UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: July 2016

Module Number: EE1301 **Module Name: Introduction to Electrical Engineering**

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1 a) i) State Faraday's Law of induction.

ii) What is the main difference between the active and the passive elements that are connected in an electric circuit?

iii) State two instances where Millmann's theorem is applied in the real world.

[3 Marks]

b) i) Explain the use of the superposition theorem in Direct Current (DC) circuit analysis.

ii) Consider the circuit shown in Figure Q1 b). The resistance values and the current flowing through the current source have the following values,

$R_1 = \alpha R$, $R_2 = \beta R$ and $I = \frac{E}{R}$

Use the superposition theorem to show that the load current i flowing across the load resistance R_L connected through terminals A and B is given by,

$$i = \left[\frac{\beta(1+\alpha)}{\alpha\beta R + (\alpha+\beta) R_L}\right] E$$

iii) If $\alpha = 1$, $\beta = 2$ and the value of the load current is the same as the current flowing through the current source, determine the load resistance.

[4 Marks]

c) i) Draw the Thevenin's equivalent circuit and determine the parameters for the circuit given in Figure Q1 c). The ratio between the load resistances $R_{L1} : R_{L2}$ is $1:3$.

ii) Calculate the values of load resistances R_{L1} and R_{L2}, if the load is delivering maximum power.
[Hint: You can assume any suitable theorem to calculate part ii).]

[3 Marks]

Q2 a) i) Define the term electrical resonance.

ii) Obtain an expression for the electrical resonance frequency for a resistor (R), inductor (L) and a capacitor (C)connected in series. Use the usual notations.

[2 Marks]

b) Consider the circuit in Figure Q2 b). Calculate the current 'I' indicated in the circuit, if the operating frequency of the AC (Alternative Current) voltage source is 50 Hz.

[3 Marks]

c) i) State four advantages of a three-phase AC power system compared to a single phase AC power system.

ii) Name two power factor improvement methods used in electrical installations.

[1.5 Marks]

d) A balanced 400 V, Y - connected three-phase source with positive phase sequence is connected to a delta-connected load having per-phase impedance of $(30+42\,j)\,\Omega$. The line impedance per phase is $(4+5\,j)\,\Omega$. Take the phase voltage of phase 'a' as the reference with the usual notation.

i) Draw the phasor diagram for the supply side, indicating phase voltages and line to line voltages.

ii) What is the per-phase line current?

iii) Calculate the power factor of the system, if a delta-connected capacitive load having per-phase impedance of $(7-32\,j)\,\Omega$ is connected in parallel with the initial load.

[3.5 Marks]

Q3 a) i) What is an instrument transformer?

ii) What are the two main types of power losses that occur in a transformer core?

[1 Mark]

b) A 50 kVA, 2000/100 V, single phase transformer has the following winding parameters where symbols have their usual meaning;

$R_P = 0.25\,\Omega$ $\quad$ $R_S = 0.00075\,\Omega$ $\quad$ $R_C = 3.5\,\text{k}\Omega$

$X_P = 0.7\,\Omega$ $\quad$ $X_S = 0.0017\,\Omega$ $\quad$ $X_M = 1.2\,\text{k}\Omega$

The transformer delivers rated kVA of 100 V and 0.9 power factor lagging. Draw the approximate equivalent circuit referred to the primary side and calculate the following.

i) Output current at the secondary side

ii) Voltage regulation

iii) Efficiency

[4 Marks]

c) i) Explain the types of common faults that occur in electrical installations.

ii) Describe the TT (Tera - Tera) earthing system using a diagram.

iii) State the two types of Circuit Breakers (CBs) that can be categorized under their operating principals and explain the operation of one of them.

iv) What advantages do the CBs provide over fuses?

[5 Marks]

Q4 a) i) What are the types of rotors used in induction motors?

ii) Why is it impossible for an induction motor to operate at synchronous speed?

iii) Clearly defining the parameters, draw the per-phase approximate equivalent circuit of a three phase induction motor at slip 's'.

