MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Third YEAR second SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)
EEE 313: TRANSMISSION LINES AND WAVE GUIDES

DATE: **TIME:**

INSTRUCTIONS TO STUDENTS

1. This paper consists of **FIVE** questions.
2. Answer **QUESTION ONE** and **ANY OTHER TWO** questions.
3. All workings must be clearly shown
4. The Smith Chart page provided should be attached to the Answer Booklet after use.
5. Take the speed of light in free space to be $c = 3x10^8 m/s$

QUESTION ONE(COMPULSORY) (30 MARKS)

a) With specific examples, give **TWO** practical applications of TEM transmission lines. (2 marks)

b) Explain the following terms as applied in Transmission Lines: (4 marks)

i) Reflection Coefficient:

ii) Characteristic impedance (Z_0)

c) Fig.Q1 c) shows an equivalent circuit model of a differential length Δz of a two-conductor transmission line.

i) Use it to derive the transmission line wave equations for both voltage $V_s(z)$ and current $I_s(z)$in the line. List any assumptions made.

ii) Find the general solutions for $V_s(z)$ and $I_s(z)$ and comment on the directions of travel for the waves involved. (8 marks)

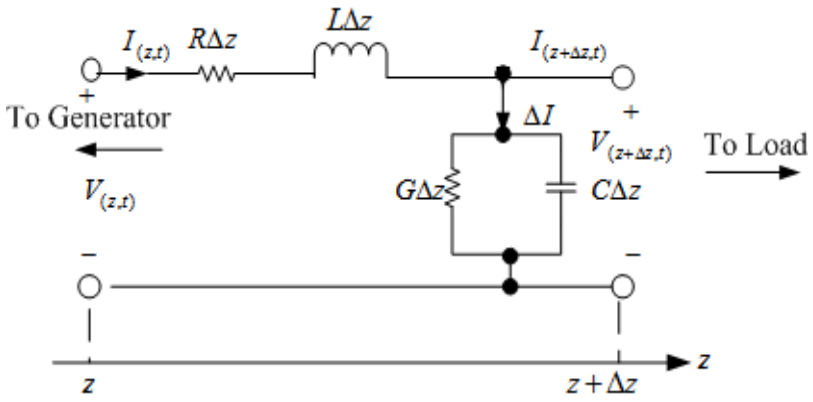


Fig.Q1 c) Two-conductor transmission line model of differential length Δz

d) In a rectangular waveguide for which $a = 1.5cm, b = 0.8cm, \sigma = 0, \mu = \mu_0$ and $\varepsilon = 4\varepsilon_0$,

$$H_x = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin(\pi \times 10^{11}t - \beta z)\ A/m$$

Determine (7 marks)

i) The mode of operation

ii) The cutoff frequency

iii) The phase constant, β

iv) The propagation constant, γ

v) The intrinsic wave impedance, η

e) A $100 + j150\ \Omega$ load is connected to 75 Ω lossless line. Use Smith Chart to find the following and check your answers analytically. (9 marks)

i) The reflection coefficient Γ

ii) The standing wave ratio s

iii) The load admittance Y_L

iv) The input Impedance Z_{in} at 0.4λ from the load

v) The locations of V_{max} and V_{min} with respect to the load if the line is 0.6λ long

vi) Z_{in} at the generator

QUESTION TWO (20 MARKS)

a) What is your take on the utilization of EM field theory and Electric Circuit theory in the analysis of transmission lines? (3 marks)

b) Explain the meaning and application of a Resonant Line as used in transmission lines. (3 marks)

c) A $40m$-long transmission line has $V_g = 15\angle 0^0 V_{rms}$, $Z_0 = 30 + j60\Omega$, and $V_L = 5\angle -48^0 V_{rms}$.. If the line is matched to the load, calculate: (6 marks)

i) The input impedance Z_{in}

ii) The sending-end current I_{in} and voltage V_{in}

iii) The propagation constant γ.

