M.Sc. TE, 2nd Sem

February 20, 2023 **(Afternoon)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Mid-Semester Examination
Course No.: EEE 6297
Course Title: Microwave Engineering

Summer Semester, A. Y. 2021-2022
Time: 90 Minutes
Full Marks: 75

There are 4 **(four)** questions. Answer any 3 **(three)** questions. The symbols have their usual meanings.

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1. a) What is the usual frequency range that microwave engineers work with? Mention some of the applications of microwave engineering. **05**

   b) Write down the integral and differential forms of Maxwell's equations. Also derive the wave equation for free space from the Maxwell's equations. **10**

   c) Show that the propagation constant $\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$ where $V(z) = Ve^{-\gamma z}$ represents the voltage wave equation for lossy transmission line. **10**

2. a) Derive the following expressions for voltage $v(z,t)$ and current $i(z,t)$ on a transmission line with characteristic impedance Z_0 and phase velocity v_p. **15**

$$v(z,t) = f_1(t - \frac{z}{v_p}) + f_2(t + \frac{z}{v_p}) \qquad i(z,t) = \frac{1}{Z_0}[f_1(t - \frac{z}{v_p}) - f_2(t + \frac{z}{v_p})]$$

   b) The load $Z_L = 25 + j50\ \Omega$ is connected to an ideal transmission line with characteristic impedance $Z_0 = 50\ \Omega$. The source is 0.5 cm away from the load. The incident voltage is $V_+ = 15\angle 75^\circ$ and reflected voltage $V_- = 5\angle 10^\circ$ at the point of source. Calculate the reflection coefficient, return loss, transmission coefficient and insertion loss at the point of load. ($\beta = \pi/2$). **10**

3. a) An ideal transmission line with characteristic impedance $Z_0 = 1/Y_0$ and phase constant, β is connected to the load impedance $Z_L = 1/Y_L$. Show that the input admittance Y_i at a distance l away from the load is given by, **10**

$$Y_i = Y_0 \frac{Y_L \cos \beta l + jY_0 \sin \beta l}{Y_0 \cos \beta l + jY_L \sin \beta l}.$$

   You may start off the derivation with the wave equations of ideal transmission line in terms of voltage and current in phasor form.

   b) A transmission line is connected to the load, $Z_L = 150 + j90\ \Omega$. The line has characteristic impedance $Z_0 = 70\ \Omega$. The operating frequency is 6 GHz. Using the Smith Chart, find the value of the transmission coefficient at load point, input impedance at a distance of 3.375 cm from the load and, the maximum and minimum impedance. Verify your results obtained from the Smith Chart using the formula. **15**

4. a) Show that an open-circuited transmission line can be used to implement inductor or capacitor of any value. **09**

