CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	APPLIED ELECTROMAGNETICS
COURSE CODE	:	BEE3223/BEX31903
PROGRAMME	:	BEE
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Define lossless and distortionless line.

(4 marks)

(b) A 50 Ω lossless transmission line is terminated with an unknown load impedance, which comprises of resistive and capacitive elements. It is found that the standing wave ratio is 3.0. The successive voltage minima are 25 cm apart, and the first minimum occurs at 5 cm from the load, where it is closer to the load compared to the first maximum. By using suitable mathematical equations, figure out the values for:

(i) the reflection coefficient, and

(7 marks)

(ii) the load impedance.

(3 marks)

(c) A single shorted parallel stub is used to match the line to its normalised load as shown in **Figure Q1(c)**. Using the Smith Chart, determine the distance, d_s and length, l_s of the stub from the load.

(4 marks)

(d) (i) Given a high-frequency RG-55/U coaxial cable with inner radius of 0.5 mm and outer radius of 2.95 mm, determine the values for the capacitance and inductance per unit length of the cable.

(3 marks)

(ii) The coaxial cable in **Q1(d)(i)** is not lossless but the losses are small, resulting in an attenuation of 0.5 dB/m at 10 GHz. Assuming the dielectric in the cable is perfect, determine the resistance per unit length that causes the losses in the conductors.
(Note: ε_r = 2.25, and μ_r = 1)

(4 marks)

Q2 (a) Differentiate the cases of cutoff, evanescent and propagation of a waveguide.

(6 marks)

(b) Specify the minimum dimensions of an air-filled rectangular waveguide so that it will operate at single mode over the frequency range of 15 GHz to 20 GHz.

(5 marks)

(c) By stating your assumption, calculate the lowest resonant frequency of a rectangular cavity resonator of dimension 2-by-1-by-3 cm.

(4 marks)

(d) A rectangular waveguide has a dimension of 5-by-3 cm and is filled with teflon ($\varepsilon_r = 2.1$).

(i) Determine the maximum operating frequency such that only TEM mode will propagate.

(3 marks)

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

(2 marks)

(iii) Calculate both the phase velocity and the group velocity for the dominant mode at the operating frequency of 4.5 GHz. Then, draw a conclusion regarding all types of velocity existing in the waveguide.

(5 marks)

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

(3 marks)

(ii) Next, examine the power density of an isotropic antenna at two different locations from the point source.

(3 marks)

(b) As a telecommunication engineer, you are asked to choose a suitable frequency between 10 and 40 GHz for a specific application. If the atmospheric absorption (refer **Figure Q3(b)**) is the sole factor in determining your choice of frequency, suggest and explain the appropriate frequency.

(4 marks)

(c) A transmitter and a receiver are separated by 10 km operate at 400 MHz and are at the same height above ground.

(i) Relative to the transmitter, estimate how much lower must an absorbing diffracting obstacles at the centre of the path be for negligible diffraction loss.

(4 marks)

(ii) Next, calculate the diffraction loss produced when the obstacle is increased to 10 m above the transmitter height.

(4 marks)

(iii) If the height of the obstacle keeps increasing, provide feasible solutions to make sure diffraction loss is within reasonable values.

(2 marks)

(d) Explain the mechanism of refraction with reference to the skywave propagation.

(5 marks)

Q4 (a) A transmitter radiates 100W of power at a frequency of 50 MHz to allow the space wave propagation to take place. The transmitting antenna has a gain of 5 and its height is 50m. The receiving antenna height is 2 m and the effective aperture is 3 m^2. It is estimated that field strength of 100 V/m is required to give a satisfactory result. Calculate:

(i) the distance between transmitter and receiver over average terrain, and

(2 marks)

(ii) the received power (in dBW) at the receiver, considering only the free space path loss.

(6 marks)

(b) Discuss the possible propagation mode for radio wave of below 2 MHz.

(5 marks)

(c) Differentiate the available methods to control EMI, and select one method that you think is the best.

