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	: 2020/2021
Date	: 15th February 2022
Time	: 0930-1230 hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Seven **(07)** questions in **five (05)** pages.
3. Answer any **Five (5)** questions only. 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 a red color pen.
8. Adhere to usual notations.

1.

a. Consider the circuit shown in Figure 01-(a).

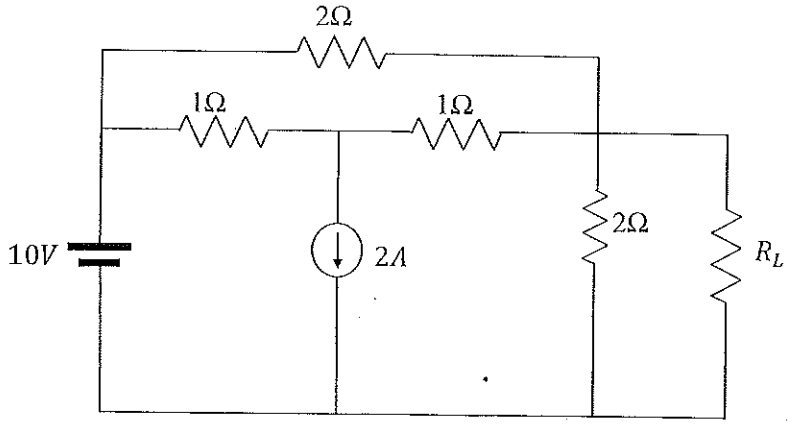

Figure 01-(a)

i. Determine the Thevenin's voltage (V_{Th}) and Thevenin's resistance (R_{Th}) with reference to the resistance R_L of the circuit. [03 marks]

ii. Represent the circuit shown in figure 01-(a) using the Thevenin's equivalent. [02 marks]

iii. Determine the value of R_L to provide the maximum power transfer from the source. [02 marks]

iv. Calculate the maximum power transfer of the circuit. [03 marks]

b. Consider the circuit shown in Figure 01-(b).

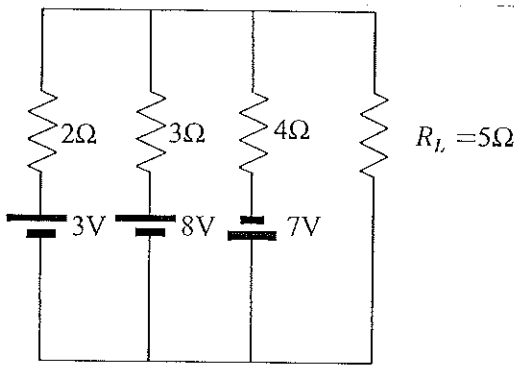

Figure 01-(b)

i. Determine equivalent source voltage of the circuit. [05 marks]

ii. Draw the simplified circuit using equivalent source voltage circuit of the Figure 01-(b). [02 marks]

iii. Calculate the current through the R_L. [03 marks]

2. Consider the RLC circuit shown in Figure 02.

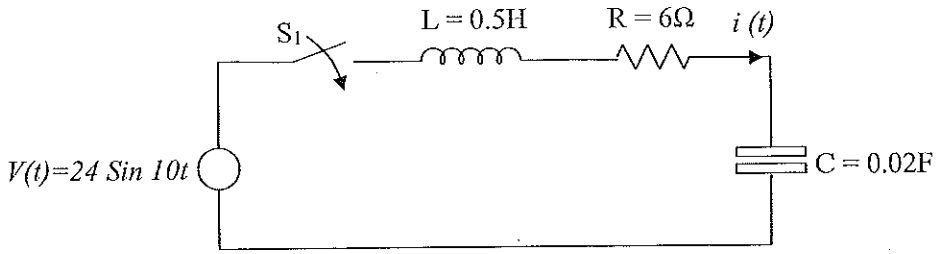

Figure 02

i. Derive the differential equation that characterizes voltage and current of the circuit at any instant of time. Assume that the capacitor (C) is initially fully discharged. *(Hint: use Kirchhoff's law).* [05 marks]

ii. Solving the differential equation you have written in 'i', obtain an expression to the charge of the capacitor (*q (t)*) at time *t*. [15 marks]

3. Consider the RLC circuit shown in Figure 03. At $t = 0$ the switch S_1 is closed.

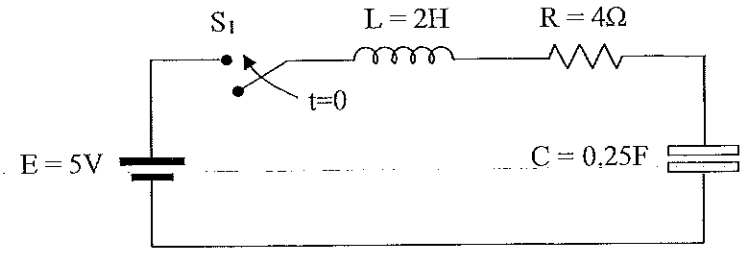

Figure 03

i. Write a differential equation relating voltages across each element using Kirchhoff's voltage law. Assume that the capacitor is initially fully discharged and no energy is stored in the inductor L. [02 marks]

ii. Solving the differential equation, you have written in 'i', obtain an expression for the current through the circuit i(t) for $t > 0$. [12 marks]

iii. Sketch the variation of current of the circuit against the time. (start from $t = 0$) [04 marks]

iv. State the type of the response of this circuit. [02 marks]