d) A 60Ω lossless line is connected to a source with $V_g = 10\angle 0^0\ V_{rms}$ and $Z_g = 50 - j40\Omega$ and terminated with a load $j40\Omega$. If the line is 100 m long and $\beta = 0.25\, rad/m$, calculate Z_{in} and V at (8 marks)

i) The sending end

ii) The receiving end

iii) 4 m from the load

iv) 3 m from the source

QUESTION THREE (20 MARKS)

a) Differentiate between a transmission line and a waveguide in terms of physical construction and the waves propagated. (2 marks)

b) Consider a lossless transmission line shown in Fig. Q3b. Use it to provide a physical description of how the waves generated by closing S_1 propagate along the transmission line. (4 marks)

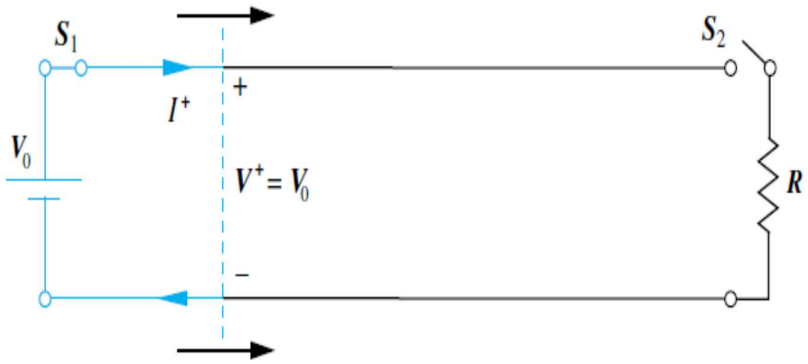


Fig.Q3b A *lossless* line

c) A signal generator is to feed equal power through a lossless air transmission line of characteristic impedance 50Ω to two separate resistive loads, 64Ω and 25Ω. Quarter-wave transformers are used to match the loads to the 50Ω line. (6 marks)

i) Sketch the quarter-wavelength impedance matching arrangement.

ii) Determine the required characteristic impedances of the quarter-wave lines.

iii) Find the standing-wave ratios on the matching line sections.

d) A lossless transmission line with $Z_0 = 50\Omega$ and $d = 1.5m$ connects a voltage V_g source to a terminal load of $Z_L = (50 + j50)\Omega$. If $V_g = 60\,V$, operating frequency $f = 100MHz$, and $Z_g = 50\Omega$ and assuming that the speed of the wave along the transmission line equal to the speed of light c,

i) Find the distance of the first voltage maximum l_M, from the load.

ii) What is the power delivered to the load P_L? (8 marks)

QUESTION FOUR (20 MARKS)

a) Derive the expression for the average power flow along a lossless transmission line. Give its physical interpretation and the condition (s) for maximum power delivery to the load.

(6 marks)

b) A distortionless line operating at $120\ MHz\ R = 20\Omega/m,\ L = 0.3\mu H/m$, and $C = 63pF/m$.

i) Determine $\gamma, u, and\ Z_0$.

ii) How far will a voltage wave travel before it is reduced to 20% of its initial magnitude?

iii) How far will it travel to suffer a 45^0 phase shift? (6 marks)

c) A certain transmission line operating at $\omega = 10^6 rad/s$ has α = 8 dB/m, $\beta = 1\, rad/m$, and $Z_0 = 60 + j40\Omega$, and is $2m$ long. If the line is connected to a source of $10 < 0^0 V$, $Z_g = 40\Omega$ and terminated by a load of $20 + j50\Omega$, determine: (8 marks)

i) The input impedance

ii) The sending-end current

iii) The current at the middle of the line

QUESTION FIVE (20MARKS)

a) Discuss the advantages and disadvantages of single-stub matching technique of transmission lines as compared to the quarter wavelength transformer. (4 marks)

b) Give at least two most popular higher order transmission lines and the frequencies under which they are used. (2 marks)

c) The parameters of a certain transmission line operating at $6 \times 10^8\, rad/s$ are $R = 20\Omega/m,\ L = 0.4\mu H/m,\ G = 80\mu S/m\ and\ C = 40pF/m.$ (6 marks)

i) Find $\gamma, \alpha, \beta, \lambda, and\ Z_0$.

