SEMESTER 2 EXAMINATIONS 2014/15

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 word to word® translation dictionary (paper version) is permitted provided it contains no notes, additions or annotations.

11 page examination paper (+ 2 page formula sheet)

SECTION A

Answer *ONE* out of *TWO* questions in this section

Question 1.

(a) Use Millman's theorem to find the values of I_1, I_2, I_3 in the circuit in fig. 1, knowing that $E_1 = 11\ V$, $E_2 = 7\ V$, $R_1 = 2\ \Omega$, $R_2 = 1\ \Omega$, $R_3 = 1\ \Omega$.

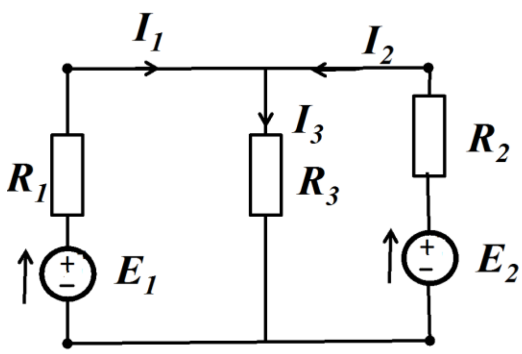

Fig. 1. The circuit for question 1(a)

[5 marks]

(b) Apply Thevenin's theorem to compute I_3, the current through the resistance R_3, for the circuit in fig. 2, knowing that $E_1 = 2\ V$, $R_1 = 200\ \Omega$, $R_2 = 4200\ \Omega$, $R_3 = 800\ \Omega$.

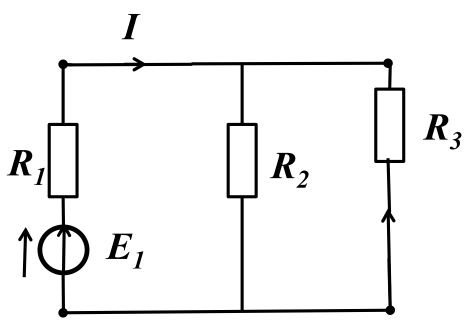

Fig. 2. The circuit for question 1(b)

[6 marks]

Question continues on following page

(c) Consider the circuit in fig. 3. Apply the mesh method (orientation indicated) to find the voltage across R_2 and R_3 knowing that $R_1 = 2\ \Omega$, $R_2 = 8\ \Omega$, $R_3 = 4\ \Omega$.

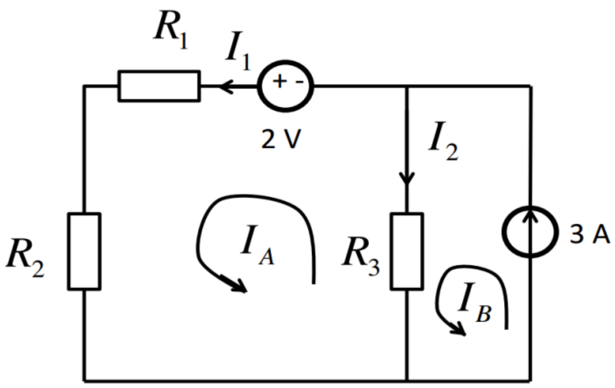

Fig. 3. The circuit for question 1(c)

[6 marks]

(d) A two-port network has the A, B, C, D representation

$$\begin{bmatrix} 2 & 1 \\ 2 & 3/2 \end{bmatrix}$$

Can it be a T-network? Justify your answer.

[6 marks]

Question continues on following page

(e) Consider the circuit in fig. 4, operating in steady state at a particular frequency. The values of the parameters are $X_1 = 50\ \Omega$, $X_2 = 50\ \Omega$, $B_1 = 1/100\ mho$. Find the impedances Z_i and Z_L so that the circuit is matched.

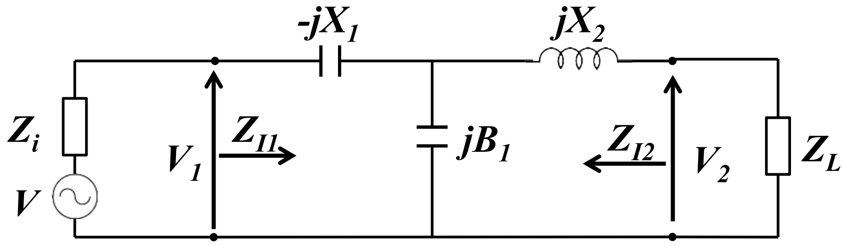

Fig. 4. The circuit for question 1(e)

[10 marks]

Question 2.

