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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4331 Circuit Theory and Design**
Academic Year	: 2021/2022
Date	: 13th February 2023
Time	: 13:30 – 16.30 hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **Six (6)** pages.
3. Answer any **Five (5)** questions. All the questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use Red colour pen.

Question 01

Part A

A small-scale DC bus bar system having four parallel connected real DC voltage sources feeds three resistive loads as given in Figure 1. The four voltage sources are used to accomplish the consumers' requirement as shown. Voltages, Resistances and Load values are as follows.

- E1 = 3 V, E2 = 6 V, E3 = 10 V, E4 = 2 V.
- R1 = 3 Ω, R2 = 2 Ω, R3 = 4 Ω, R4 = 0.5 Ω.
- Load A = 30 Ω, Load B = 5 Ω, Load C = 15 Ω.

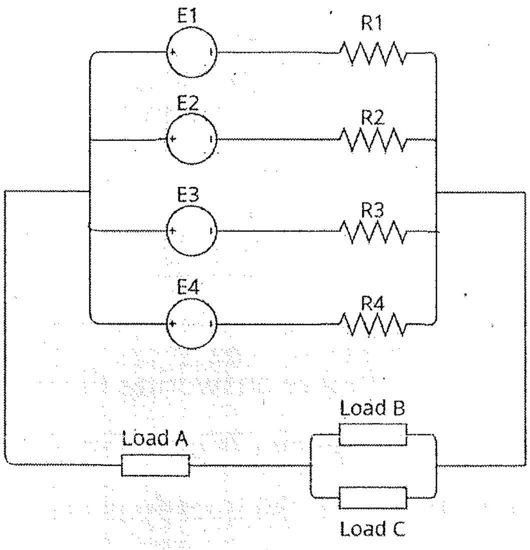

Figure 1

I. Supplier of the DC bus system is planning to replace the given DC voltage sources with a single source. Calculate the equivalent DC voltage source required. *(05 marks)*

II. Draw the equivalent circuit after the above replacement. *(02 marks)*

III. Calculate the current through the load B in the Figure 1 *(04 marks)*

Part B

Verify the reciprocity theorem in the network given in Figure 2. *(04 marks)*

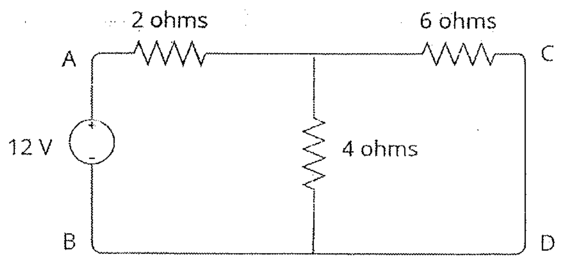

Figure 2

Part C

Solve the loop currents of the circuit given in figure 3 using the matrix method. *(05 marks)*

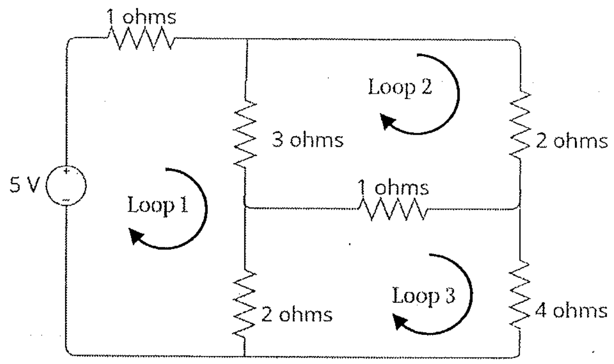

Figure 3

Question 02

Figure 4 shows a RL circuit. The circuit is excited using a square wave signal generator [$v_s(t)$].

- $v_s(t) = \frac{12}{\pi}\sum_{n=1}^{\alpha}(-1)^{n+1}\frac{1}{(2n-1)}\cos(2n-1)\pi t$
- $L1 = \frac{2}{\pi}$ H, $R1 = 4\Omega$

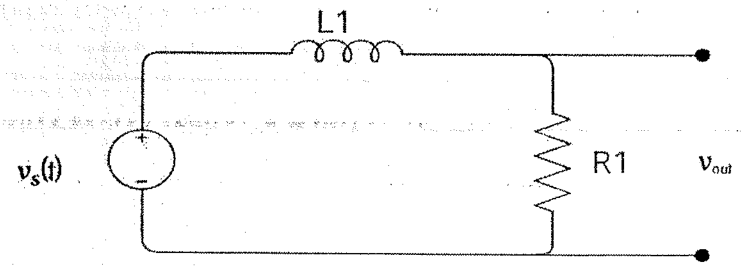

Figure 4

Follow the given steps to find the output voltage (Vout) of the RL circuit.