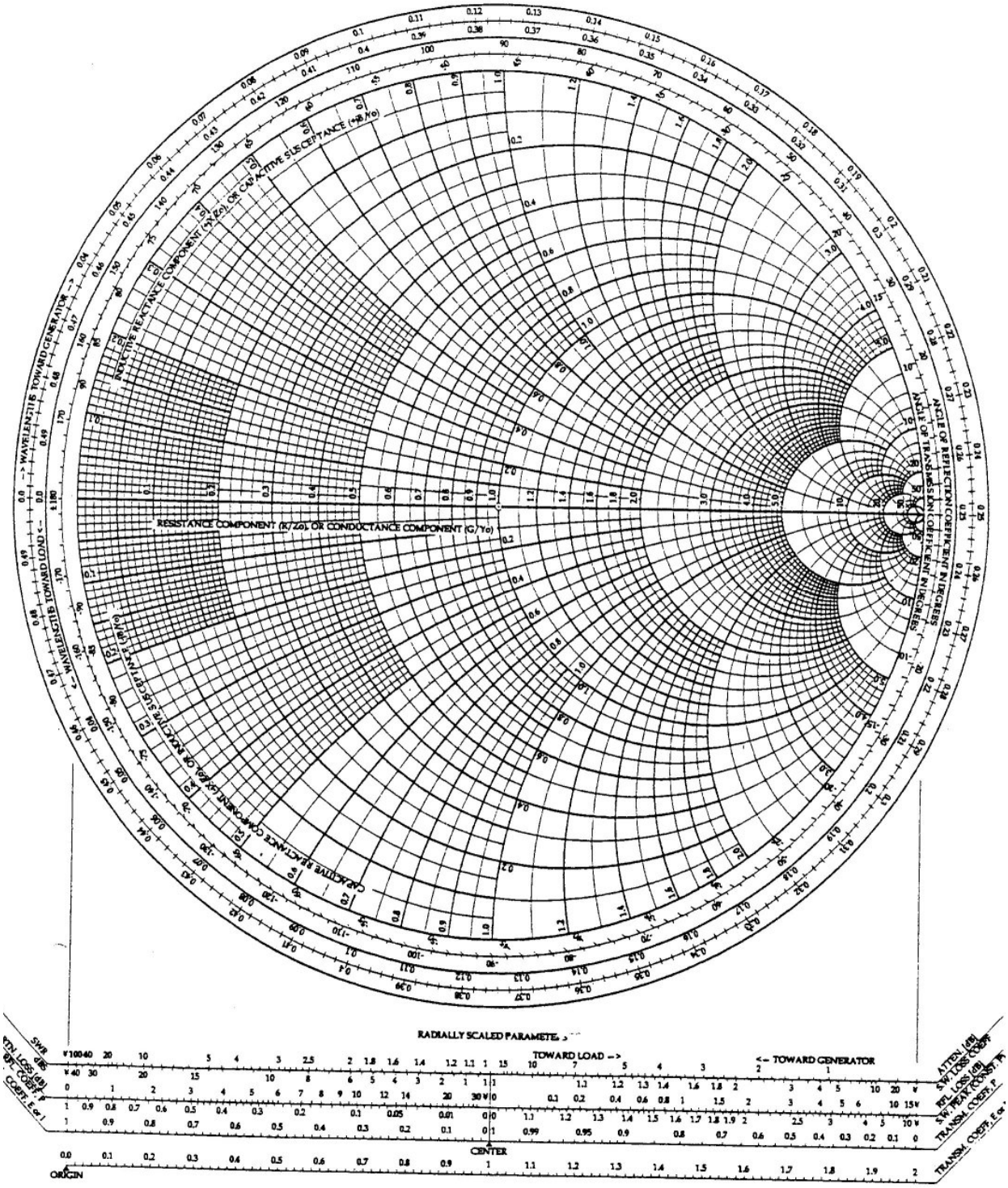
ii) If a voltage wave travels 20 m down the line, what percentage of the original amplitude remains and by how many degrees is it phase shifted?

d) For a guided wave between two infinite conducting planes separated by a distance of 0.25 m, find the cutoff frequency for the TM_{20} mode. If the operating frequency is 3 GHz, find the phase velocity of the wave. (4 marks)

e) A TE_{10} mode propagates between two parallel planes separated by a distance of 0.25 m. The planes are lossy and have a conductivity of $5 \times 10^7\, S/m$. If the maximum electric field strength between the planes is $1000\, V/m$, determine the power loss per square meter on each plate when the operating frequency is 2 GHz. (4 marks)