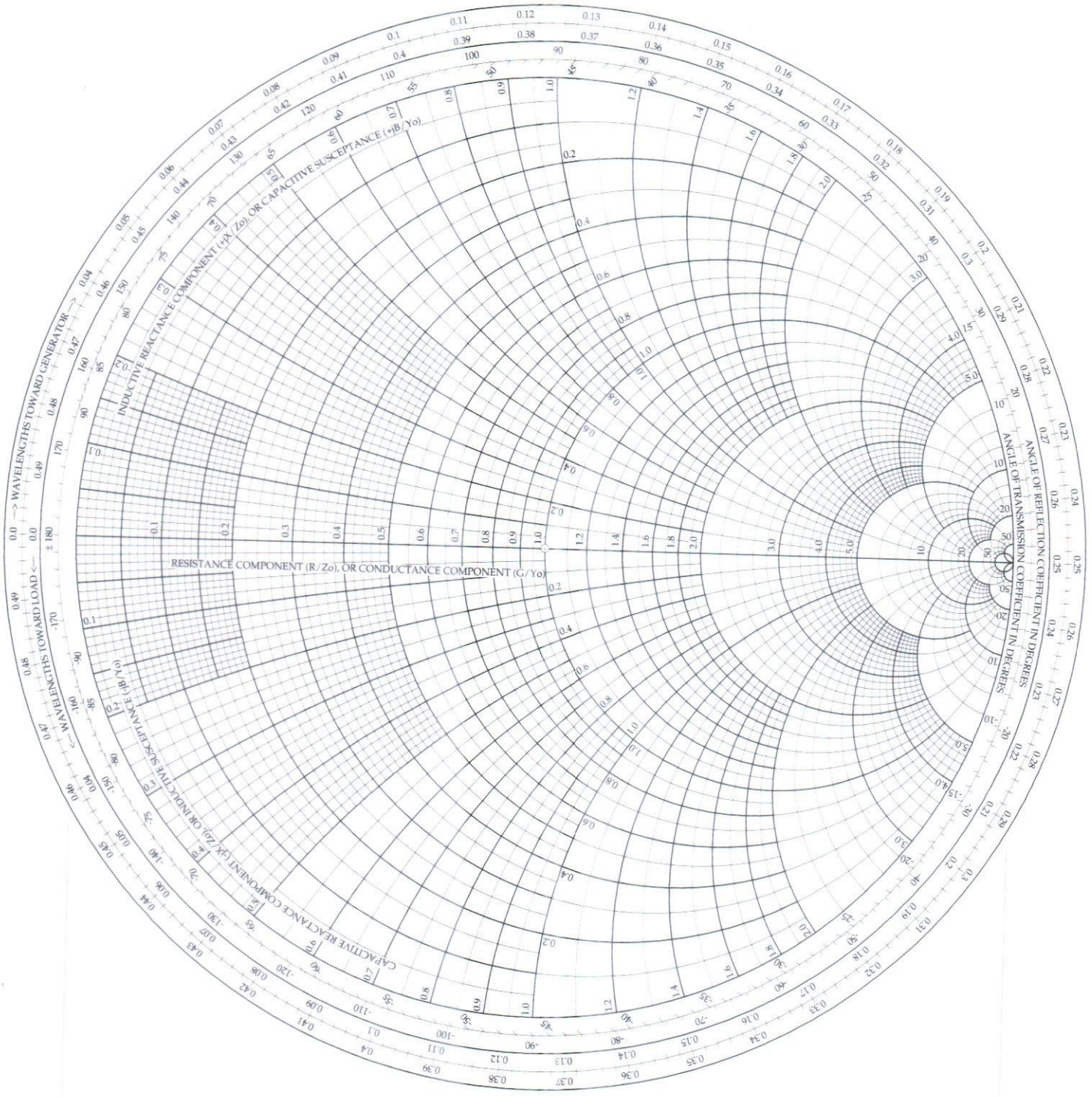
   b) Prove that the same Smith chart can be alternately used as either impedance Smith chart or admittance Smith chart by simply rotating halfway (180°) on SWR circle. **09**

   c) Draw the voltage and current wave shapes for short circuited and open circuited transmission lines. Clearly indicate the maxima and minima. **07**

Student No.:

Signature of the Invigilator:

(Please get it signed by the invigilator before using)



RADIALLY SCALED PARAMETERS

SWR ∞ 100 40 20 10 5 4 3 2.5 2 1.8 1.6 1.4 1.2 1.1 1 1.5 10 7 5 4 3 2 1

TOWARD LOAD —> <— TOWARD GENERATOR

RTN. LOSS [dB] dBS ∞ 40 30 20 15 10 8 6 5 4 3 2 1 1 1 1.1 1.2 1.3 1.4 1.6 1.8 2 3 4 5 10 20 ∞

RFL. COEFF. P 0 1 2 3 4 5 6 7 8 9 10 12 14 20 30 ∞ 0 0.1 0.2 0.4 0.6 0.8 1 1.5 2 3 4 5 6 10 15 ∞

RFL. COEFF. E or I 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.05 0.01 0 0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.5 3 4 5 10 ∞

ATTEN. [dB] 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

S.W. LOSS COEFF 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6

RFL. LOSS [dB] ∞ 40 30 20 15 10 8 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13

S.W. PEAK (CONST. P) 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.5 3 4 5 6 7 8 9 10 11 12 13 14 15

