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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	APPLIED ELECTROMAGNETICS
COURSE CODE	:	BEB 30603
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

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Q1 A transmission line is a distributed parameter network, where voltages and currents can vary in magnitude and phase over its length.

(a) Sketch and label the lumped-element equivalent circuit of a transmission line.

(4 marks)

(b) For a transmission line terminated with Z_L, characteristic impedance of Z_0 and length $l = \frac{\lambda}{4}$, show that the input impedance Z_{in} is,

$$Z_{in} = \frac{{Z_0}^2}{Z_L}$$

(4 marks)

(c) Construct the open-ended stub matching network for a 50 Ω line terminated with a load $Z_L = 150 + j100\ \Omega$, with the aid of Smith Chart.

(12 marks)

(d) **Figure Q1(d)** shows a transmission line system terminated with a load. The reflection coefficient measured at the input is $0.6\measuredangle 166^o$. Calculate the value of reflection coefficient at the load.

(5 marks)

Q2 (a) An air-filled rectangular waveguide with width dimensions of, a = 8 cm, and height of b = 4 cm is made of copper. Draw the field patterns of its cross section during the,

(i) fundamental frequency mode operation, and

(5 marks)

(ii) TE_{20} mode of operation.

(5 marks)

(b) A WR284 waveguide is used for signal transmission in a telecommunication system where the cross section dimension is $a = 2b$.

(i) Determine the cutoff frequencies for the first four modes.

(9 marks)

(ii) Determine the useful operating frequency range for the waveguide to support single mode operation.

(6 marks)

Q3 Antenna is a specialized transducer to convert radio frequency fields into alternating current or vice versa.

(a) Name **FOUR (4)** types of antenna and sketch the radiation patterns of each.

(7 marks)

(b) Suppose a 0.485 λ dipole antenna supplied with power source of 12-V is in series with a 25 Ω source resistance

(i) Determine the total power radiated from the antenna.

(6 marks)

(ii) If a matching network is inserted, determine the resulting radiated power.

(6 marks)

(c) Consider a pair of half-wavelength dipole antennas, separated by 1 km and aligned for maximum power transfer. The transmission antenna is drive with 1.0 kW of power at 1.0 GHz. By assuming that the antenna is 100% efficient, calculate the received power at the receiving antenna.

(6 marks)

Q4 (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 250 km. They plan to use antennas with power gain of 13 dB for the link for both transmitting and receiving stations. The transmitting antenna will be fed with 5 W of power at carrier frequency of 300 MHz. Calculate:

(i) effective Isotropic Radiate Power, (EIRP)

(4 marks)

(ii) free space loss.,(L_F)

(3 marks)

(iii) power density at the receiving antenna, (P_d), and

(4 marks)

(iv) power received, (P_R) at the receiving antenna. Assuming no other losses.

(4 marks)

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(b) After conducting site survey, it is found that the 800 meter Gunung Batang Kali in Pahang located 50 km from the transmitter in Kuala Lumpur will become a major obstruction to the line of sight system planned in **Q4(a)**. Find:

(i) the knife-edge loss, L_{ke} caused by the hill if both transmitter and receiver are 30 meters above sea level,

(4 marks)

(ii) the total path loss due to free space loss and the knife-edge loss, and

(3 marks)

(iii) power received, (P_R) at the receiving antenna. Assuming no other losses.

(3 marks)

Q5 (a) A stub length of 0.12 λ is used to match a 60 Ω lossless line to a load. If the shorted-stub is located at 0.3 λ from the load, use Smith Chart to calculate:

(i) the load impedance (Z_L),

(6 marks)

(ii) the length of an alternative stub and its location from the load, and

(6 marks)

(iii) the standing wave ratio between the stub and the load.

(6 marks)

(b) A 1 meter long car radio antenna (monopole) operates in the AM frequency of 1.5 MHz. Calculate the current required to transmit 4 W of power.

(For Hertzian monopole, $R_{rad} = 40\pi^2\left(\frac{l}{\lambda}\right)$)

(7 marks)

- END OF QUESTION –

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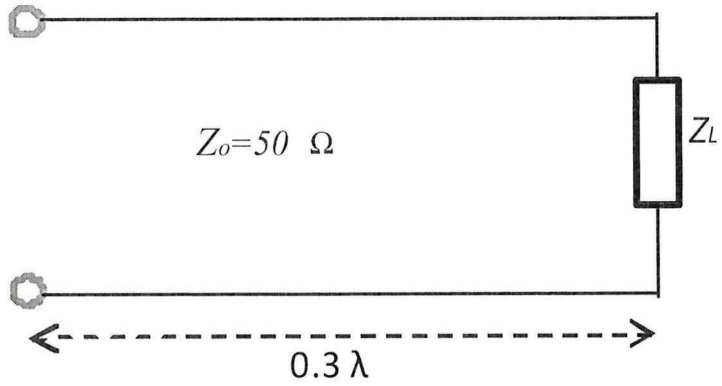

FIGURE Q1 (d)

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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:

α_c for TM modes:

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α_d for both TE and TM modes:

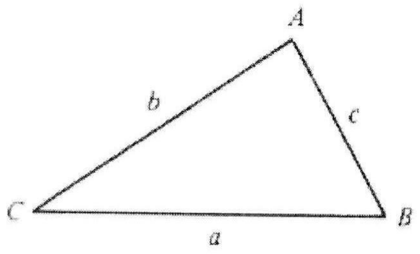
$$\alpha_d = \frac{\sigma\eta'}{2\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

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 a lossless line,

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