MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATIONA FOR

BACHELOR OF TECHNOLOGY IN TELECOMMUNICATION ENGINEERING

SPH 313: TRANSMISSION LINES

DATE: **TIME:**

INSTRUCTIONS

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 (30 MARKS) – COMPULSORY

a) Define a Transmission Line and outline **THREE** broad categories of Transmission Lines. **[4marks]**

b) A $30m$ long lossless transmission line with $Z_0 = 50\Omega$ operating at $2MHz$ is terminated with a load $Z_L = 60 + j40\ \Omega$. If $u = 0.6c$ on the line, where c is the speed of light in a vacuum, find the parameters listed below both without using the Smith Chart and by using the Smith Chart and comment on the results. **[10marks]**

i) The reflection coefficient Γ

ii) The standing wave ratio s

iii) The input Impedance Z_{in}

c) Define the following terms as used in Transmission Lines: **[4marks]**

i) Phase velocity (v_p):

ii) Dispersion:

iii) Voltage Standing Wave Ratio (VSWR):

iv) Characteristic impedance (Z_0):

d) Fig. Fig.Q1 d) shows an L-type equivalent circuit model of a differential length Δz of a two-conductor transmission line. **[8marks]**

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

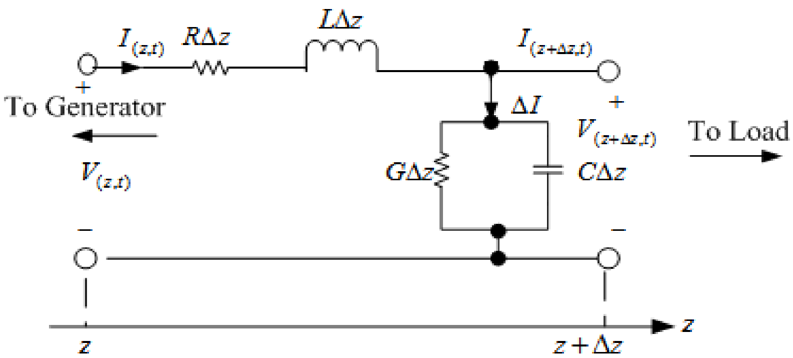

Fig.Q1 d) Two-conductor transmission line model of differential length Δz

e) A generator with an open-circuit voltage $V_g(t) = 100\sin\,(8000\pi t)$ and internal impedance $Z_g = 40 + j30\ \Omega$ is connected to a 50Ω distortionless line. The line has a resistance of $0.5\Omega/\mathrm{m}$, and its lossy dielectric medium has a loss tangent of 0.18%. The line is $50m$ $50m$ long and is terminated in a matched load. Find the instantaneous expressions for the voltage and current at an arbitrary location on the line.
[4marks]

QUESTION TWO (20 MARKS)

a) With practical examples, distinguish between wave propagation in bounded media and unbounded media. **[4marks]**

b) Explain the meaning of transit time and use the concept to distinguish between Lumped and distributed parameters as used in transmission line modelling and analysis. **[4marks]**

c) With the aid of block diagrams and mathematical expressions, distinguish between ABCD – Parameters and S-parameters as used in two-port networks analysis of transmission lines. Hence, show that for the case where a 2-port network is created by cascading two networks having transmission matrices defined as T_A and T_B, respectively, the total transmission T is given by $T = T_A T_B$.
[7marks]

d) A lossless transmission line is 80cm long and operates at a frequency of $600MHz$. The line parameters are $L = 0.25\mu H/m$ and $C = 100pF/m$. Find: **[5marks]**

i) the characteristic impedance of the line
ii) the phase constant
iii) the velocity on the line

iv) the input impedance for $Z_L = 100\Omega$.

QUESTION THREE (20 MARKS)

a) List **FOUR** differences between a transmission line and waveguide. **[4marks]**

b) Using the circuit of Fig. Q3 b) of a finite transmission line connected to a load, show that the input impedance is given by $Z_i = (Z)_{\substack{z=0 \\ z'=l}} = Z_0\left[\frac{Z_L + Z_0 \tanh \gamma l}{Z_0 + Z_L \tanh \gamma l}\right]$ **[6marks]**

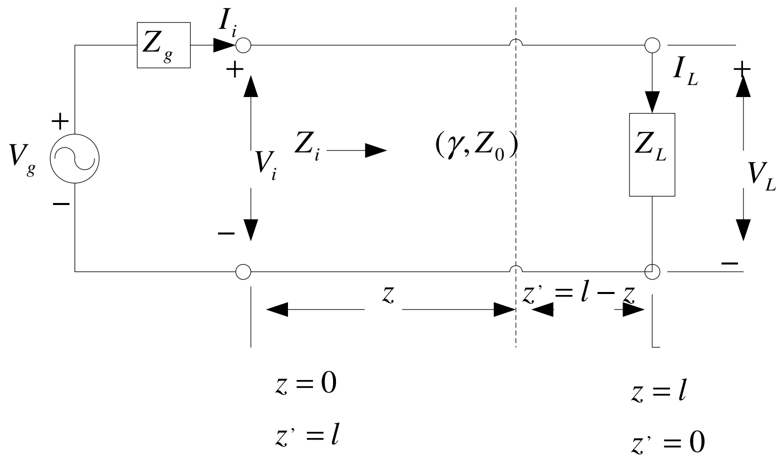

Fig. Q3 b) Finite Transmission Line Connected to Load

c) A certain transmission line operating at $\omega = 10^6 rad/s$ has $\alpha = 8$ 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 $10\llcorner 0^0 V$, $Z_g = 40\Omega$ and terminated by a load of $20 + j50\Omega$, determine: **[10marks]**
   (i) The input impedance
   (ii) The sending-end current
   (iii)The current at the middle of the line

QUESTION FOUR (20 MARKS)

a) With aid of examples and block diagrams, explain the difference between balanced and unbalanced transmission lines or systems. **[4marks]**

b) Discuss the meaning of Resonant Line and Anti-resonant Line as used in transmission lines. **[4marks]**

c) Prove that a maximum power is transferred from a voltage source with an internal impedance Z_g to a load impedance Z_L over a lossless transmission line when $Z_i = Z_g^*$ where Z_i is the impedance looking into the loaded line. What is the maximum power transfer efficiency?
[4marks]

d) A $100MHz$ generator with $V_g = 10\llcorner 0^0\ (V)$ and internal resistance 50Ω is connected to a lossless 50Ω air line that is 3.6m long and terminated in a $25{+}j25\Omega$ load. Find:
   (i) $V(z)$ at a location z from the generator,

(ii) V_i at the input terminals and $V_L$at the load,

(iii)the voltage standing-wave ratio on the line, and

(iv)the average power delivered to the load. **[8marks]**

QUESTION FIVE (20MARKS)

a) In the analysis of transmission lines there are **TWO** main approaches which can be adopted. Give these approaches and justify the selection made between them in this unit.
[3marks]

b) A distortionless line has $Z_0 = 60\Omega$, $\alpha = 20mNp/m$, $u = 0.6c$, where c the speed of light in a vacuum is. Determine $R,\ L,\ G,\ C$ and λ for the line at $100MHz$. **[5marks]**

c) Explain **ONE** Advantage and **ONE** Disadvantage of single-stub matching technique of transmission lines as compared to the quarter wavelength transformer. **[4marks]**

d) A 50Ω transmission line is connected to a load impedance $Z_L = 35 - j47.5\Omega$. Using Smith Chart, find the position and length of a short-circuited stub required to match the line
[8marks]