UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: October 2019

Module Number: EE1302 **Module Name: Introduction to Electrical Engineering**

[Three Hours]

[Answer **all questions**, each question carries **ten** marks]

Q1 a) i) Explain what a "super node" is with regard to nodal analysis in dc circuits.

ii) Find the node voltages of the non-reference nodes of the dc circuit shown in Figure Q1 (a) by using nodal analysis.

iii) Hence or otherwise find the current I_0 shown in Figure Q1 (a).

[5 Marks]

b) i) State Thevenin's theorem with regard to dc circuit analysis.

ii) Find the Thevenin's equivalent circuit across the terminals a and b of the circuit shown in Figure Q1 (b) removing the load resistance R_L.

iii) Hence, find the load current if a $R_L = 8$ kΩ load resistor is connected across the terminals a and b.

[5 Marks]

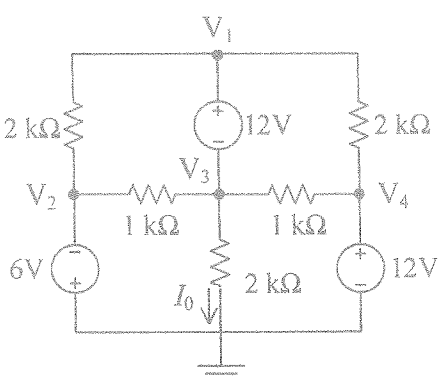

Figure Q1 (a)

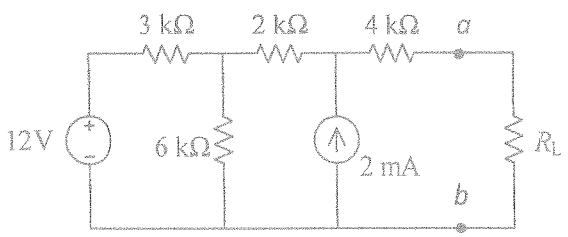

Figure Q1 (b)

Q2 a) i) Briefly explain the time constant of RL and RC circuits.

ii) The switch in the series connected RL dc circuit shown in Figure Q2 (a) closes at $t = 0$. Show that the total response of the inductor current $i(t)$ can be given as

$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$$

where $i(0)$ and $i(\infty)$ are the initial and final values of the inductor current and τ is the time constant of the circuit, respectively.

iii) The switch of the circuit shown in Figure Q2 (b) has been closed for a long time. It opens at $t = 0$. Find $i(t)$ for $t > 0$.

[5 Marks]

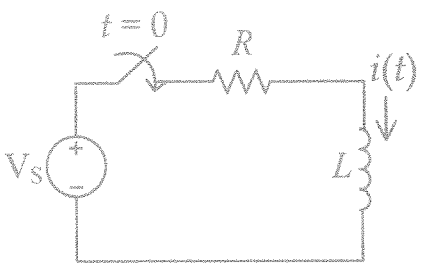

Figure Q2 (a)

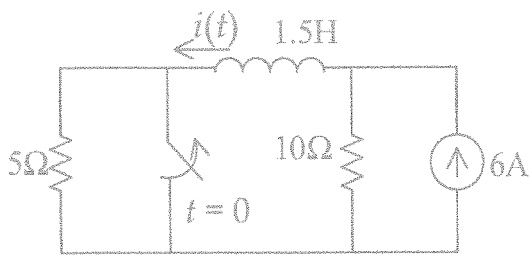

Figure Q2 (b)

b) The switch of the RLC circuit shown in Figure Q2 (c) has been closed for a long time. It opens at $t = 0$.

i) Check whether the circuit is underdamped, over damped, critically damped or un-damped and justify your answer.

ii) Find the total response of the capacitor voltage $v(t)$ for $t > 0$.

iii) Hence or otherwise find the inductor current $i(t)$ for $t > 0$.

