00100

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	: 2019/2020
Date	: 25th September 2020
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Seven **(7)** 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 hand writing.
7. **Do not** use a red colour pen.
8. Adhere to usual notations.

Q1. (a). Consider the circuit shown in Figure 01-(a).

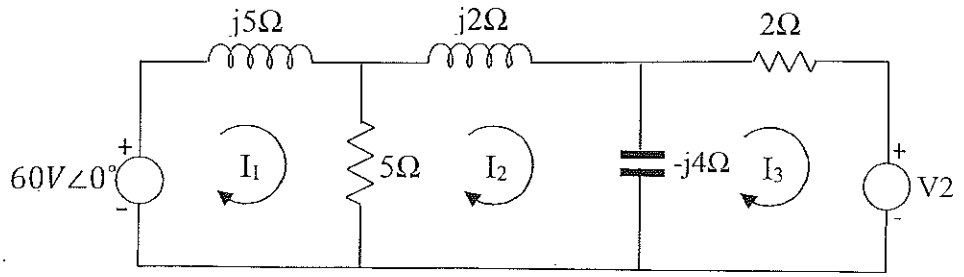

Figure 01-(a)

i. Apply mesh analysis method to obtain the matrix equation. [03 Marks]

ii. Use above matrix equation to determine the value of V_2 such that $I_3 = 0$. [07 Marks]

(b). Use Millman's theorem to simplify the circuit given in Figure 01-(b). Hence or otherwise determine the current through Z_L. [10 Marks]

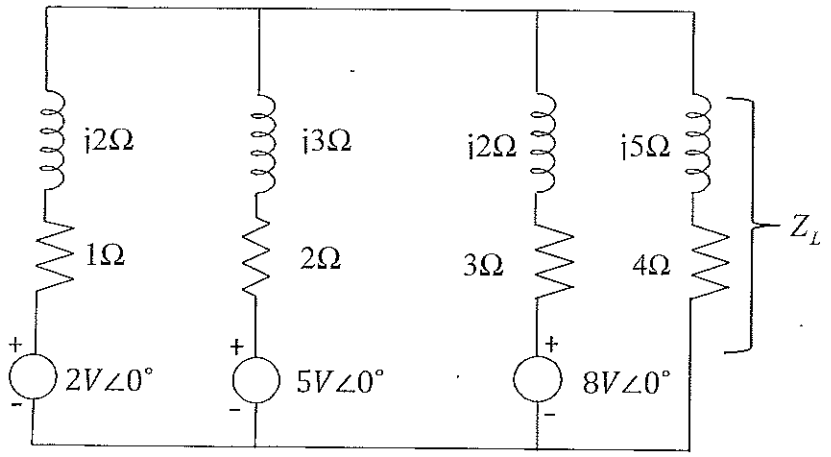

Figure 01-(b)

Q2. A circuit having a capacitor and a resistor is shown in Figure 02. Switch S1 is used to connect sources either E1 or E2 (E2>E1) to the RC branch of the circuit. Initially the switch S_1 is at position X and the capacitor is fully discharged.

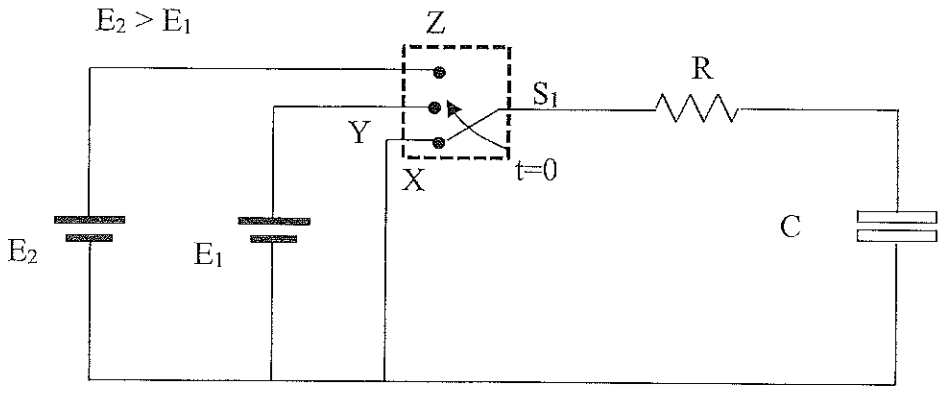

Figure 02

i. At $t = 0$ the switch is moved from position X to Y. Apply Kirchhoff's voltage law and write the voltage equation in differential form. [02 Marks]

