



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: October 2019

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 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]

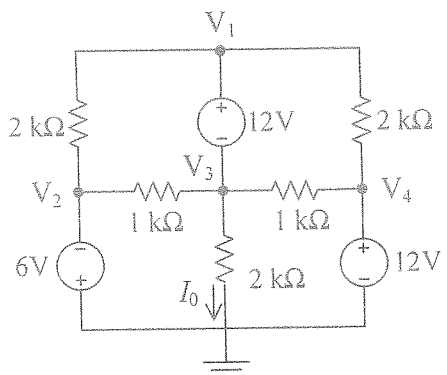


Figure Q1 (a)

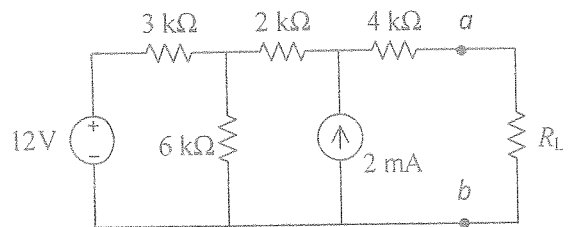


Figure Q1 (b)

- Q2 a) The current $i(t)$ drawn by a series connected load in a single phase system and the applied voltage $v(t)$ are given by

$$i(t) = 4 \cos(100\pi t + 10^\circ) \text{ A}$$

$$v(t) = 120 \cos(100\pi t - 20^\circ) \text{ V.}$$

- 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]

- Q3 a) i) Briefly explain the main advantage of using transformers in power systems.
- ii) Explain why a transformer cannot be used to either step up or step down a dc voltage.
- iii) Explain why the core losses of a transformer remain constant when the load is varied.

[4 Marks]

- b) 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.

$$R_P = 4\Omega \quad R_S = 0.0045\Omega \quad R_C = 105 \text{ k}\Omega$$

$$X_P = 5\Omega \quad X_S = 0.0145\Omega \quad X_M = 11 \text{ k}\Omega$$

- 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.

[6 Marks]

- Q4 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 $10\ \Omega$ and a field resistance of $50\ \Omega$. The value of the voltage constant is $0.5\ \text{Vs/rad}$. 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 dc series motor is connected to a 100 V constant dc supply. The motor shaft is mechanically coupled to a fan. The armature and the field resistance are $0.6\ \Omega$ and $0.4\ \Omega$, respectively. At a certain operating point, the motor draws 10 A and runs at 400 rpm. Assume that except for copper losses, there are no other types of losses in the motor.

- i) Determine the power delivered to the fan and the torque developed by the motor at the given operating point.
ii) If the motor current is increased by 50%, calculate the new speed of the motor in rpm.

[4 Marks]

- Q5 a) i) State and explain the types of losses that occur in a three phase induction motor using a power flow diagram.
ii) Explain why an induction motor can never be rotated at its synchronous speed.
iii) Induction machines are being frequently used as generators in wind power plants. State the main operational requirement in order to run an induction motor as a generator.

[4 Marks]

- b) A 460 V, 50 Hz, 4-pole, star connected three phase induction motor has the following per-phase equivalent circuit parameters referred to its stator with the usual notation.

$$R_1 = 0.64 \Omega \quad X_1 = 1.11 \Omega$$

$$R'_2 = 0.33 \Omega \quad X'_2 = 0.46 \Omega \quad X_m = 26.3 \Omega$$

The rotational losses and the core losses are 800 W and 300 W respectively and are assumed to be constant. The motor is operating at a slip of 2%. Determine:

- i) The speed of the motor.
- ii) The line current drawn by the motor.
- iii) The Efficiency of the motor.

[6 Marks]