[3 Marks]

b) The shaft output of a three-phase 6 pole, 60- Hz induction motor is 80 kW. The friction and windage losses are 920 W, the stator core loss is 4300 W and the stator copper loss is 2690 W. The rotor current and rotor resistance referred to stator are respectively 110 A and 0.15 W. If the slip is 3.8%, calculate the efficiency of the motor.

[2 Marks]

c) A 400 V, 4-pole, 3-phase, 50 Hz, Y connected induction motor has the following per-phase equivalent circuit parameters referred to the stator

$R_1 = 1.6\,\Omega$ $X_1 = 2.4\,\Omega$

$R_2' = 0.48\,\Omega$ $X_2' = 1.2\,\Omega$ $X_m = 40\,\Omega$

Rotational losses are 720 W. Neglect core losses. For a speed of 1470 rpm, calculate

i) the stator current.

ii) the power factor.

iii) the stator copper losses.

iv) the air gap power P_{AG}.

v) the efficiency.

[5 Marks]

Q5 a) i) In order to operate as a generator what are the requirements to be fulfilled in a rotating electric machine? Explain your answer using a suitable law.

ii) In terms of steady-state operation, how do you differentiate AC asynchronous motors and AC synchronous motors?

iii) What are the advantages and the disadvantages when field windings are used to produce the field in a DC electric machine?

iv) Define "EMF constant" and "torque constant" of a DC electric machine.

[3.5 Marks]

b) A DC shunt motor drives a load which requires a constant torque of 200 Nm. The motor is connected to a 600 V constant DC supply and the armature current is measured as 80 A. For this motor, the armature resistance is 0.5 Ω and the field resistance is 3 Ω. Assuming that except for copper losses, there are no other types of losses in the motor, determine the speed of the motor.

[2.5 Marks]

c) A DC series motor is supplied by a 50 V constant DC supply. It has an armature resistance of 2 Ω and a field resistance of 3 Ω. This motor requires 100 W input power at full-load. The full-load speed is 2000 rpm. In a certain test the rotor of the motor is mechanically locked so that it cannot rotate. Calculate the motor produced torque in Nm during this test. Assume that except for copper losses, other losses are negligible in the motor.

[4 Marks]

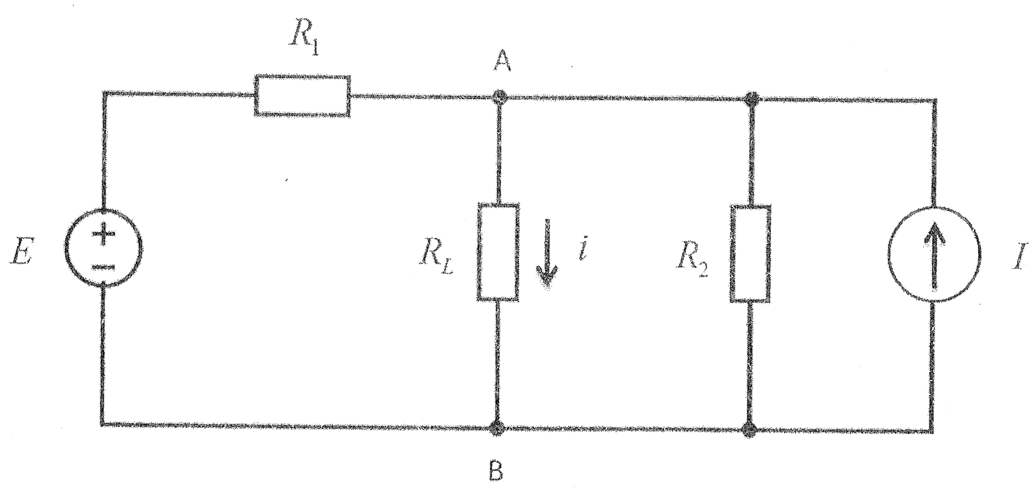

Figure Q1 b)