(a) Consider the circuit in fig. 5, where $I_0 = 50\ A$, $R_0 = \frac{6}{5}\ \Omega$, $R_1 = 6\ \Omega$, $R_2 = \frac{41}{10}\ \Omega$, $R_3 = \frac{14}{5}\ \Omega$, $E_1 = 40\ V$ and $E_2 = 13\ V$. Use Thevenin's and Millman's theorems to compute I_2. Show clearly how you arrive at your result.

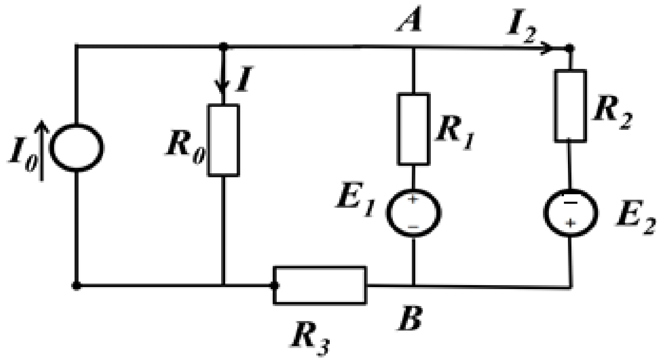

Fig. 5. The circuit for question 2(a)

[10 marks]

(b) Write down the A, B, C, D representation of the π-network in fig. 6.

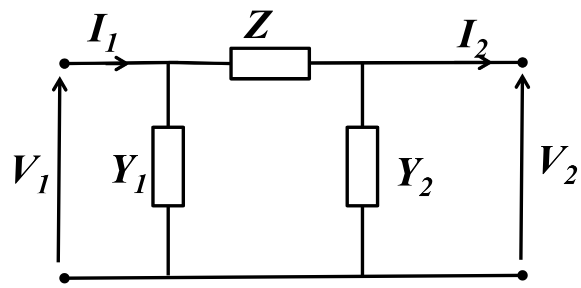

Fig. 6. The circuit for question 2(b) and 2(c)

[6 marks]

Question continues on following page

(c) Write down the A, B, C, D representation of a 2-port network obtained by cascading two π-networks, each equal to that shown in fig. 6.

[3 marks]

(d) Consider the network represented in fig. 7, where $Z_1 = Z_2$. Find the iterative impedance of the network. Explain clearly how you arrived at your answer.

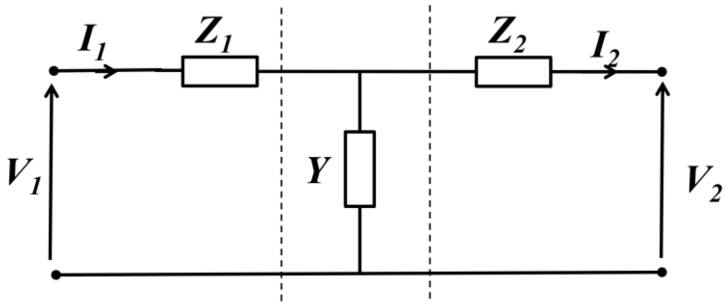

Fig. 7. The circuit for question 2(d)

[6 marks]

(e) Consider the circuit depicted in fig. 8. Applying the mesh method (meshes and directions are indicated in dotted lines), find the numerical value of the current flowing through the 25Ω resistance.

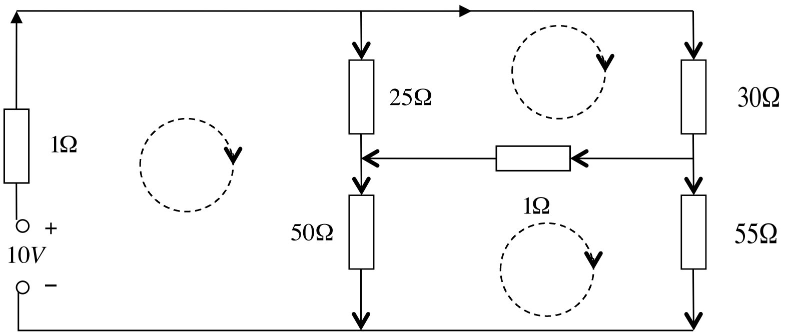

Fig. 8. The circuit for question 2(e)

[8 marks]

SECTION B

Answer *ONE* out of *TWO* questions in the section

Question 3.

(a) Explain why there are distortions in signal transmission in lossy transmission lines. Explain what relation among the line parameters should hold to correct such distortions and why such a relation corrects the distortions.

