SEMESTER 2 EXAMINATIONS 2017/18

CIRCUITS AND TRANSMISSION

Duration 120 mins (2 hours)

This paper contains 6 questions

Answer **ONE** question in **Section A, ONE** question in **Section B** and **ONE** question in **Section C.**

Section A carries 33% of the total marks for the exam paper.

Section B carries 33% of the total marks for the exam paper.

Section C carries 33% of the total marks for the exam paper.

Only University approved calculators may be used.

A foreign language dictionary is permitted ONLY IF it is a paper version of a direct 'Word to Word' translation dictionary AND it contains no notes, additions or annotations.

11 page examination paper (+ 2 page formula sheet, 1 page The Complete Smith Chart)

SECTION A

Answer ONE out of TWO questions in this section

1 (a) In the network shown in Figure 1, two voltage sources act on the load impedance connected between A, B. If the load is variable in both resistance and reactance, what load Z_L will receive the maximum power and what is the value of the maximum power? Use Millman's theorem.

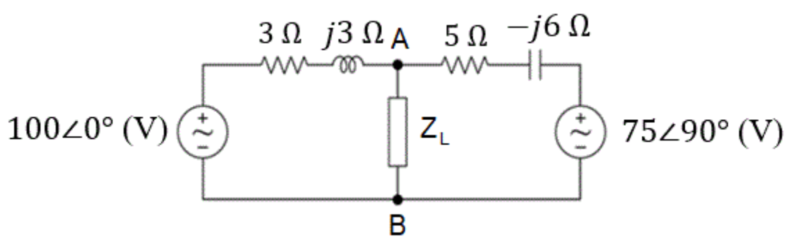

Fig. 1. The circuit for question 1(a)

[7 marks]

(b) Consider the circuit in Figure 2, operating in steady state at a particular frequency. The values of the parameters are $X_1 = 40\ \Omega$, $X_2 = 40\ \Omega$, $B_1 = 1/80\ mho$. Find the impedances Z_i and Z_L so that the circuit is matched.

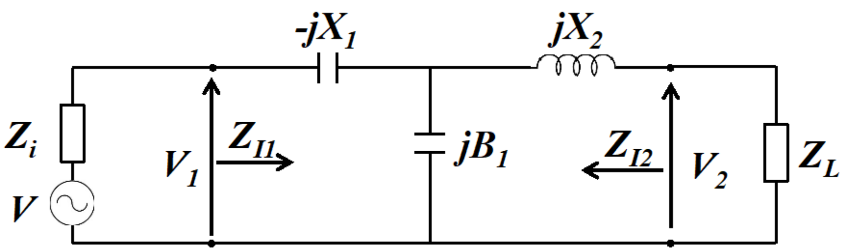

Fig. 2. The circuit for question 1(b)

[10 marks]

Question continues on following page

(c) Consider the two-port network in Figure 3, where the first impedance is $Z_1 = j\omega L$(an inductor), the second one is $Z_2 = R$(a resistor), and the admittance $Y = j\omega C$ (a capacitor). Derive the (A,B,C,D) representation of this network and explain how this representation is related to the Y representation of the same network (i.e. how the Y-matrix is related to the (A,B,C,D) matrix).

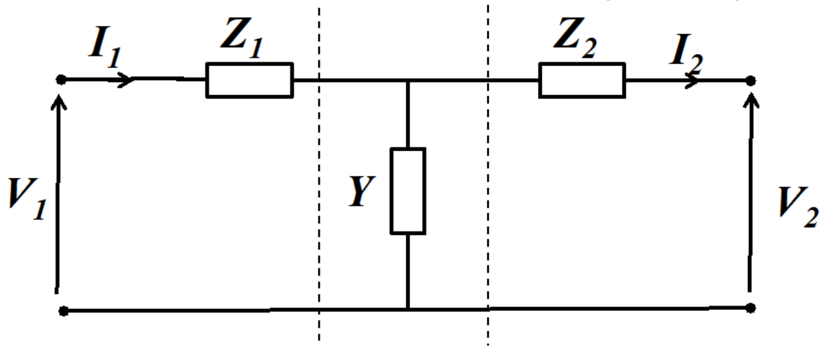

Fig. 3. The circuit for question 1(c) and 1(d)

[9 marks]

(d) Under which conditions is the two-port network in Figure 3 is reciprocal? What are the consequences of reciprocity on the (A,B,C,D) representation of a two-port? Give a symbolic expression for the iterative impedance of a symmetric, reciprocal network as a function of its (A,B,C,D) parameters.

[7 marks]

TURN OVER

Question 2

(a) Find and draw the Norton equivalent to the circuit shown in Figure 4 (with respect to the terminals A and B). The values of the components are $V_0 = 8\ V$, $R_1 = 4\ \Omega$, $R_2 = 1\ \Omega$, and $R_L = 5\ \Omega$.