ii. Derive an expression for the instantaneous current $i(t)$ by solving the differential equation obtained in 'i' [06 Marks]

iii. Calculate the voltage across the capacitor at $t = 100$ ms. Use R = 10 kΩ, C = 10 μF and $E_1 = 10$ V. [02 Marks]

iv. While the circuit is in operation at $t = 5$s the switch S1 is suddenly moved from position Y to Z without any interruption. Using the results obtained above, deduce an expression to determine the voltage across the capacitor from $t = 5$s onwards. State any assumptions you made. Select initial state as t = 0. [05 Marks]

v. Using the two expressions obtained in (ii) and (iv), sketch the voltage variation of the capacitor against time of this new condition. (starting from 5s) [05 Marks]

Q3. Consider the RLC circuit shown in Figure 03. At $t = 0$ the switch S_1 is closed.

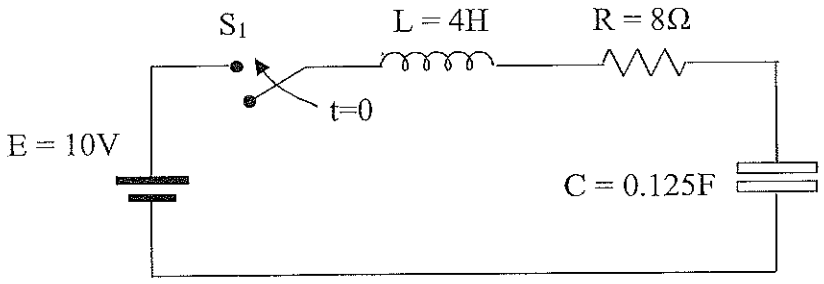

Figure 03

i. Write a differential equation relating voltages across each element using Kirchhoff's voltage law. Assume the capacitor is initially fully discharged. [02 Marks]

ii. Solving the differential equation you have written in 'i', obtain an expression to the current through the circuit for $t > 0$. (consider the initial voltages across and currents through each element) [12 Marks]

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

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

Q4. Consider the circuit given in Figure 04. The switch S_1 is closed at t = 0s.

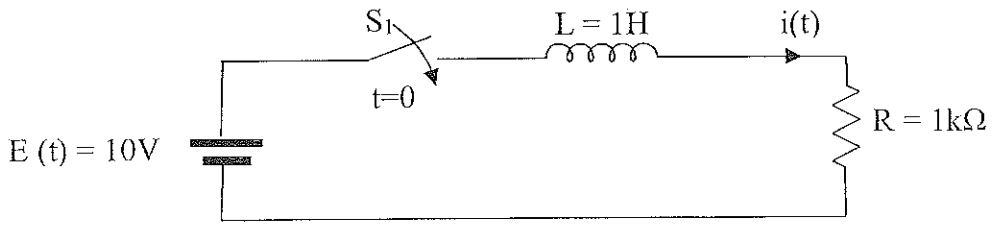

Figure 04

i. Write the differential equation to find 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.

Q5.

i. Determine whether the following functions are positive real. [02 Marks]

Hint- Use the partial fraction expansions where necessary.

(a). $F(s) = \dfrac{S^2+1}{S^3+4S}$ (b). $F(s) = \dfrac{(S+2)(S+4)}{(S+1)(S+3)}$

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

$$Z(s) = \frac{2S^2+8S+6}{S^2+2S}$$

iii. Synthesize the following RLC driving point impedance function. [02 Marks]

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

Q6.

Pole zero maps of four different impedance functions Z(s) are shown in Figure 6. Note that the locations of poles and zeros are not drawn to scale.