[6 marks]

(b) A lossless transmission line has the following per-unit-length parameters: $L = 0.5\ \mu H/m,\ C = 200\ pF/m$.
Calculate the propagation constant and characteristic impedance, wavelength and the phase velocity for this lossless line at $800MHz$.

[5 marks]

(c) Calculate the propagation constant and characteristic impedance of the line defined in 3(b) at frequency $800\ MHz$ for the case when the line is lossy with,
$R = 4.0\ \Omega/m$ and $G = 0.02\ S/m$. If the line is $30\ cm$ long, calculate the attenuation in dB.

[6 marks]

(d) A coaxial transmission line with the characteristic impedance of $75\ \Omega$ has a length of $2.0\ cm$ and is terminated with a load impedance of $(37.5+j75)\ \Omega$. If the line has permeability of free space and the relative permittivity of 2.56 and the frequency is $3.0\ GHz$, find the input impedance of the line, the reflection coefficient at the load, the reflection coefficient at the input and the SWR on the line.

[9 marks]

Question continues on following page

TURN OVER

(e) Let Z_{sc} be the input impedance of a length of coaxial line when one end is short-circuited, and let Z_{oc} be the input impedance of the line when one end is open-circuited. Derive an expression for the characteristic impedance of the cable in terms of Z_{sc} and Z_{oc}.

[7 marks]

Question 4.

A transmission line used at a frequency of *400 MHz* has the following distributed circuit coefficients at that frequency:
$R = 0.085\ \ \Omega/\mathrm{m};\ \ L = 0.32 \times 10^{-6}\ \ \mathrm{H/m};$
$G = 1.35 \times 10^{-6}\ \ \mathrm{S/m};\ C = 40 \times 10^{-12}\ \ \mathrm{F/m}.$

(a) Find the characteristic impedance of the line at the frequency of operation and comment on the result obtained.

[6 marks]

(b) Assuming that at a coordinate z on this transmission line the instantaneous current is given by
$i(t) = 100 \times 10^{-3} \cos(\omega t)\ A$. Find an expression of the voltage gradient along the line at the point z in *V/m*.

[9 marks]

(c) Assuming that the losses of this transmission line can be ignored (lossless case) calculate the wavelength, phase velocity as well as the phase difference that a phasor voltage will experience if the length of this transmission line is *5 m*.

[6 marks]

(d) Assuming that this transmission line is lossless and is terminated with a load impedance $Z_L = 100\ \Omega$ calculate the reflection coefficient for voltage waves at the terminal load end of the line.

[5 marks]

(e) If this transmission line is terminated with a load that has a $Z_L = 27\ \Omega$ calculate the reflection coefficient for this case. Calculate the characteristic impedance and the length in meters of a quarter wavelength transformer that could be used to match the lossless transmission line with this load.

[7 marks]

SECTION C

Answer *ONE* out of *TWO* questions in this section

Question 5.

(a) An unbalanced star connected load is connected to a balanced star supply with a three line system. The phase supply voltages are $230\ V$ positive rotation and the load has the following impedances:

$Z_A = 20\ \Omega$
$Z_B = (15 + j20)\ \Omega$
$Z_C = (60 - j40)\ \Omega$

The three lines have a purely resistive impedance of $1\ \Omega$. Determine the line currents and the potential difference between the two star points.

[20 marks]

(b) The load impedances in a three phase circuit are defined as $Z_{AS} = Z_{BS} = Z_{CS} = (40 + j30)\ \Omega$. They are supplied by a star connected negative sequence supply with a phase voltage of $24\ V$.

i) Transform these star connected impedances to their delta equivalents.

[4 marks]

ii) Demonstrate that the line currents drawn from the supply would be the same for both the star and delta cases.

[9 marks]

Question 6.

(a) Each element of a delta connected load has an equal impedance, Z. Show how two wattmeters could be connected in the circuit to measure the total power. Demonstrate that this would give the same result as using one wattmeter per phase.

[16 marks]

(b) A four wire star connected system has load impedances of $50\ \Omega$ and a neutral line impedance of $10\ \Omega$. The remaining lines have zero impedance. The supply phase voltages each have a magnitude of:

$V_{AN} = 120\angle 0°\ V$
$V_{BN} = 120\angle -100°\ V$
$V_{CN} = 120\angle -250°\ V$

i) Explain how to obtain Zs, the sequence impedance matrix

[9 marks]

ii) Use the method of symmetrical components to determine the neutral current.

[8 marks]

END OF PAPER