I. Express the periodic excitation ([$v_s(t)$]) in terms of Fourier harmonics for the first three components. (n=1,2,3) *(06 marks)*

II. Determine the counterpart of the above three components in the phasor domain. *(03 marks)*

III. With help of part II above, derive an expression for V_{out} *(02 marks)*

IV. Determine the output response relevant to part I. The input values are in time domain. *(07 marks)*

V. Determine the output voltage in time domain. *(02 marks)*

Question 03

Consider the RLC circuit shown in Figure 5. At $t = 0$ the switch SW is closed.

- E1 = 10 V, L1 = 4H, R1 = 8 Ω, C1 = 0.125 F

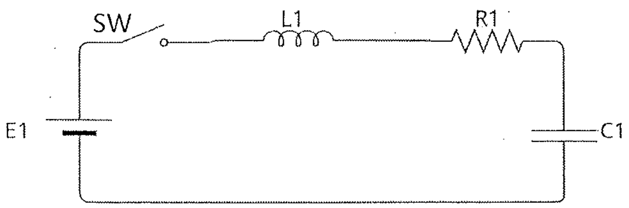

Figure 5

I. Write a differential equation relating the voltages across each of the passive element using Kirchhoff's voltage law. Assume that the capacitor is initially fully discharged and the inductor doesn't contain any stored energy in it. *(03 marks)*

II. Solving the differential equation written in 'I', obtain an expression to the current through the circuit for $t > 0$. (Consider that the initial voltages across the capacitor and current through each element as zero) *(11 marks)*

III. Sketch the variation of current through the circuit against time. (Start from $t = 0$) *(04 marks)*

IV. State the type of the response of this circuit. *(02 marks)*

Question 04

I. Realize the following LC impedance function using Foster 1st and 2nd forms. *(10 marks)*

$$Z(s) = \frac{4\,(s^2+1)(s^2+16)}{s^3+4s}$$

II. Realize the following LC impedance function using Cauer 1st and 2nd forms. *(10 marks)*

$$Z(s) = \frac{(s+1)(s+4)}{s^3+7s^2+10s}$$

Question 05

Part A

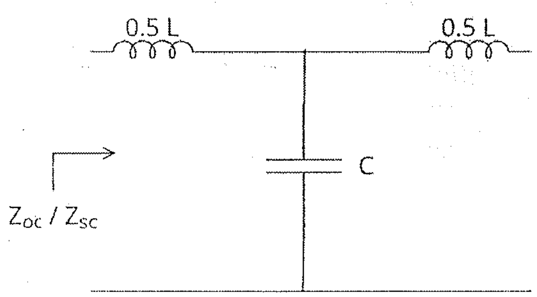

Figure 6

Figure 6 shows a T-Network.

I. Calculate Open circuit impedance (Zoc) and Short circuit impedance (Zsc) of the above T network. *(04 marks)*

II. If the value of the two inductors equal to 6 H and the value of the capacitor is equal to 1.5 micro farad, determine the type of filter and the cutoff frequency .
(Hint: Refer the given Figure 7 and Table 1) *(06 marks)*

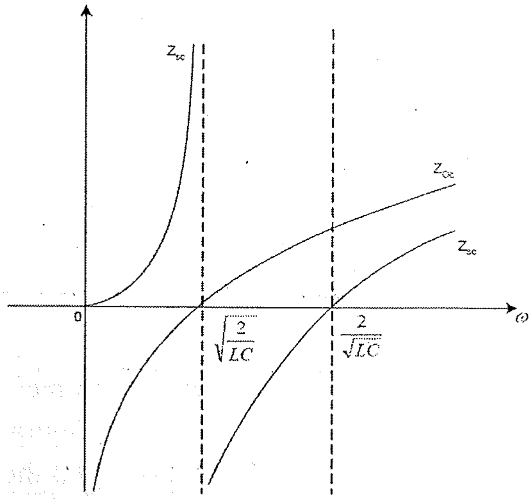

Figure 7

X_{OC}	X_{SC}	Z_O	Tanh γ	Band	α
>0	>0	Imag.	real	stop	$\neq 0$
>0	<0	real	Imag.	pass	=0
<0	>0	real	Imag.	pass	=0
<0	<0	Imag.	real	stop	$\neq 0$