CANDIDATE REG. NO……

THE SMITH CHART- NO.1



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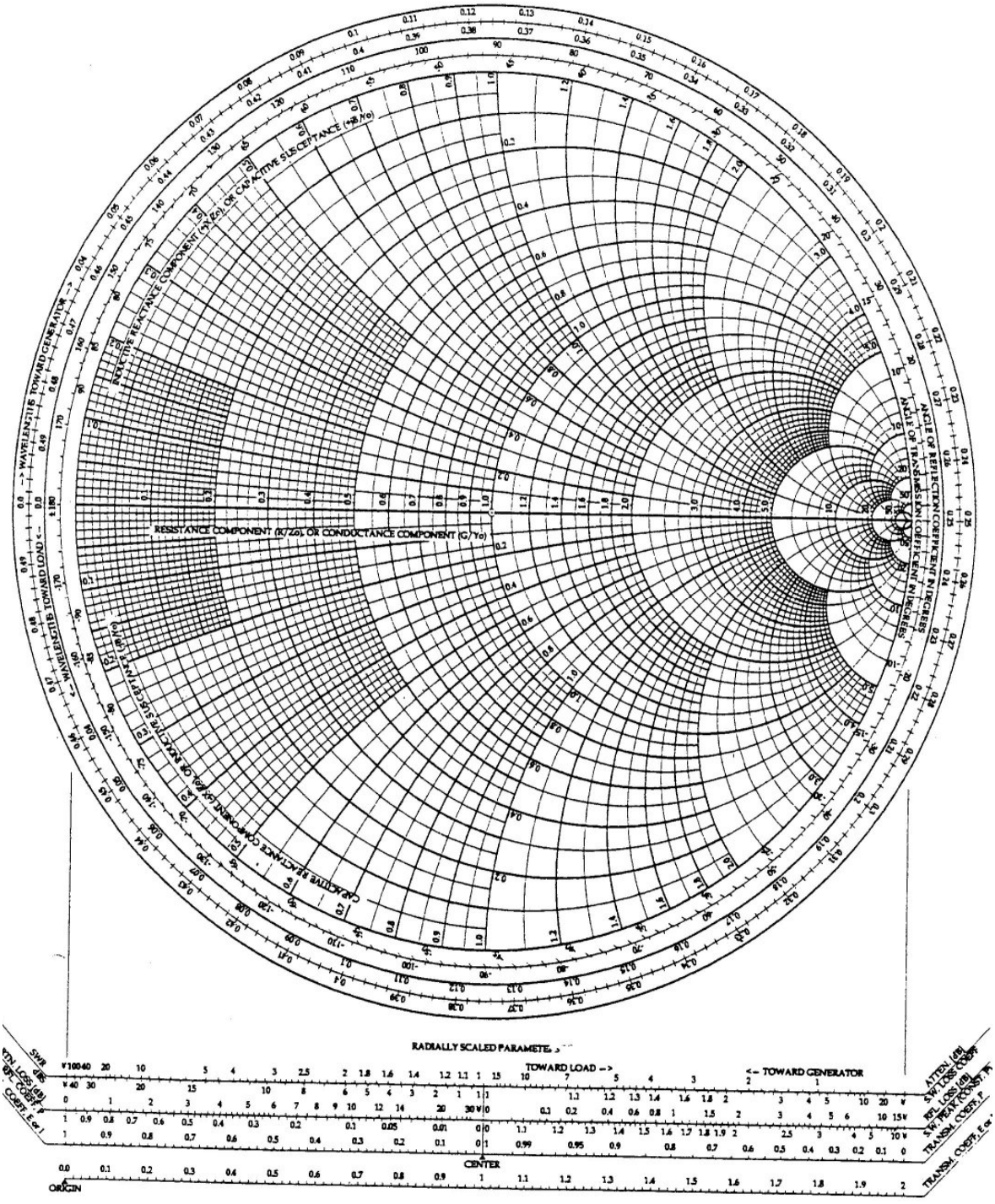
THE SMITH CHART-NO.2



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