UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: October 2019

Module Number: EE1302 **Module Name: Introduction to Electrical Engineering (Repeat)**

[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 $R_L = 8\ \text{k}\Omega$ load resistor is connected across the terminals a and b.

[5 Marks]

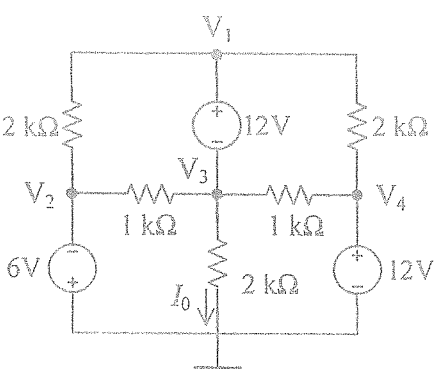

Figure Q1 (a)

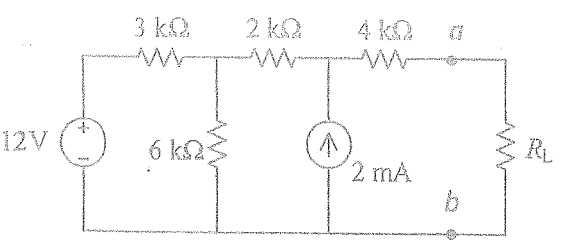

Figure Q1 (b)

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]

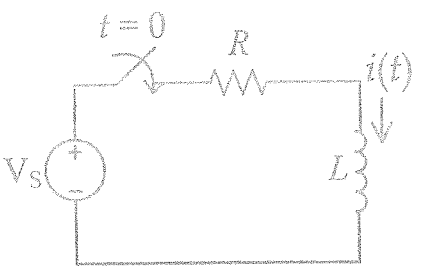

Figure Q2 (a)

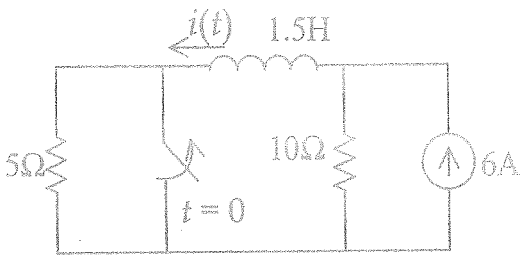

Figure Q2 (b)

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]

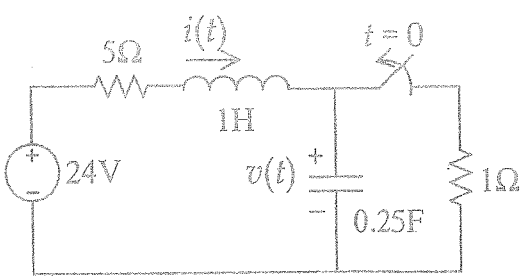

Figure Q2 (c)

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

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

[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]

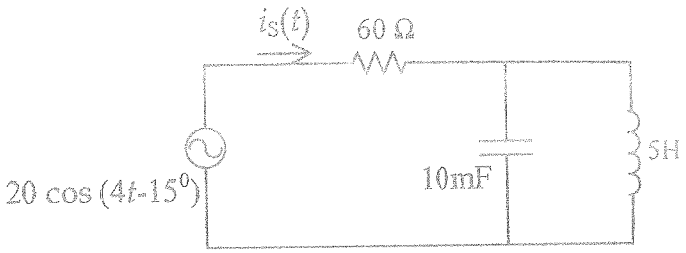

Figure Q3

Q4 a) The current $i(t)$ drawn by a series connected load in a single phase system 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) Define a rotating electric machine.

ii) State and define the two major types of rotating electric machines.

iii) In order to operate as a motor, state the requirements to be fulfilled in a rotating electric machine. Explain your answer using a suitable law you have learnt.

[2 Marks]

b) A dc shunt motor is supplied by a 250 V constant dc supply. It has an armature resistance of 10 Ω and a field resistance of 50 Ω. The value of the voltage constant is 0.5 Vs/rad. At a certain operating point, the motor runs at 2000 rpm. Assume that except for copper losses, there are no other types of losses in the motor and the friction torque is negligible.

i) Calculate the load-torque at this operating point.

ii) Calculate the efficiency of the motor at this operating point.

[4 Marks]

c) A 15 kVA, 2300/230 V single phase transformer has the following equivalent circuit parameters where the symbols have their usual meaning. The excitation branch impedances are given referred to the high-voltage side of the transformer.

$R_P = 4\Omega$	$R_S = 0.0045\Omega$	$R_C = 105\ k\Omega$
$X_P = 5\Omega$	$X_S = 0.0145\Omega$	$X_M = 11k\Omega$

i) Derive the primary referred approximate equivalent circuit for this transformer.

ii) This transformer is delivering the rated load at the rated voltage at a 0.8 lagging power factor. Calculate the primary voltage and hence the voltage regulation of the transformer.

iii) Determine the efficiency of the transformer under the above loading condition.

[4 Marks]