CONFIDENTIAL

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	APPLIED ELECTROMAGNETICS
COURSE CODE	:	BEB 30603
PROGRAMME	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

CONFIDENTIAL

Q1 High speed PCB component networks are connected using transmission line traces. The 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.

(5 marks)

(b) Signal return current will flow directly under the signal trace,

(i) with proper diagram, explain how magnetic radiation is cancelled along the trace.

(5 marks)

(ii) What would happen if there is a gap on the ground plane crossing the trace?

(5 marks)

(c) Refer to **FIGURE Q1 (a)** and **(b)**, the time taken by a signal to propagate from the source to receiver is T_p. The rise time of the signal is given as T_r. In this case it is assumed that the trace is electrically short.

(i) Define electrically short trace

(3 marks)

(ii) If $R_p = 100\text{M}\Omega$, sketch the resultant signal at the receiver.

(7 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.

(8 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.

(5 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 Smith chart is a useful tool for microwave network analysis. Referring to **FIGURE Q2**, and with the used of Smith chart,

(a) Find the reflection coefficient at load.

(5 marks)

(b) Determine the VSWR,of the system.

(5 marks)

(c) Find the input impedance, Z_{in}.

(5 marks)

(d) Construct a shorted shunt stub matching network to the circuit in **FIGURE Q2**.

(10 marks)

Q5 (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)

(5 marks)

(ii) Free space loss.,(L_F)

(4 marks)

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

(5 marks)

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

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

(6 marks)

-END OF QUESTIONS -

FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2019/2020 PROGRAMME : BEJ
COURSE NAME : APPLIED ELECTROMAGNETICS COURSE CODE: BEB 30603

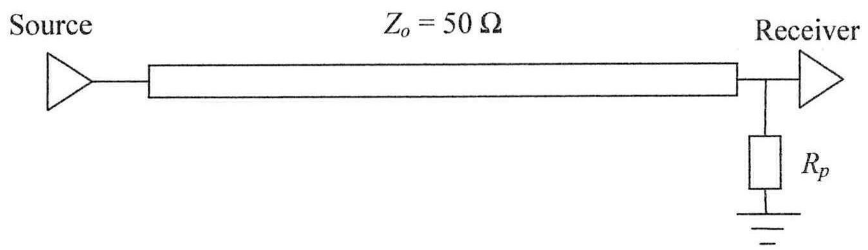


FIGURE Q1 (a)

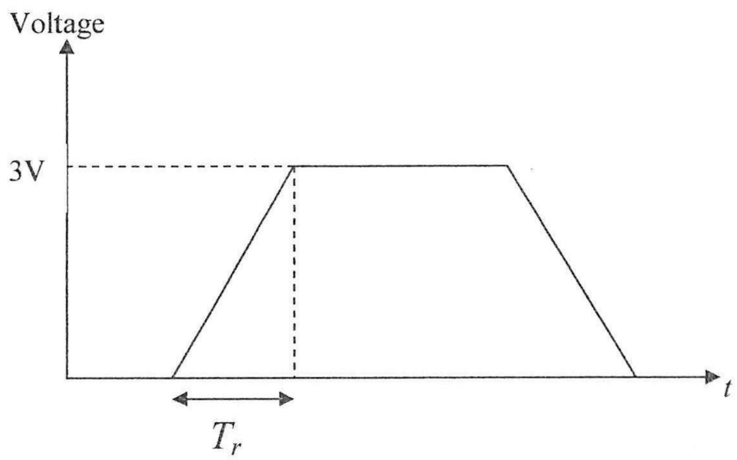


FIGURE Q1 (b)

FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2019/2020 | PROGRAMME : BEJ
COURSE NAME : APPLIED ELECTROMAGNETICS | COURSE CODE: BEB 30603

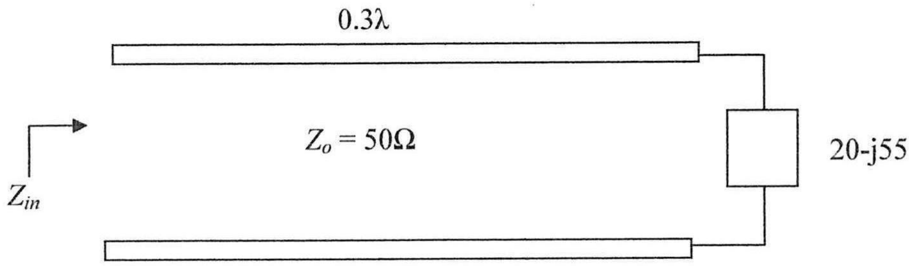


FIGURE Q2

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020 PROGRAMME : BEJ
SUBJECT : APPLIED ELECTROMAGNETICS COURSE CODE : BEB 30603

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:

FINAL EXAMINATION

SEMESTER/SESSION : SEM I / 2019/2020 PROGRAMME : BEJ
SUBJECT : APPLIED ELECTROMAGNETICS COURSE CODE : BEB 30603

α_d for both TE and TM modes:

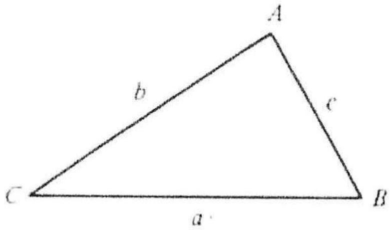
$$\alpha_d = \frac{\sigma\eta'}{2\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

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,

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