4. Consider the circuit given in Figure 04. The switch S_1 is closed at t = 0 s.

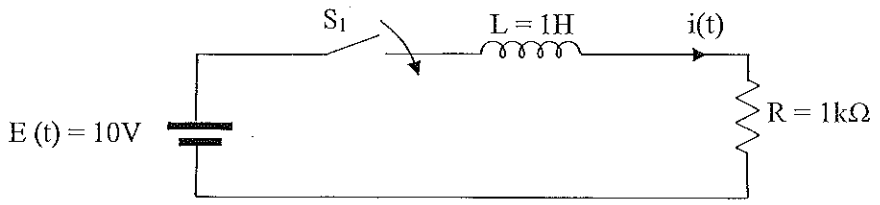

Figure 04

i. Write the differential equation to determine the current through the circuit after closing the switch. [02 marks]

ii. Convert the differential equation in to s – domain using Laplace Transform and obtain an expression to the impedance function Z(s) which is also in s – domain. [02 marks]

iii. Derive the solution for current through the circuit in s – domain I(s). [02 marks]

iv. Using inverse Laplace transform, derive the solution for current through the circuit in time domain I (t). [08 marks]

v. Using the expression derived in step iii above, obtain the natural response of the circuit in both time and s – domain. [06 marks]
(Hint – Replace the voltage source with a voltage impulse)

5. Consider the circuit is shown in Figure 05. The switch S_1 is closed at t = 0s.

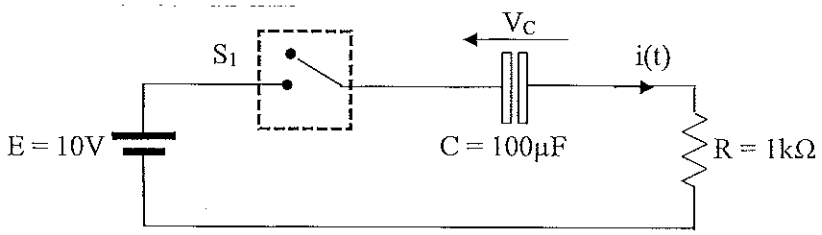

Figure 05

i. Write the differential equation to find the current through the circuit after closing the switch S_1. [02 marks]

ii. Write the characteristic equation of the differential equation derived in step i above and find root/s of it. [03 marks]

iii. Solve the differential equation and obtain the complete solution to the current *i(t)* through the circuit. Use the initial conditions as given below. [12 marks]
$V_C(0^+) = 5V$

(Hint: Consider the polarity of the capacitor voltage as indicated in the Figure 05).

iv. Sketch the variation of current *i(t)*, starting at t = 0s. [03 marks]

6.

i. Synthesize the following RC impedance function using Foster I and II, Cauer I and II forms. [16 marks]

$$Z(s) = \frac{(S+2)}{(S+1)(S+3)}$$

ii. Realize the following LC impedance function using Foster 1st form. [04 marks]

$$Z(s) = \frac{(S^2+1)(S^2+3)}{S(S^2+2)}$$

7.

i. Write the terminal characteristic equations of a general two-port network in matrix form using,
   a. open circuit impedance (Z) parameters.
   b. ABCD Transmission parameters. [02 marks]

ii. Consider the two port network in the Figure 07.

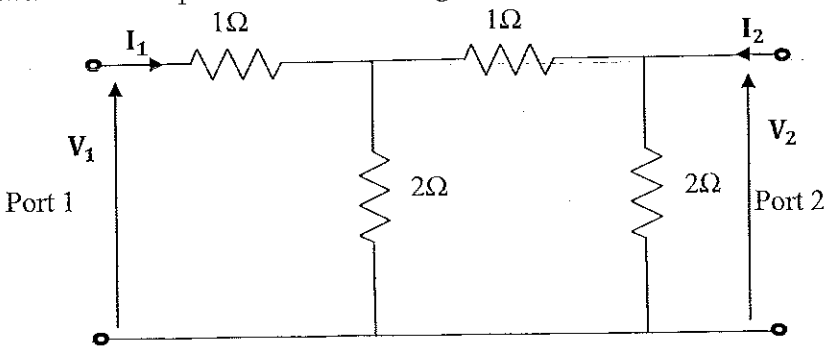

Figure 07

a. Determine the ABCD parameters of the above network. [08 marks]
b. Is the network reciprocal? Justify your answer. [02 marks]
c. Calculate the image impedances at port 1 and port 2. [06 marks]
d. Hence, find the image transfer constant of the network. [02 marks]

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