Table 1

Part B

I. State one of the key advantages in Butterworth filter. *(01 marks)*

The magnitude function of a certain filter needs to be determined using Butterworth approximation. Specification of the filter as follows,

- Pass Band = 0-5MHz
- Pass Band tolerance = 0.25dB
- High frequency attenuation(minimum) 20dB at 7.5MHz
- Attenuation, $A_{db} = 10\log_{10}(1+\epsilon^2 X^{2n})$

II. Find the magnitude function of the above filter. *(09 marks)*

Question 06

I. Write the terminal characteristic equations of a general two port network in matrix. form using, *(04 marks)*

a. Open circuit impedance (Z) parameters.
b. ABCD Transmission parameters.

II. Find the Z parameters of the network shown in Figure 8. *(10 marks)*

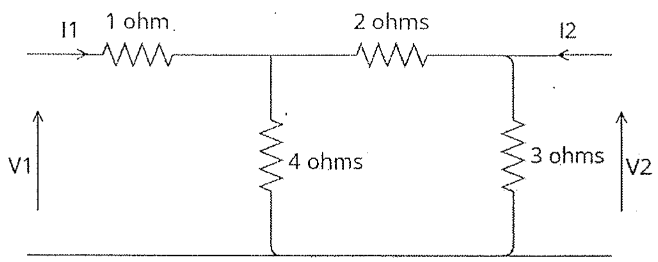

Figure 8

III. State the conditions that are needed for the reciprocity. Give your comments on the reciprocity of the above network shown in Figure 8. *(03 marks)*

IV. Figure 9 shows a reciprocal T network. Find the Input impedance (Z_{in}) of the given network if the load (Z_L) is terminated with 1 Ω. Z parameters of the network as below. *(03 marks)*

$$[Z] = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

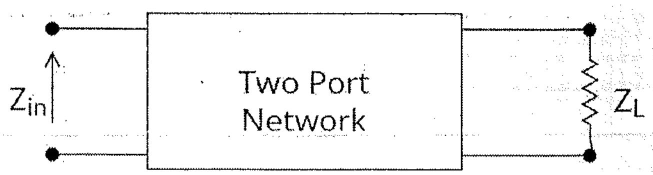

Figure 9

Question 07

Part A

I. A linear system is described by a differential equation given bellow. Find the system poles and zeros. (Hint: take the Laplace transform of the given system) *(04 marks)*

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 6y = 2\frac{du}{dt};$$
$$initial\ conditions, u(0) = 1; y(0) = 1;\ y^{|}(0) = 1.$$

II. A system has a pair of complex conjugate poles p_1, p_2 equals to $-1 \pm j2$, a single real zero $z_1 = -4$, and a gain factor $K = 3$. Find the differential equation representing the system. *(04 marks)*

Part B

Consider the circuit in Figure 10.

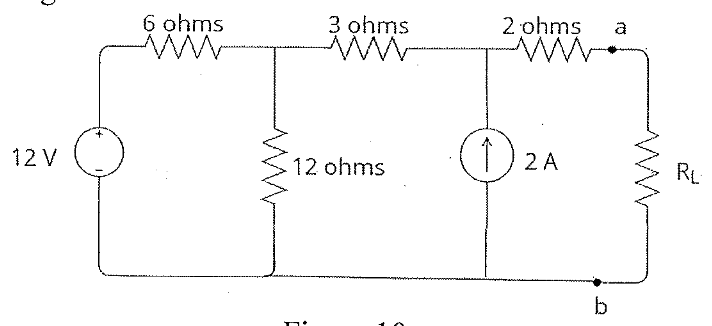

Figure 10

I. Find the Thevenin's Voltage and Thevenin's Resistance of the above circuit. *(05 marks)*

II. Draw the Thevenin's equivalent of the given circuit. *(01 marks)*

III. State the maximum power transfer theorem. *(02 marks)*

IV. Find the value of load resistance RL that gives maximum power of the circuit *(04 marks)*

-End of Paper-