UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: August 2018

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

[Three Hours]

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

Q1 a) i) Explain what a "super mesh" is with regard to mesh analysis in DC circuits.

ii) Use mesh analysis to determine i_1, i_2 and i_3 in Figure Q1 (a).

[4 Marks]

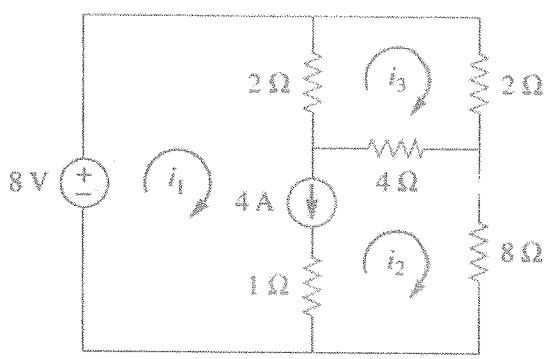

Figure Q1 (a)

b) i) State Norton's Theorem with regard to DC circuit analysis.

ii) Find the Norton Equivalent circuit at terminals $a - b$ of the circuit shown in Figure Q1 (b).

iii) Hence, find the load current if a 6 Ω load resistor is connected across terminals $a - b$.

[6 Marks]

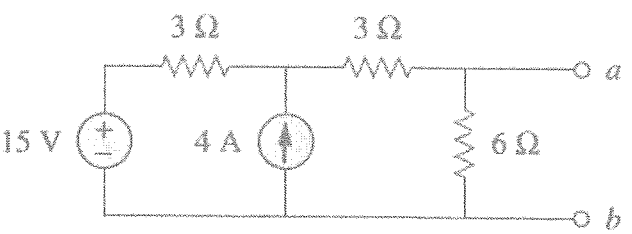

Figure Q1 (b)

Q2 a) A single phase AC voltage is described by the following expression.

$$v(t) = 120\cos(314.16t + 10^0)\ \text{V}$$

Calculate its

i) rms value
ii) frequency
iii) period
iv) half cycle average value and
v) form factor.

[4 Marks]

b) Figure Q2 (b) shows a three phase power system with two loads. The Y connected generator is producing a phase voltage of 120 V. Load 1 is Δ connected with a phase impedance of $24 - j30\ \Omega$ and Load 2 is Y connected with a phase impedance of $12 + j5\ \Omega$. Calculate

i) the line current drawn by Load 1
ii) the line current drawn by Load 2
iii) the line current supplied by the generator
iv) the real, reactive and the apparent power supplied by the generator
v) the operating power factor of the generator.

[6 Marks]

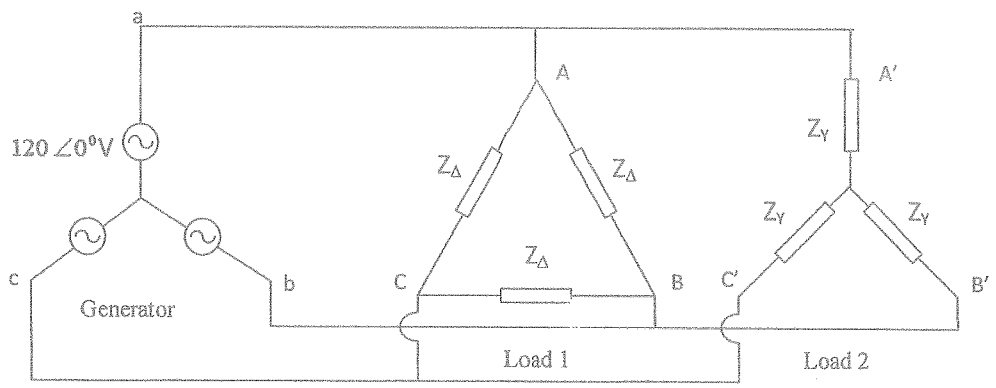

Figure Q2 (b)

Q3 a) i) Explain how voltage is induced in the secondary winding of a single phase transformer, when the primary winding is supplied with an AC voltage.

ii) "Core losses of a transformer remain constant as the load varies from no load to full load". Do you agree with this statement? Justify your answer.

iii) What are the types of losses that occur in a transformer?

iv) What are the constructional features developed to reduce such losses mentioned in iii)?