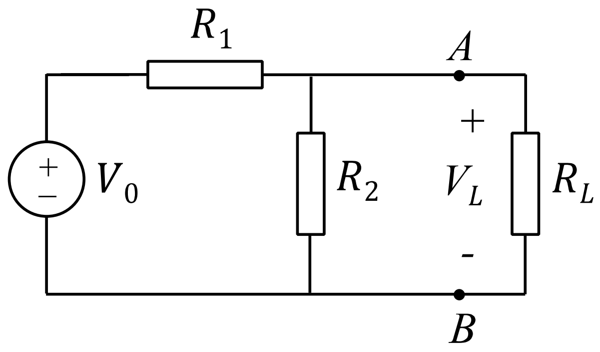

Fig. 4. The circuit for question 2(a)

[5 marks]

(b) Consider the circuit in Figure 5. Using mesh analysis, find the values of i_1, i_2, and i_3 when $V_0 = 4\ V$, $I_0 = 1\ A$, $R_1 = R_2 = 2\ \Omega$, $R_3 = 3\ \Omega$, and $R_4 = 4\ \Omega$.

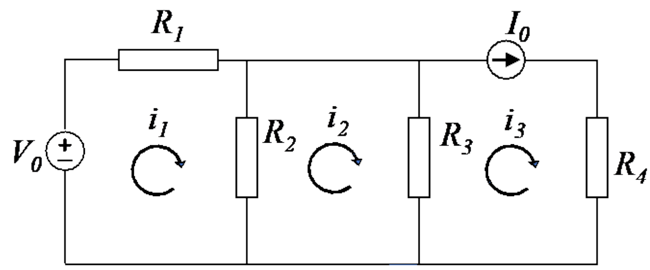

Fig. 5. The circuit for question 2(b)

[8 marks]

Question continues on following page

(c) Starting with the (A,B,C,D) representation of a two-port network, derive the equivalent Y-representation of a general two-port, giving the Y-parameters in terms of the (A,B,C,D) parameters. Calculate the Y-representation of two identical two-port networks connected in parallel, each having the following (A,B,C,D) representation:

$$\begin{bmatrix} 1 & 5 \\ \frac{3}{10} & 1 \end{bmatrix}.$$

[9 marks]

(d) Using Rosen's theorem, find the equivalent "star" circuit of the "delta" circuit shown in Figure 6. Draw the equivalent star, and mark clearly the calculated resistances and their positions relative to nodes 1, 2, and 3.

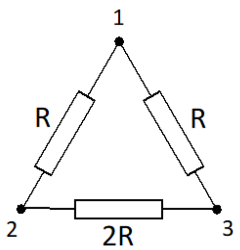

Fig. 6. The circuit for question 2(d)

[5 marks]

(e) Write down the (A,B,C,D) matrix for the two-port network shown in Figure 7. Calculate its image impedances if $R = 10\ \Omega$, and $Y_1 = Y_2 = 0.1\ \Omega^{-1}$.

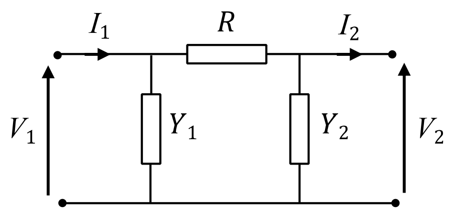

Fig. 7. The circuit for question 2(e)

[6 marks]

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SECTION B

Answer ONE out of TWO questions in this section

Question 3

(a) Describe what are meant by characteristic impedance and phase velocity. Explain when propagation constant becomes purely an imaginary number.

[6 marks]

(b) A 75 Ω coaxial transmission line has a length of 2.0 cm and is terminated with a load impedance of $37.5+j75$ Ω. Find the input impedance to the line, the reflection coefficient at the load and the reflection coefficient at the input and the SWR on the line for a wave traveling along the line with the wavelength of 16.0 cm.

[8 marks]

(c) Consider a lossless transmission line having different propagation constants β^+ and β^-, for propagation in the forward and reverse directions, with corresponding characteristic impedances Z_0^+ and Z_0^- (An example of such a line could be a microstrip transmission line on a magnetized ferrite substrate). If the line is terminated with the load Z_L as shown in figure 8, derive expressions for the reflection coefficients at the load and in the input as well as the impedance seen at the input of the line.

[15 marks]

Question continues on following page

(d) Show that if in figure 8, $\beta^{+} = \beta^{-} = \beta$ and $Z_0^{+} = Z_0^{-} = Z_0$, then the reflection coefficients at the load and the input, and the input impedance are reduced to:

$$\Gamma_{Load} = \frac{Z_L - Z_0}{Z_L + Z_0}$$
$$\Gamma_{Input} = \Gamma_{Load} e^{-2j\beta l}$$
$$Z_{Input} = Z_0 \frac{1 + \Gamma_{Load} e^{-2j\beta l}}{1 - \Gamma_{Load} e^{-2j\beta l}}$$

[4 marks]