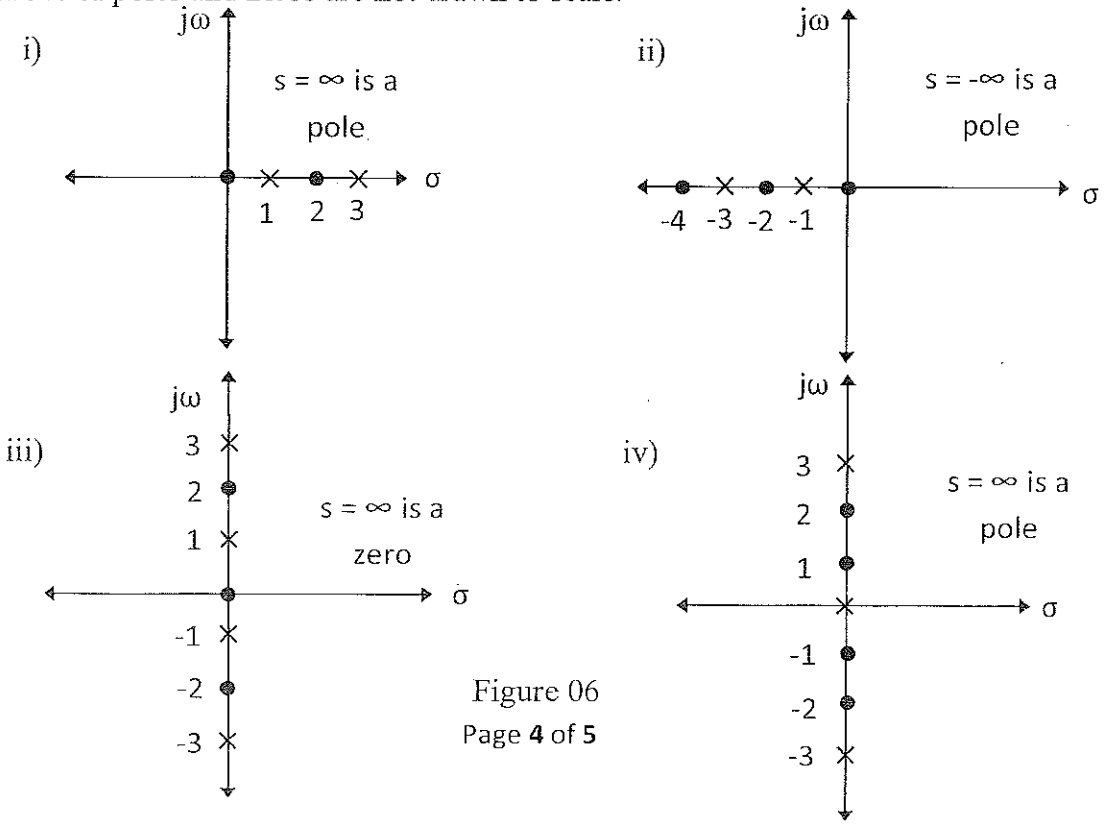

Figure 06

i. Giving reasons state which of the above systems are realizable in the form of RC, RL or LC. [04 Marks]

ii. Formulate the driving point impedance function for the realizable systems that you have figured out. [04 Marks]

iii. Realize each network using:
   a. Foster 1st form.
   b. Cauer 2nd form. [12 Marks]

Q7.

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. A simplified equivalent circuit diagram of a transmission line is given in Figure 07.

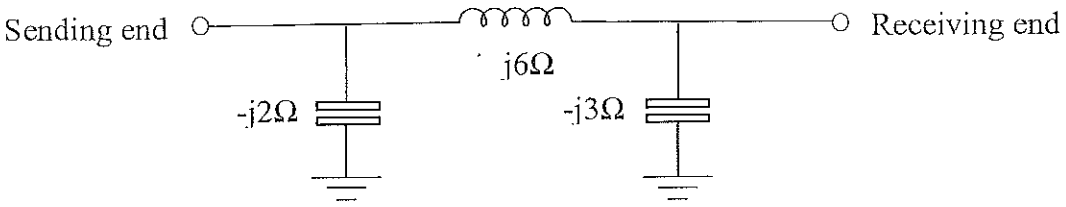

Figure 07

a. Considering the circuit as a two port network; find the open circuit impedance parameters. [04 Marks]
b. Convert the impedance parameters in to ABCD parameters. [02 Marks]
c. Derive an expression to the characteristic impedance (Z_0) of the network and obtain the value of it. [04 Marks]
d. A load is connected to the receiving end and a generator is connected to the sending end of the above transmission line. The impedance of the load and internal impedance of the generator are equal to the characteristic impedance (Z_0). Determine the generator output terminal voltage (magnitude and phase) to maintain the Voltage (V_{RMS}) across the load at 150V. [08 Marks]

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