[4 Marks]

b) Primary referred approximate equivalent circuit of a 15 KVA, 2300/230 V single phase transformer with the usual notations is shown in Figure Q3 (b). The transformer is supplying the rated load at the rated voltage and 0.8 lagging power factor. Calculate its

i) secondary current
ii) primary input voltage
iii) voltage regulation
iv) efficiency.

[6 Marks]

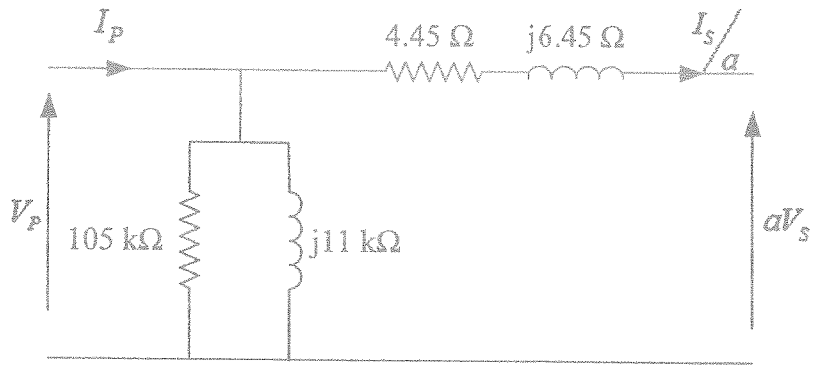

Figure Q3 (b)

Q4 a) i) What are the requirements that need to be fulfilled in a structure of a rotating electric machine? Explain your answer using suitable laws you have learnt.

ii) What are the basic types of ac rotating electric machines? How do you differentiate them?

ii) Why do the armature windings of a dc motor produce an electromotive force?

[2.5 Marks]

b) The field circuit of a separately excited dc motor is connected to a constant dc source. The armature applied voltage is 200 V. It rotates at 1000 rpm generating an armature emf of 180 V. The armature current is 50 A. Assume that except for copper losses, there are no other types of losses in the machine and the friction torque is negligible.

i) Determine the resistance of the armature circuit.
ii) Determine the electromagnetic torque in Nm.
iii) If the load connected to the machine is removed, what will be the rotation speed of the machine in rpm?

[3.5 Marks]

c) A dc series motor is supplied by a 100 V constant dc supply. It has an armature resistance of 3 Ω and a field resistance of 1 Ω. This motor requires input power of 200 W at full load. The full-load speed is 1200 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 copper losses, other losses are negligible in the motor.

[4 Marks]

Q5 a) i) Explain why three phase induction motors are so popular in industry.

ii) By mistake, Phase *a* and Phase *b* connections were interchanged while giving the supply to a three phase induction motor. Explain what the consequences would be.

iii) Explain what will happen if an induction motor rotates faster than the synchronous speed.

[4 Marks]

b) A 460 V, 60 Hz, four-pole, star connected induction motor has the following per phase equivalent circuit parameters referred to the stator circuit.

$R_1 = 0.64\ \Omega$ $X_1 = 1.11\ \Omega$ $X_m = 26.3\ \Omega$

$R_2 = 0.33\ \Omega$ $X_2 = 0.46\ \Omega$

The rotational losses are 800 W and core losses are 300 W and are assumed to be constant. Determine the following when the motor operates at full load at the rated speed of 1760 rpm.

i) the synchronous speed

ii) the slip

iii) the input current

iv) the input power

v) the useful mechanical output power

vi) the output torque

vii) the efficiency of the motor.

[6 Marks]