TRANSM. COEFF. P 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5

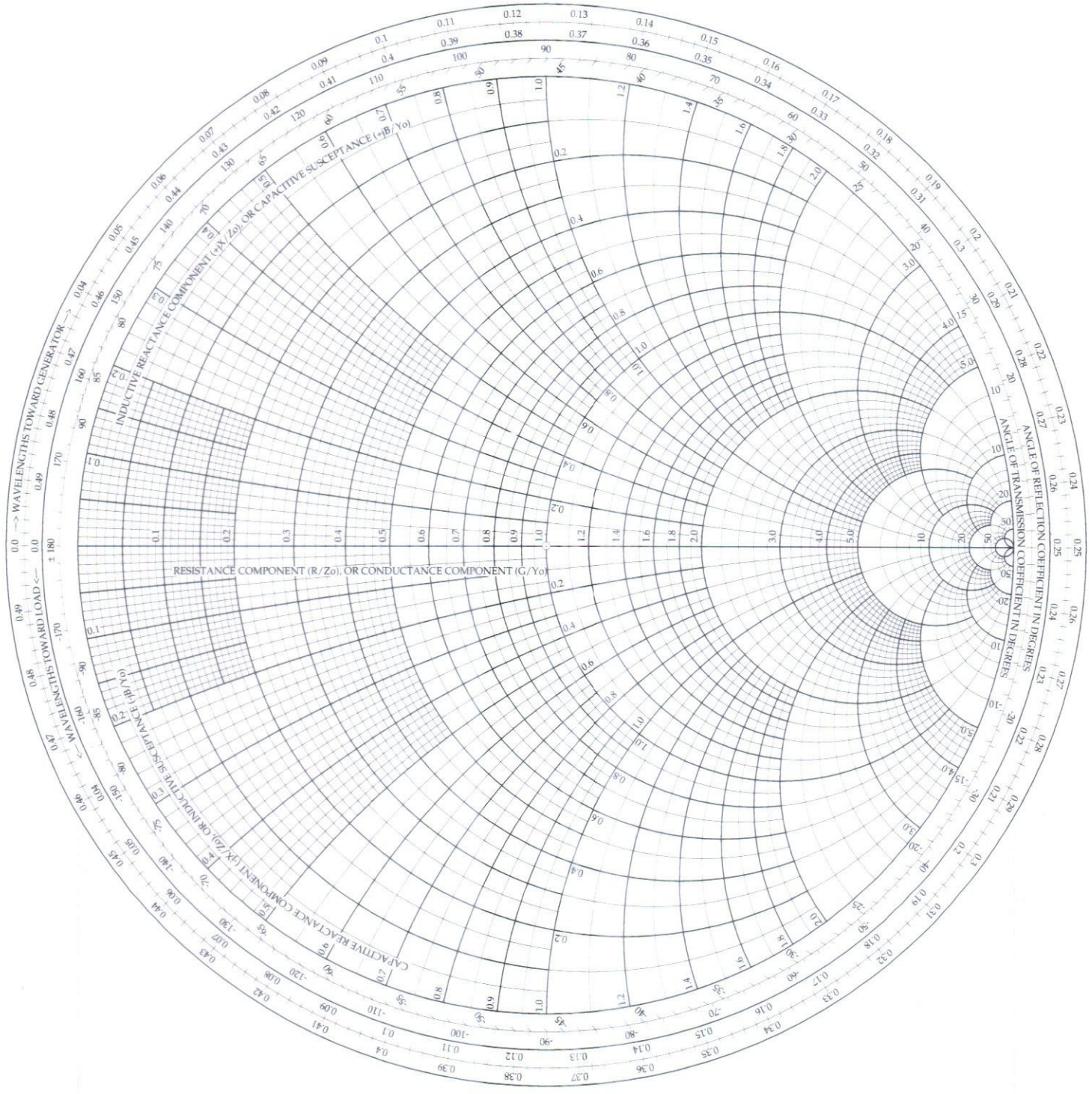
TRANSM. COEFF. E or I 1 0.99 0.95 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

ORIGIN CENTER

Student No.:

Signature of the Invigilator:

(Please get it signed by the invigilator before using)



RADIALLY SCALED PARAMETERS

TOWARD LOAD —> <— TOWARD GENERATOR

SWR ∞ 10 40 20 10 5 4 3 2.5 2 1.8 1.6 1.4 1.2 1.1 1 1.5 10 7 5 4 3 2 1

dBS ∞ 40 30 20 15 10 8 6 5 4 3 2 1 1 1 1.1 1.2 1.3 1.4 1.6 1.8 2 3 4 5 10 20 ∞

RTN. LOSS [dB] 0 1 2 3 4 5 6 7 8 9 10 12 14 20 30 ∞ 0 0.1 0.2 0.4 0.6 0.8 1 1.5 2 3 4 5 6 10 15 ∞

RFL. COEFF. P 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.05 0.01 0 0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.5 3 4 5 10 ∞

RFL. COEFF. E or I 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0 1 0.99 0.95 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

ATTEN. [dB]

S.W. LOSS COEFF

RFL. LOSS [dB]

S.W. PEAK (CONST. P)

TRANSM. COEFF. P

TRANSM. COEFF. E or I

CENTER 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

ORIGIN