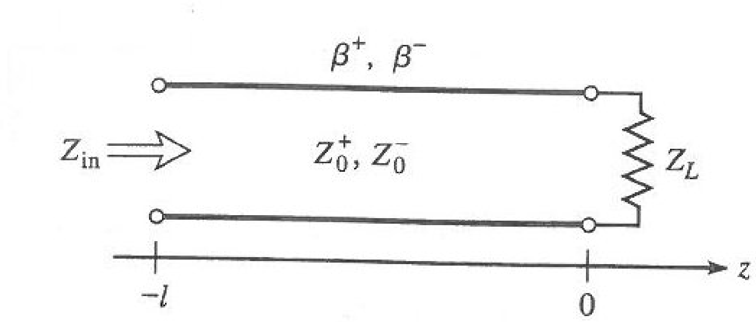

Fig. 8. The circuit for question 3(c) and 3(d)

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Question 4

(a) A distortion-less transmission line has $Z_0 = 60\ \Omega, \alpha = 20 \times 10^{-3}\ Np/m,\ v_p = 0.6c$, where c is the speed of light in vacuum. Find R, L, G, C and λ at 100 MHz.

[7 marks]

(b) A transmission line has the following distributed parameters $R = 30\ \Omega/km\,, L = 100\ mH/km\,, G = 0, and\ C = 20\ \mu F/km$. Calculate the characteristic impedance of the line, the propagation constant of the line and the phase velocity at frequency of 1 kHz.

[5 marks]

(c) A 2 m long transmission line operates at $\omega = 10^6\ rad/s$. This transmission line has an attenuation coefficient $\alpha = 8\ dB/m$, a phase coefficient $\beta = 1\ rad/m$ and a characteristic impedance $Z_0 = 60 + j40\ \Omega$. The line is connected between a source of $10\ \angle 0°\ V$ and source impedance $Z_s = 40\ \Omega$ and a load with a load impedance $Z_L = 20 + j50\ \Omega$. Calculate for this line the input impedance, the current at the sending end (at the source) and the current in the middle of the line.

[17 marks]

(d) A lossless transmission line with a characteristic impedance $Z_0 = 50\ \Omega$ operating at 2 MHz is terminated with a load $Z_L = 60 + j40\ \Omega$. If the length of the line is 30 m and the phase velocity on this line is $v_p = 0.6c$, where c is the speed of light in vacuum, find the reflection coefficient, the standing wave ratio and the input impedance of this line.

[4 marks]

SECTION C

Answer ONE out of TWO questions in this section

Question 5

A balanced three phase delta connected load has a per phase impedance $Z = 21\angle 30\ \Omega$.

The load is connected to a star connected voltage supply, where the neutrally is solidly grounded.

The lines which connect the load to the voltage supply have an entirely resistance impedance equal to $0.5\ \Omega$.

The phase voltages of the supply are:

$$V_{AN} = 110 \angle 0° \ V$$
$$V_{BN} = 110 \angle -100° \ V$$
$$V_{CN} = 105 \angle 105° \ V$$

(a) Obtain the sequence impedances, as seen from the terminals of the supply.

[6 marks]

(b) Use the symmetrical components method to obtain the line currents.

[18 marks]

(c) Find the complex power consumed by the load.

[9 marks]

TURN OVER

Question 6

A balanced, star-connected three-phase voltage source is connected to an unbalanced star-connected three-phase load as shown in the Figure 9 below:

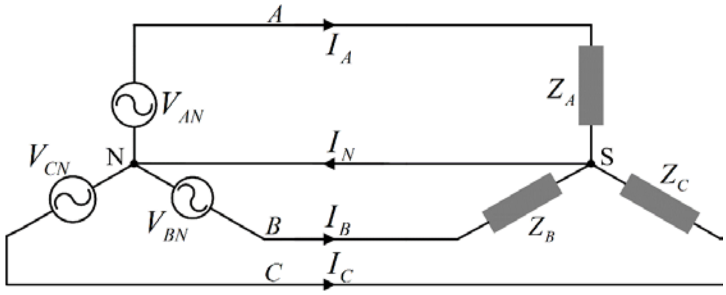

Fig. 9. The circuit for question 6

The phase voltage phasors and the loads are:

$V_{AN} = 230 \angle 0° \ V\ (rms)$ $\qquad$ $Z_A = 10 \angle 0° \ \Omega$

$V_{BN} = 230 \angle -120° \ V\ (rms)$ $\qquad$ $Z_B = 15 \angle 45° \ \Omega$

$V_{CN} = 230 \angle 120° \ V\ (rms)$ $\qquad$ $Z_C = ?\ \Omega$

(a) Calculate the neutral current, IN and phase C impedance, ZC if the total complex power consumed by the three-phase load is $10772 \angle 20.7° \ VA$.

[16 marks]

(b) Neutral current, I_N can be reduced by connecting an impedance, Z_N between the two neutral terminals N and S. Determine Z_N such that the neutral current is reduced to $1 \angle 0° \ A$.

[6 marks]

(c) Using Millman's theorem, calculate the voltage between the two neutral terminals N and S if the neutral wire in Fig. 1 is disconnected. Then, calculate phase voltages across the load, phase currents and total complex power consumed by the three-phase load.

[11 marks]

END OF PAPER