UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	ELECTROMAGNETIC WAVE PROPAGATION
COURSE CODE	:	BEJ31103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Define the definition of a Transmission Line (TL) with several Guided Transmission Line examples.

(4 marks)

(b) Standing wave can be used as an indication of how many signal reflections occur in the line, i.e. voltage standing wave ratio (VSWR).

(i) Describe the three different cases of standing waves with an appropriate figure (or graph).

(4 marks)

(ii) A 50-ohm TL is connected to a 75-ohm load at 100 MHz. Given velocity factor, $v_f = 0.5$, determine:

a. reflection coefficient,
b. Standing Wave Ratio (SWR), and,
c. A distance of the first voltage maximum and minimum.

(6 marks)

(c) The Smith chart has been introduced to reduce the tedious manipulations involved in calculating the characteristics of a transmission line by means of graphical representation.

(i) Discuss the importance of the Smith chart with several important parameters to be solved using the smith chart.

(4 marks)

(ii) A 30 m long lossless transmission line with characteristic impedance, Zo = 50 Ω operating at 2 MHz is terminated by a load of Z_L= 60 + j40 Ω. If velocity, v=0.6c on the line, find:

a. Reflection Coefficient, *R*,
b. VSWR, and
c. *Zin.*

(7 marks)

Q2 (a) Describe 2 types of propagation modes.

(2 marks)

(b) Waveguide is used for transporting electromagnetic (EM) waves from the source to the load which consists of a hollow, metal tube through which waves propagate.

(i) Discuss the advantage of the waveguide over a transmission line.

(4 marks)

(ii) Describe the definition of evanescent, cutoff, and propagation with an appropriate figure/graph.

(6 marks)

(iii) A rectangular waveguide with dimensions of a = 0.3 m and b = 0.1 m operates at frequency below 15.1 GHz. How many TE and TM modes can the waveguide transmit if the guide is filled with a medium characterized by $\sigma = 0$, $\varepsilon = 4\varepsilon_o$, $\mu_r = 1$? Calculate the cutoff frequencies of the modes.

(10 marks)

(c) Elaborate on the function of electromagnetic cavity resonators.

(3 marks)

Q3 (a) Antenna is a transducer that converts a guided wave propagating on a transmission line (TL) into an electromagnetic (EM) wave propagating in an unbounded medium.

(i) Describe the importance of a far-field in antenna transmission.

(3 marks)

(ii) List the parameters that govern radiations and impedance properties of the antenna.

(2 marks)

(iii) Describe the importance of antenna impedance matching.

(4 marks)

(b) Antenna polarization is one of the important antenna parameters.

(i) Describe how to determine the antenna polarization.

(4 marks)

(ii) A transmit antenna with a radiation resistance $Rrad = 72\ \Omega$ and an effective antenna resistance, $Re = 8\ \Omega$, a directive gain, $Gd = 20$ and an input power $Pin = 100$ W, determine:

(a) antenna efficiency,
(b) antenna gain, Gp (Absolute and dB),
(c) radiated power in Watts, dBm and dBW, and
(d) EIRP in Watts, dBm and dBW.

(8 marks)

(c) A 4 cm long center-fed dipole is used as an antenna at 75 MHz. The antenna wire is made of copper and has a radius of 0.4 mm. Calculate the radiation resistance and the radiation efficiency of the dipole antenna. For copper, $\mu c \approx \mu 0 = 4\pi$ x 10-7 H/m and $\sigma c = 5.8$ x 107 S/m.

(4 marks)

Q4 (a) Radio wave propagation is also known as free-space propagation of electromagnetic waves or radio-frequency (RF) propagation.

(i) Describe the 3 modes of radio wave propagation.

(2 marks)

(ii) Discuss the importance of FRISS transmission with related formulas and equations.

(3 marks)

(b) A 2.4 GHz microwave link consists of two identical antennas each with a gain of 30 dB. Given that the transmitter output power is 2 kW and the two antennas are 15 km apart, determine the received power.

(6 marks)

(c) Free space loss is the loss incurred by the EM waves as it propagates in a straight line through the vacuum with no absorption or reflection of energy from nearby objects.

(i) Calculate the free space loss for a microwave link that is 150 km apart operating at frequency of 1 GHz.

(2 marks)

(ii) If a parabolic antenna with an effective area (or capture area) of 2 m^2 is used at both transmitter and receiver, what is the gain of the antenna at this frequency?

(2 marks)

(iii) If the transmitter is producing a 45 dBm EIRP, calculate the received power. Assume the feeder loss is negligible, and there is no other loss in the system.

(3 marks)

(iv) Repeat **Q4(c)(i)** for f = 3 GHz. What is the effect of frequency to antenna gain and free space loss?

(3 marks)

(v) Conclude based on your calculation and observation in **Q4(c)(iv).**

(4 marks)

END OF QUESTIONS