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

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4331 Circuit Theory and Design**
Academic Year	: 2022/2023
Date	: 13th February 2024
Time	: 13:30 – 16:30hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Four (4)** pages.
3. Answer any **Five (5)** questions. All 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 – Answer both part A and B.

Part A

Consider the circuit shown in Figure Q1.1

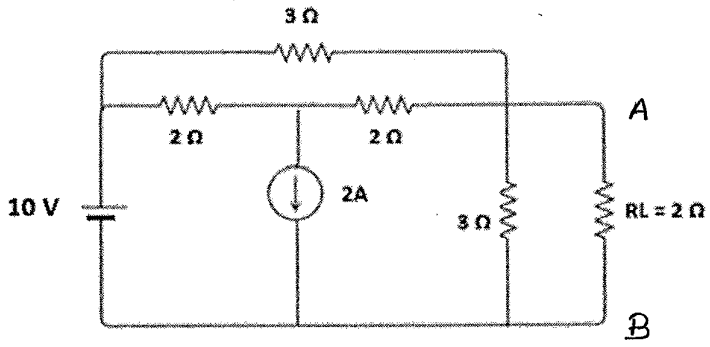

Figure Q1.1

I. Calculate the Thevenin's equivalent voltage and impedance at points A and B of the circuit shown in figure Q1.1 *(03 marks)*

II. Using the calculations made in part I, draw the Thevenin's equivalent circuit of the network. *(02 marks)*

III. Calculate the value of *RL* to deliver the maximum power. *(02 marks)*

IV. Hence or otherwise find the maximum power delivered to RL. *(03 marks)*

Part B

Consider the circuit shown in Figure Q1.2

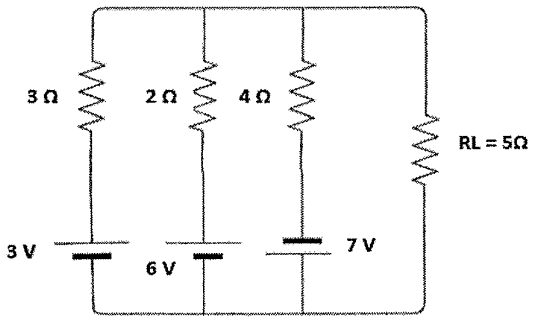

Figure Q1.2

I. Use Milliman's theorem to determine the current through the resistor *RL*. Include a sketch of the simplified circuit in your answer. *(10 marks)*

Question 02

The RL circuit shown in figure Q2 is excited with a square wave [$v_s(t)$] voltage signal

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

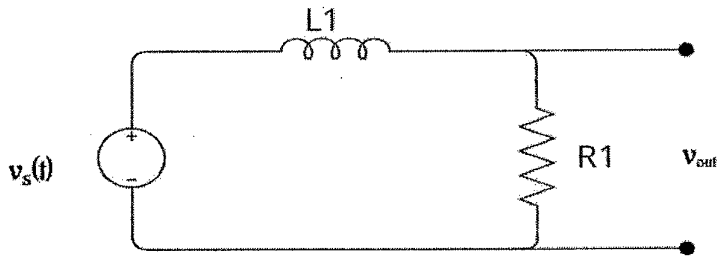

Figure Q2

I. Express the periodic excitation (input) in terms of Fourier expansion for the first three frequency components. (n=1,2,3) *(05 marks)*

II. Write an expression to the output of the circuit (V_{out}) in the complex frequency domain (s-domain). *(05 marks)*

III. Using the results of part II, derive an expression for V_{out} in the time domain. *(10 marks)*

Question 03

Consider the RLC circuit shown in Figure Q3. At $t = 0$ the switch is closed.