[5 Marks]

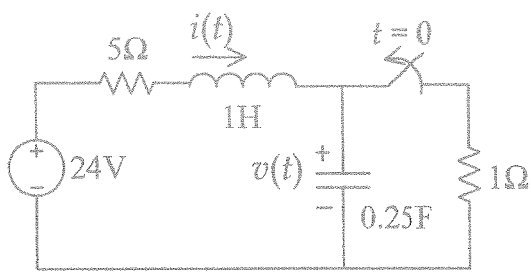

Figure Q2 (c)

Q3 a) A single phase ac voltage is given by $v(t) = V_P \sin(\omega t)$. Show that the;

i) Half cycle average voltage is $2V_P/\pi$.

ii) RMS voltage is $V_P/\sqrt{2}$.

iii) Form factor of the voltage waveform is 1.11.

iv) Peak factor of the voltage waveform is 1.414.
Note: $cos2\theta = 1 - 2sin^2\theta$

[4 Marks]

b) i) Find the phase angle between the two currents $i_1 = -4\sin(377t + 55^0)$ and $i_2 = 5\cos(377t - 65^0)$.

ii) Does i_1 lag or lead i_2?

Note: $\sin(\theta \pm 90^0) = \pm\cos\theta$ $\quad \sin(\theta \pm 180^0) = -\sin\theta$

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[2 Marks]

c) i) Find the phasor domain equivalent circuit of the ac circuit shown in Figure Q3.

ii) Hence or otherwise, find the instantaneous source current $i_S(t)$ of the circuit.

[4 Marks]

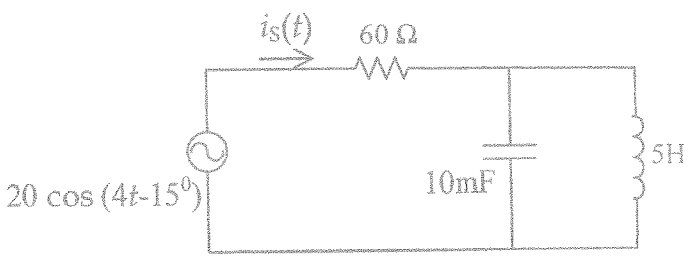

Figure Q3

Q4 a) The current $i(t)$ drawn by a series connected single phase load and the applied voltage $v(t)$ are given by

$i(t) = 4\cos(100\pi t + 10^0)$ A

$v(t) = 120\cos(100\pi t - 20^0)$ V.

i) Find the real power, reactive power and the apparent power drawn by the load.

ii) Calculate the power factor of the load.

iii) Determine the load impedance and the values of the elements that form the load.

iv) Calculate the value of the element to be connected in parallel with the load in order to bring the overall power factor to 0.95 lagging.

[5 Marks]

b) Three equal impedances, $60 + j30\Omega$ each, are delta connected and connected to a 230 V three phase supply. Another three equal impedances, $40 + j10\Omega$ each are star connected across the same circuit at the same points. Determine;

i) The line current.

ii) The total complex power supplied to the two loads.

iii) Overall power factor of the combined load.

[5 Marks]

Q5 a) i) State are three most common types of faults thatoccur in a domestic wiring system?

ii) Various protective mechanisms are employed to safeguard the consumer and the equipment in an electrical installation. What are the favorable characteristics of a protective equipment used in an electrical installation?

iii) Briefly explain the operation of a Miniature Circuit Breaker (MCB) during a short circuit and over loading faults.

iv) What are the basic elements available in a domestic wiring system up to the distribution box? Draw a sketch showing how they are connected.

[5 Marks]

c) Suppose you are asked to measure the current and the voltage across the resistor R_1 in the circuit shown in Figure Q5. You are given an ammeter with internal resistance R_a and a voltmeter with internal resistance R_v.

i) On separate figures, show how you connect the ammeter and the voltmeter for measuring the current through the resistor R_1 and the voltage across R_1.

ii) Derive expressions for the voltage across the resistor R_1 in terms of V, R_1, R_2 and R_v with and without the voltmeter connected to the circuit. From these expressions, what can be said about the construction of a voltmeter and the accuracy of the voltage measurement?

iii) Explain how a galvanometer with 100μA full scale and 50 Ω internal resistance be converted to a multi-range ammeter with 3-full scales of 0.5A, 2A and 5A.

iv) Draw a circuit diagram of the suggested multi-range ammeter in part iii).

[5 Marks]

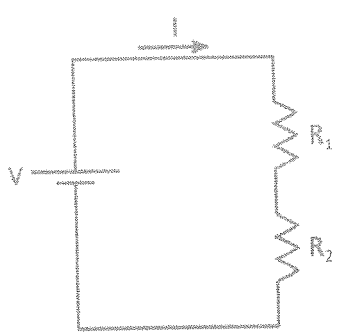

Figure Q5