MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 313: TRANSMISSION LINES

DATE: 9/8/2021 **TIME:2:00 – 4:00 PM**

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-COMPULSORY (30 MARKS)

a) In the application of transmission line models, explain the circumstances under which we consider and use distributed parameter model and lumped parameter model. (4 marks)

b) Using the circuit of Fig. Q1 b) of a finite lossless transmission line connected to a load, show that the input impedance is given by $Z_i = (Z)_{\substack{z=0 \\ z'=l}} = Z_0 \left[\frac{Z_L \cos\beta l + jZ_0 \sin\beta l}{Z_0 \cos\beta l + jZ_L \sin\beta l}\right]$ (6 marks)

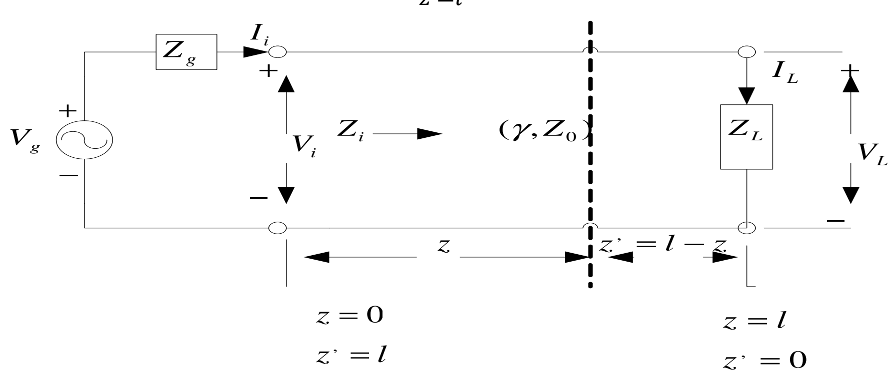

Fig. Q1 b) Finite Transmission Line Connected to Load

c) Identify four main problems associated with the standing waves on a transmission lines and the main mitigation measures. (4 marks)

e) A 0.6λ long lossless transmission line with $Z_0 = 75\Omega$ operating at $2MHz$ is terminated with a load $Z_L = 100 + j150\ \Omega$. Determine the following parameters **with and without** using the Smith Chart and comment on the results. (16 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.
vi) The input impedance Z_{in} at at the generator.

QUESTION TWO (20 MARKS)

a) Give at least two most popular higher order transmission lines and the frequencies under which they are used. (3 marks)

b) Identify the three simplifications that are used to model a communication transmission line system, clearly stating the function of each of the elements in the model. (3 marks)

c) The following characteristics have been measured on a lossy transmission line at $100\ MHz$: $Z_0 = 50\Omega$, $\alpha = 0.01dB/m = 1.15 \times 10^{-3}Np/m$, $\beta = 0.8\pi(rad/m)$. Determine R, L, G, and C for the line. (4 marks)

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. (10 marks)

QUESTION THREE (20 MARKS)

a) 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? (4 marks)

b) 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 $C = 40pF/m$. Find $\gamma, \alpha, \beta, \lambda,$ and Z_0.

(4 marks)

c) A Television antenna with impedance $40 + j30\Omega$ is to be matched to a 100Ω lossless transmission line with a single shorted stub. Using Smith Chart, determine: (12 marks)

i. The required stub admittance
ii. The distance between the stub and the antenna
iii. The stub length
iv. The standing wave ratio on each section of the system

QUESTION FOUR (20 MARKS)

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

(2 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 25% of its initial magnitude?
iii) How far will it travel to suffer a 30^0 phase shift? (6 marks)

c) A 300Ω feedline is to be connected to a $3m$ long, 150Ω line terminated in a 150Ω resistor. Both lines are lossless and use air as the insulating material, and the operating frequency is $50\, MHz$. Determine

i) the input impedance of the 3-m long line,
ii) the voltage standing-wave ratio on the feedline, and
iii) the characteristic impedance of a quarter-wave transformer if it was to be used between the two lines in order to achieve S = 1 on the feedline. (6 marks)

d) 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.

QUESTION FIVE (20MARKS)

a) Explain **the main** advantage of single-stub matching technique of transmission lines as compared to the quarter wavelength transformer. (2 marks)

b) What is dispersion? How is the term used with TEM lines and waveguides? (3 marks)

c) Explain the meaning of a Resonant Line as used in transmission lines. (2 marks)

c) A certain 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: (6 marks)

i) the characteristic impedance of the line
ii) the phase constant
iii) the velocity on the line
iv) the input impedance for $Z_L = 100\Omega$.

d) Derive the ABCD parameters for the T-network shown in Fig. Q5 d). Given that $V_1 = 10V, Z_1 = Z_2 = 15 + j20\ (\Omega), Z_3 = 30 - j45(\Omega)$. (7 marks)

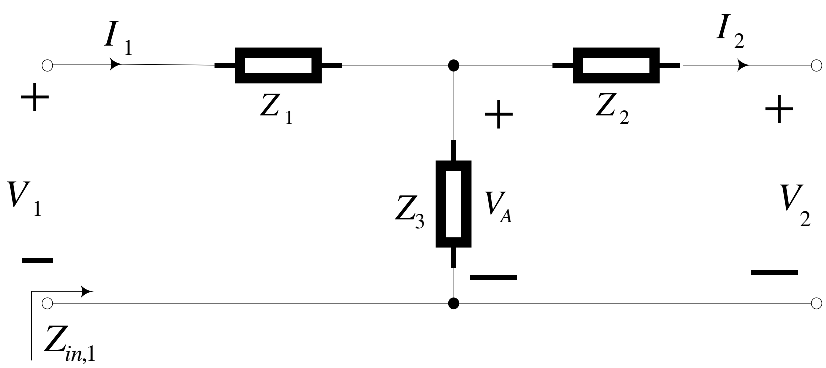

Fig. Q5 a)

Insert the smith chart in the answer booklet on the page relating to the question