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

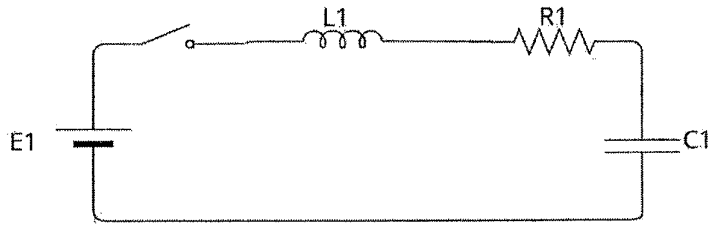

Figure Q3

I. Write a differential equation relating voltages across each element using Kirchhoff's voltage law. Assume the capacitor is initially fully discharged and the inductor does not contain any stored magnetic energy. *(04 marks)*

II. Solving the differential equation, you have written in 'I', obtain an expression to the current through the circuit for $t > 0$. *(10 marks)*

III. Sketch the variation of current in 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. *(14 marks)*

$$Z(s) = \frac{3\,(s^2+1)(s^2+16)}{s(s^2+9)}$$

II. Realize the following LC impedance function using Cauer 1st form. *(06 marks)*

$$(s) = \frac{2\,s^5 + 12\,s^3 + 16\,s}{s^4 + 4s^2 + 3}$$

Question 05

Part A

Figure Q5.1 shows a T-Network.

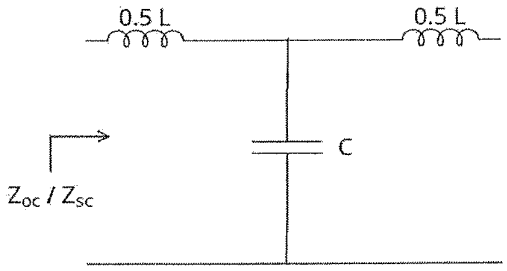

Figure Q5.1

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

II. If the two inductor values are equal to 6 H and the capacitor value is equal to 1.5 μF, find the type of filter and the cutoff frequency of it.
(**Hint**: Refer to the chart and table given in figure Q5.2 and Table Q5) *(06 marks)*

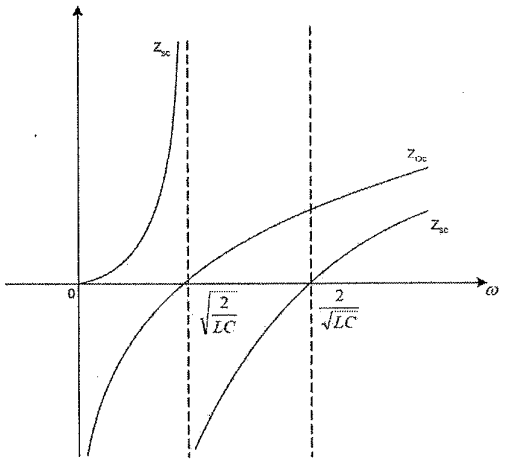

Figure Q5.2

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 Q5

Part B

I. State one key advantage in Butterworth filter *(02 marks)*

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

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

Find the magnitude function of the above filter. *(08 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. Determine the ABCD parameters of the circuit shown in figure Q6. *(08 marks)*

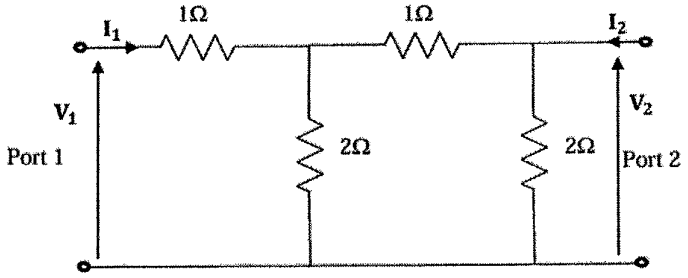

Figure Q6

III. Is the network shown in figure Q6 reciprocal? Justify your answer using the results obtained in part II. *(04 marks)*

IV. Calculate the image impedance at port 1 and port 2. *(04 marks)*

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