PAPER 2

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering and Technology

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 4401 TRANSMISSION LINES

END OF SEMESTER EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE: July 2025

<u>Instructions to Candidates</u>

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt **Question ONE and ANY other TWO questions.**

1. $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9} F/m; \mu_0 = 4\pi \times 10^{-7} H/m$

<u>Do not write on the question paper</u>

Question ONE (Compulsory 30 marks)

(a) A 1-meter length of coaxial cable, with $Z_0 = 75\,\Omega$ and a capacitance of 64 pF/m, is used at a frequency of $2\,GHz$ and is considered lossless.

(i) Explain why it possible for this cable to be considered lossless.

(ii) Prove that the equation for the phase velocity of this lossless line is given by

(iii) If this 1m length of coaxial cable ($\varepsilon_r = 3.1$) is terminated with a load impedance of 100Ω, determine (analytically) the input impedance of the cable. (14 marks

(b) A coaxial transmission with a characteristic impedance of $Z_0 = 75\,\Omega$ is 2cm long, and is terminated with a load impedance $Z_L = 37.5 + j75\,\Omega$. If the dielectric constant of the line is 3.56 and the frequency is 2 GHz, find using a Smith chart:

(i) The input impedance of this line (ii) The VSWR on the line (8 marks

(c) For each of the following engineering applications describe the technological challenges inherent in their implementation and how the adoption of transmission line theory has been able to either overcome or minimize such challenges:

(i) High speed digital interconnects

(ii) Fabrication of microwave circuit components

(iii) Antenna feed lines (8 marks)

Question TWO

(a) The transmission line circuit of figure (Qu.2b) has $Vg=15\,V\ RMS$; $Z0=75\,\Omega$; $Zg=75\,\Omega$; $Z=40+j60$ and the length $l=0.7$. Compute the power delivered to the load using two different techniques:

(i) Find $|\Gamma|$ and compute $P_L=(\frac{V_g}{2})^2\frac{1}{z_0}(1-|\Gamma|^2)$

(ii) Find $Z_{\text{¿}}$ and compute $P_L=\left|\frac{V_g}{Z_g+Z_{\text{¿}}}\right|^2\Re(Z_{\text{¿}})$ (10 Marks)

(b) With the aid of a Smith chart design a quarter-wave transformer to match a load impedance $Z_L=41.25-j22.5\,\Omega$ to a transmission line with characteristic impedance $Z_0=75\,\Omega$, velocity factor of 0.7 and a frequency of $1.5\,GHz$.

(10 marks)

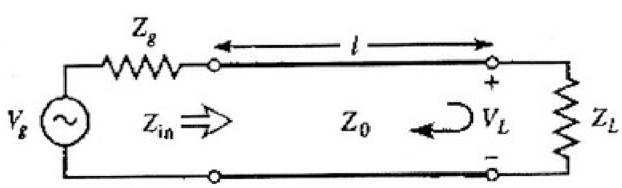

Fig. Qu.2(b)

Question THREE

(a) (i) With reference to transmission lines explain why the load impedance should always be matched to the source impedance.

(ii) Describe what happens when a line is terminated in an impedance other than the characteristic impedance of the line and a single pulse of energy is injected into the line. (6 marks)

(b) Motivating all your steps derive the following transmission line equations:

$\hat{V}(Z)=V_0^{+\text{¿}e^{-\gamma z}+V_0^{-\text{¿}e^{\gamma z}\text{¿}}}$ $\hat{I}(Z)=I_0^{+\text{¿}e^{-\gamma z}-I_0^{-\text{¿}e^{\gamma z}\text{¿}}}$

(14 marks)

Question FOUR

(a) Compare and contrast key differences between circuit and transmission line theory. (4 marks)

(b) With the aid of a Smith chart design a parallel short-circuited stub to match a load impedance

$Z_L = 22.5 + j\,41.25\,\Omega$ to a transmission line with characteristic impedance $Z_0 = 75\,\Omega$, a velocity factor of 0.9 and a frequency of 1GHz.

(10 marks)

(c) (i) How does the presence of standing waves affect voltage and current along a transmission line?

(ii) Describe the consequence of standing waves in the following situations:

- Transmitting applications
- Receiving applications
- Data transmission (6 marks)

Question FIVE

(a) A single short pulse is launched on a coaxial cable of unknown termination. The velocity factor of the coaxial cable is 0.9. The source can be assumed to be matched to the coaxial line. An oscilloscope shown in Figure Qu.(5a) measures the following at the input to the coaxial line, where the source is connected:

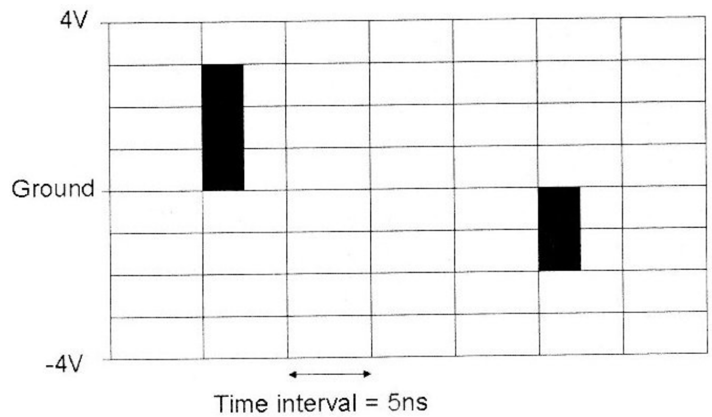

Figure Qu.(5a)

Find:

(i) The length of the line

(ii) The type of load termination that will cause this reflection

(iii) The attenuation of the cable in dB per metre. (9 marks)

(b) (i) Prove that for a line that has a purely resistive characteristic Impedance which is terminated in a load that is purely resistive, the VSWR = R_0/R_L for $R_0>R_L$ and R_L/R_0 for $R_L>R_0$

(ii) A transmission line with a characteristic impedance of 300Ω is terminated in a purely resistive load. It is found by measurement that the minimum value of voltage upon it is 5μV and the maximum 7.5μV. Calculate the possible values of the load resistance. (11 marks)