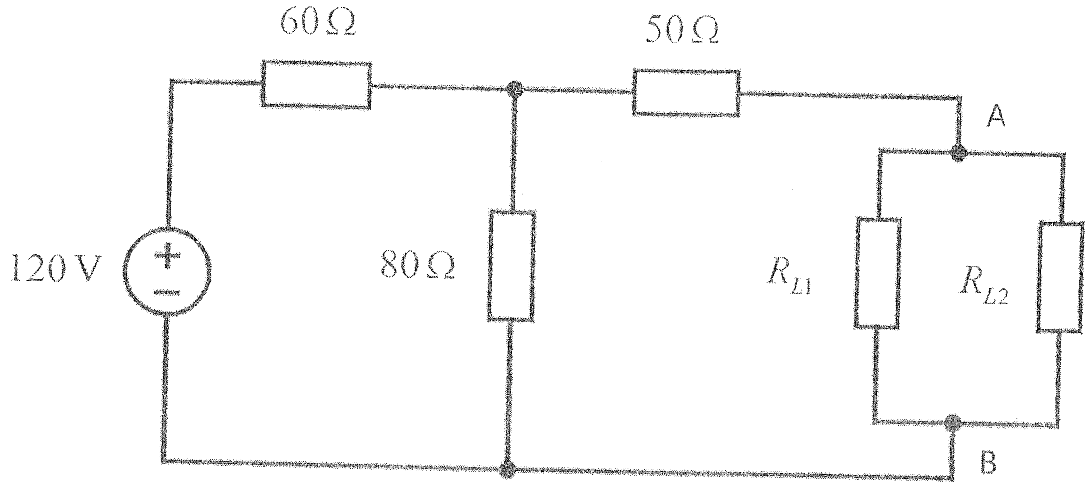

Figure Q1 c)

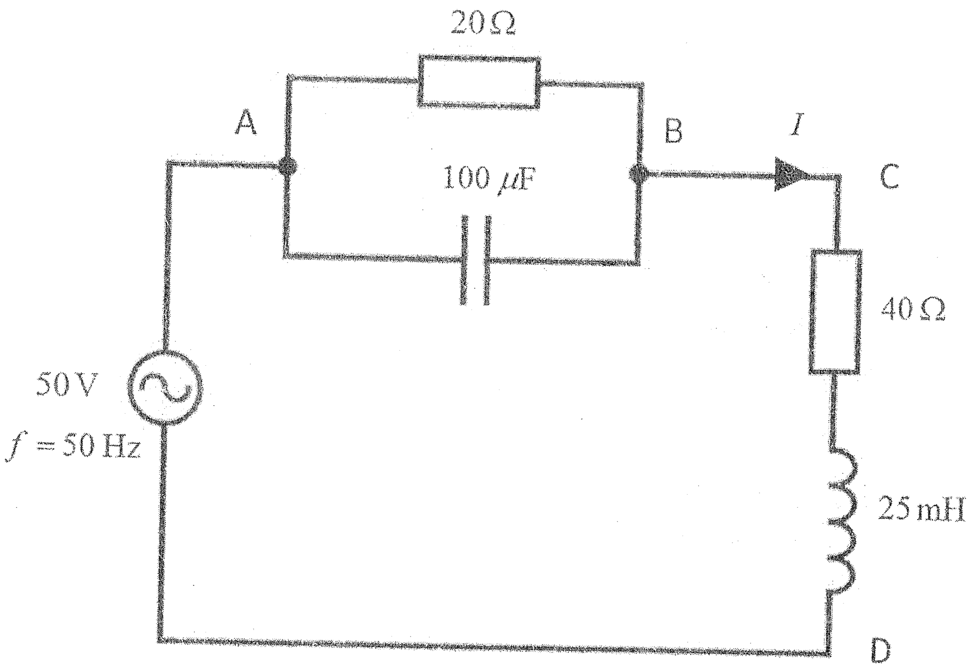

Figure Q2 b)