(6 marks)

(d) Explain the radiated and conducted emission, and also the test methods for both.

(6 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) Then, explain the basic principle of this radar.

(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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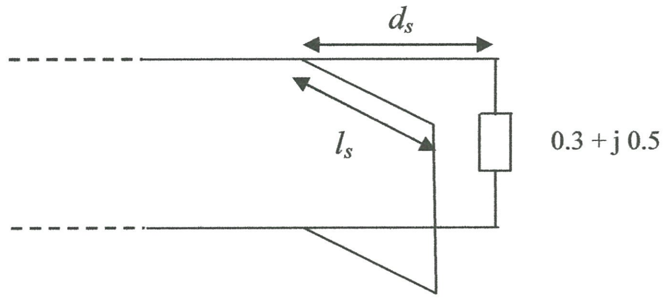

FIGURE Q1(c)

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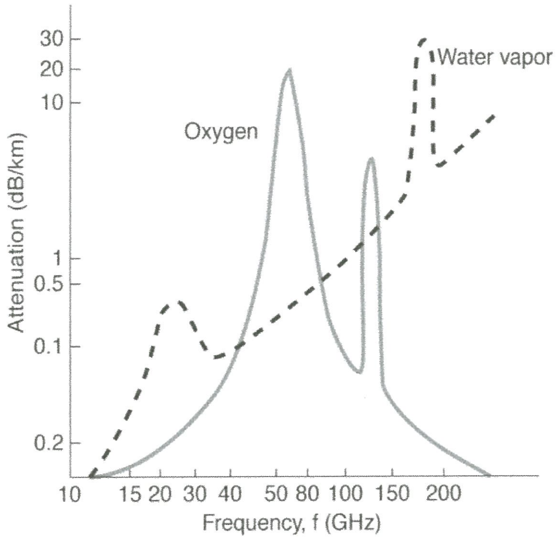
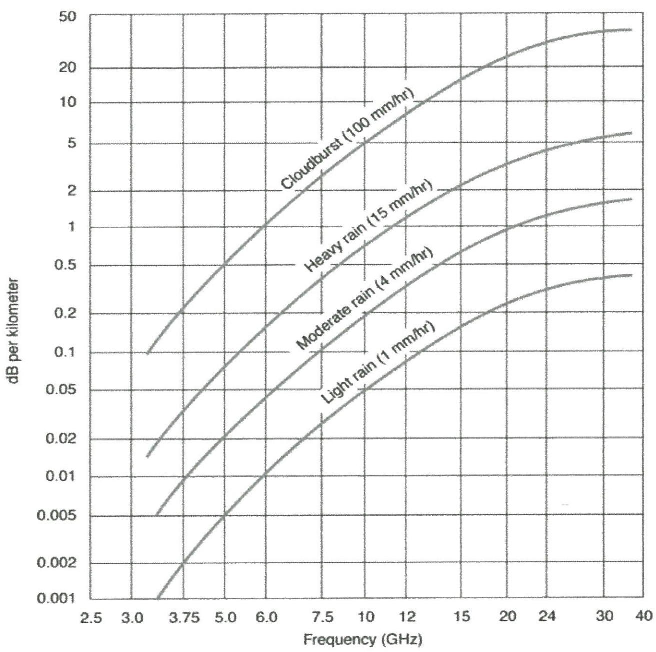


(a)



(b)

FIGURE Q3(b)

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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:

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

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

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

$$\eta_{TM} = \frac{E_x}{H_y} = -\frac{E_y}{H_x}$$

TE mode:

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

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

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

$$\eta_{TE} = \frac{E_x}{H_y} = -\frac{E_y}{H_x}$$

$$h^2 = \left[\frac{m\pi}{a}\right]^2 + \left[\frac{n\pi}{b}\right]^2 \qquad k^2 = \omega^2 \mu\varepsilon \qquad \gamma = \sqrt{h^2 - k^2}$$

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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 $D \gg d$	$\frac{60}{\sqrt{\varepsilon_r}}\ln\frac{b}{a}$