in the waveguide.

(5 marks)

(c) By stating your assumption, calculate the lowest resonant frequency of air-filled rectangular cavity resonator of dimension 5-by-4-by-10 cm.

(4 marks)

(d) A rectangular waveguide has a dimension of 2.5-by-1 cm and is filled with a medium characterized by $\sigma = 0$, $\varepsilon = 4\varepsilon_0$, $\mu_r = 1$.

(i) Determine the cutoff frequency of the waveguide.

(3 marks)

(ii) Estimate the range of frequencies over which the lowest mode for both TE and TM will propagate.

(4 marks)

Q3 (a) (i) Define the term 'isotropic antenna'.

(2 marks)

(ii) Power density of an isotropic antenna is inversely proportional to the square of the radius, r of a sphere. Illustrate that concept with the aid of a diagram.

(3 marks)

(b) Consider a transmit antenna where the values of the radiation resistance $R_{rad} = 85.75\ \Omega$, the effective antenna resistance $R_e = 15.5\ \Omega$, the directive gain $G_d = 14.5$ and the input power P_{in}=125 W;

(i) Calculate the radiation/antenna efficiency.

(2 marks)

(ii) Determine the antenna gain, G_p (absolute and dB).

(2 marks)

(iii) Calculate the radiated power in Watts, dBm and dBW.

(3 marks)

(iv) Calculate the effective isotropic radiated power (EIRP) in Watts. Based on the EIRP result, evaluate the performance of the transmit antenna in comparison to the isotropic antenna.

(3 marks)

(c) A 2 m diameter parabolic reflector is employed at the Control Tower of Subang International Airport with 10 Watt of power radiated by the fed mechanism operating at 6 GHz with transmit antenna efficiency of 55%, Determine the:

(i) beamwidth,

(2 marks)

(ii) transmit power gain and receive power gain (dB), and

(2 marks)

(iii) effective isotropic radiated power (EIRP).

(2 marks)

(iv) Predict the performance of the parabolic antenna in Q3(c) if the transmit efficiency is increased to 65%.

(4 marks)

Q4 (a) Explain the meaning behind the two logos shown in Figure 4(a)? Determine the difference between the two logos.

(4 marks)

(b) Describe the difference between the initial E M I and E M C.

(3 marks)

(c) A worker in a welding factory nearby is performing some welding job while you are listening to a radio program. You noticed that every time the welding machine is fired, the sound from the radio is filled with noise.

(i) Identify the source, the receptor and the coupling path.

(4 marks)

(ii) Explain the phenomena in relation to the equivalent EMC Tests.

(3 marks)

(iii) Suggest a method to prevent the interference

(3 marks)

(d) EMC measurements using Open Area Test Site (OATS) involves moving antennas vertically (height scans).

(i) With the aid of a diagram, explain why it is necessary to move the antennas vertically in the OATS.

(4 marks)

(ii) Propose a method of how the height scans can be omitted.

(4 marks)

Q5 (a) Using the radar range equation for a point target, analyse the effect of modifying radar characteristics (i.e., the antenna gain, transmitter power, and transmitter wavelength) on the received power for a given target at a specified range. Include any assumptions you take into consideration.

(6 marks)

(b) (i) With the aid of diagrams, show the antenna feeding arrangement for amplitude-comparison monopulse radar.

(2 marks)

(ii) Explain the basic principle of the radar in Q5(b)(i).

(5 marks)

(c) With the aid of a diagram, explain the following for a pulse radar:

(i) pulse length,
(ii) pulse repetition frequency, and
(iii) interpulse period.

(4 marks)

(d) The transmitters pulse width of a pulsed radar is 1.5 μs and the duplexer's recovery time is 0.5 μs. Determine:

(i) the location of the antenna of an airplane to be unambiguously detected by the radar, and

(3 marks)

(ii) the minimum interpulse period of the second target so that both targets can be distinctly detected, and its corresponding range. Decide the determining factors for the maximum unambiguity range that radar could detect.

(5 marks)

- END OF QUESTION –

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FIGURE Q4(a)

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USEFUL EQUATIONS:

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta\ell}{Z_0 + jZ_L \tan \beta\ell} \right]$$

TM mode:

$$E_x = -\frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)E_0 \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma Z} \qquad H_x = \frac{j\omega\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_0 \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma Z}$$

$$E_y = -\frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)E_0 \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma Z} \qquad H_y = -\frac{j\omega\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_0 \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma Z}$$

$$E_z = E_0 \sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma Z} \qquad H_z = 0$$

TE mode:

$$E_x = \frac{j\omega\mu}{h^2}\left(\frac{n\pi}{b}\right)H_0 \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma Z} \qquad H_x = \frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)H_0 \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma Z}$$

$$E_y = -\frac{j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)H_0 \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma Z} \qquad H_y = \frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)H_0 \cos\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)e^{-\gamma Z}$$

$$E_z = 0 \qquad H_z = H_0 \cos\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)e^{-\gamma Z}$$

$$l_{max} = \frac{\theta_r \lambda}{4\pi} + \frac{n\lambda}{2}$$

$$f_c = \frac{u'}{2}\sqrt{\left[\frac{m}{a}\right]^2 + \left[\frac{n}{b}\right]^2} \qquad u' = \frac{1}{\sqrt{\mu\varepsilon}}$$

$$f_r = \frac{u'}{2}\sqrt{\left[\frac{m}{a}\right]^2 + \left[\frac{n}{b}\right]^2 + \left[\frac{p}{c}\right]^2}$$

$$u_p = \frac{u'}{\sqrt{1-(f_c/f)^2}} \qquad u'^2 = u_p u_g$$

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Table 1: Transmission line parameters

Parameter	Two-wire line	Coaxial line
R' (Ω/m)	$\frac{1}{\pi a}\sqrt{\frac{\pi f \mu_c}{\sigma_c}}$	$\frac{1}{2\pi}\left[\frac{1}{a}+\frac{1}{b}\right]\sqrt{\frac{\pi f \mu_c}{\sigma_c}}$
L' (H/m)	$\frac{\mu}{\pi}\cosh^{-1}\left(\frac{D}{2a}\right)$	$\frac{\mu}{2\pi}\ln\frac{b}{a}$
G' (S/m)	$\frac{\pi\sigma}{\cosh^{-1}\left(\frac{D}{2a}\right)}$	$\frac{2\pi\sigma}{\ln\left(\frac{b}{a}\right)}$
C' (F/m)	$\frac{\pi\varepsilon}{\cosh^{-1}\left(\frac{D}{2a}\right)}$	$\frac{2\pi\varepsilon}{\ln\left(\frac{b}{a}\right)}$
Z_0 (Ω)	$\frac{120}{\sqrt{\varepsilon_r}}\ln\frac{2D}{d}$ if $D \gg d$	$\frac{60}{\sqrt{\varepsilon_r}}\ln\frac{b}{a}$

Nama / Name: ____________________

No Matrik / Matric No. : ____________________ No KP / IC No.: ____________________

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The Complete Smith Chart