UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: February 2020

Module Number: EE8209 **Module Name: Microwave Communication**

[Three Hours]

[Answer **all questions,** each question carries **10 marks]**

- All the notations have their usual meanings.
- Assume permittivity of free space is $\frac{10^{-9}}{36\pi}\ F/m$

Q1 a) Show that the admittance matrix of the two parallel-connected two-port π networks shown in Figure Q1.a) below can be found by adding the admittance matrices of the individual two-ports. Apply this result to find the admittance matrix of the bridged-T circuit shown in Figure Q1.b). What is the corresponding result for the impedance matrix of two series-connected T-networks?

[5 Marks]

b) Consider a series *RLC* circuit with a current *I*. Calculate the power lost and the stored electric and magnetic energies and show that the input impedance can be expressed as stored energy and power lost.

[5 Marks]

Q2 a) Show that the input impedance Z of a parallel *RLC* circuit satisfies the condition that $Z^*(\omega) = Z(-\omega)$. [3 Marks]

b) Consider a two-port network, and let $Z_{SC}^{(1)}, Z_{SC}^{(2)}, Z_{OC}^{(1)}$ and $Z_{OC}^{(2)}$ be the input impedance seen when port 2 is short-circuited, when port 1 is short-circuited, when port 2 is open- circuited, and when port 1 is open-circuited, respectively. Show that the impedance matrix elements are given by, $Z_{11} = Z_{SC}^{(1)}$, $Z_{22} = Z_{OC}^{(2)}$, $Z_{12}^2 = Z_{21}^2 = (Z_{0C}^{(1)} - Z_{SC}^{(1)})Z_{oC}^{(2)}$ [4 Marks]

c) Find the impedance parameters of a section of transmission line with length *l*, characteristic impedance Z_0, and propagation constant β.

[3 Marks]

Q3 a) Briefly explain the following parameters of a transmission line.

i) Intrinsic impedance
ii) Wave impedance
iii) Characteristics impedance

[3 Marks]

b) i) Assume that reflection takes place at height of 400 km and that the maximum density in the ionosphere corresponds to a 0.9 refractive index at 10 MHz. What will be the range for which the MUF at 10 MHz. [4 Marks]

ii) What is the critical frequency for reflection at vertical incident if the maximum value of electron density is $2.58\times10^{6}\ cm^{-3}$. [3 Marks]

Q4 a) What do you mean by the effective area of an antenna? [1 Mark]

b) The electric far-field component of a Hertzian dipole antenna with usual notation is given by $\bar{E}_{far} = \frac{j\eta_0\beta_0 I.\delta l.\sin\theta}{4\pi r} e^{-j\beta_0 r}\,\bar{a}_\theta$ where $\eta_0, I, \delta l$ and β_0 are the intrinsic impedance in free space, the amplitude of current, the length of Hertzian dipole and the propagation constant, respectively.

i) Show that the radiation power density vector in the radial direction is, $\hat{S}_{av} = \frac{\beta_0^2\eta_0 |I^2|(\delta l)^2\sin^2\theta}{32\pi^2 r^2}\,\bar{a}_r$, where $\bar{a}_r$ is the unit vector in the radial direction. [3 Marks]

ii) Using the expression derived in part (i) and applying $\eta_0 = 120\pi$, show that the total radiated power from a Hertzian dipole antenna can be given with usual notation as $P_{rad}(t) = \frac{2\pi\eta_0}{3}(\frac{\delta l}{\lambda_0})^2 \frac{|I^2|}{2}$ W. [4 Marks]

iii) Hence, calculate the radiation resistance R_{rad} of Hertzian dipole antenna. [2 Marks]

Q5 a) Find the Z parameters of the two-port T-network shown in Figure Q5.a). [3 Marks]

b) Find the *ABCD* parameters of a two-port network showing figure 5. b) consisting of a series impedance Z between ports 1 and 2. [3 Marks]

c) The impedance parameters of a network can be converted to *ABCD* parameters. Using the definition of the *ABCD* parameters in $\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$ and from the defining relations for the Z parameters of

$[V]=[Z][I]$ for a two-port network. Compute the A, B, C and D parameters with respect to Z parameters.

[4 Marks]

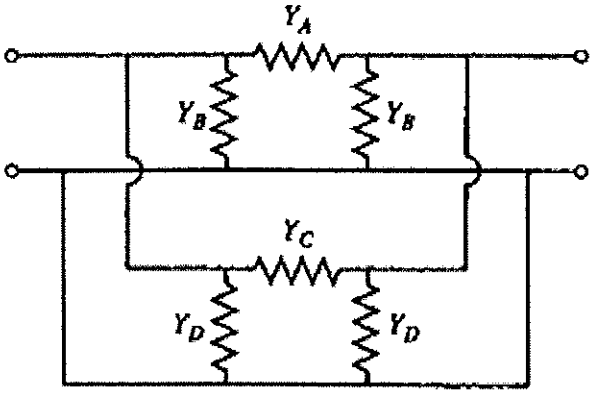

Figure Q1. a)

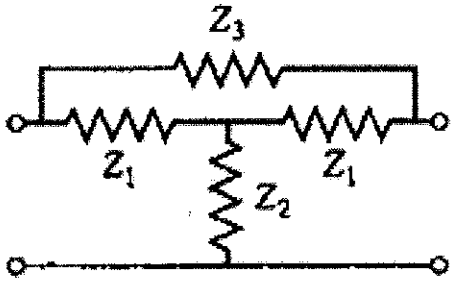

Figure Q1. b)

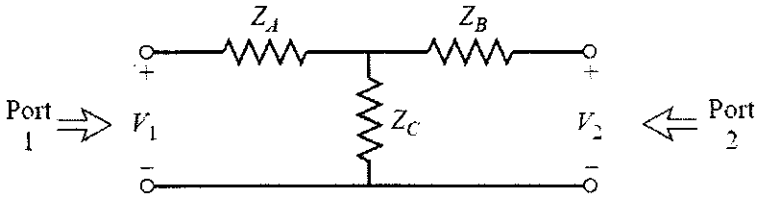

Figure Q5. a)

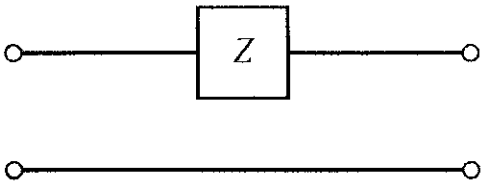

Figure Q5. b)