UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: May 2022

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

[Three Hours]

[Answer **five questions including Q1, Q2, Q3 and Q4**. Each question carries **ten** marks]

Q1 a) i) What is a supernode with regard to nodal analysis in a dc circuit?

ii) State the Thevenin's theorem with regard to dc circuit analysis.

iii) State the Maximum Power Transfer theorem with regard to dc circuits.

[4 Marks]

b) i) Find the Thevenin's equivalent circuit across the terminals a and b in Figure Q1.

ii) Hence, find the maximum power that can be delivered to a load resistor connected across the terminals a and b in the circuit shown in Figure Q1.

[6 Marks]

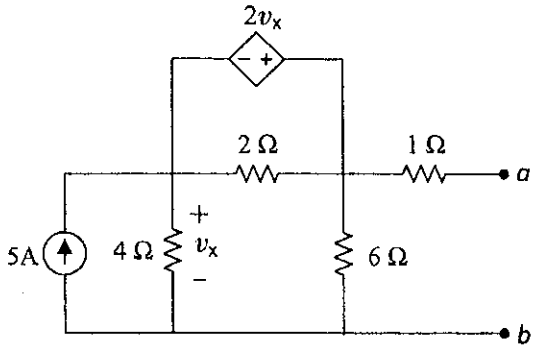

Figure Q1

Q2 a) i) Second order, source-free, series RLC dc circuit shown in Figure Q2 is excited at $t = 0$ by the energy stored in the inductor and the capacitor. Obtain the differential equation of the inductor current in terms of the circuit parameters which exhibits the transient behavior of the circuit variables.

ii) What are the four possible types of responses (variations) the inductor current can exhibit and on what conditions do they occur?

iii) Write the general expressions of the inductor current for the four different responses identified above. Define any additional symbols used.

[5 Marks]

b) The series RLC circuit shown in Figure Q2 has the following parameters: $R = 6\ \Omega$, $L = 1$ H, $C = 0.04$ F. The initial inductor current $i(0) = 4$ A and the initial capacitor voltage $v(0) = -4$V.

i) Obtain the differential equation which exhibits the behavior of the inductor current for $t \geq 0$.

ii) What is the type of the response of the inductor current?

iii) Find the expression for the inductor current $i(t)$ for $t \geq 0$.

[5 Marks]

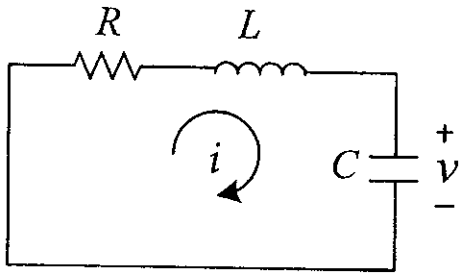

Figure Q2

Q3 a) A sinusoid is a signal that has the form of the sine or cosine function. However, in general, phase angle of a sinusoid is derived from the cosine function. A voltage of a single phase ac source is given by $v(t) = 12\sin(50t + 100^0)$ V. Determine its

i) Amplitude,
ii) Phase angle,
iii) Period,
iv) Frequency,
v) Half cycle average value,
vi) RMS value,
vii) Form factor,
viii) Peak factor.

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

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

[4 Marks]

b) Consider the single phase ac circuit shown in Figure Q3. The frequency and the rms value of the voltage of the ac source are 50 Hz and 100 V, respectively.

i) Find the two impedances connected parallelly across the nodes a and b.

ii) Find the current delivered by the source, I_1.

iii) Using the current division rule or otherwise, find the currents through the inductor and the capacitor, I_2 and I_3.

iv) Calculate the real power, the reactive power and the apparent power supplied by the source.

[6 Marks]

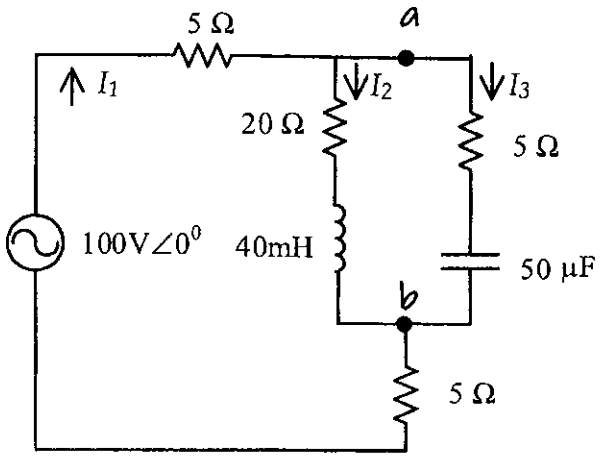

Figure Q3

Q4 a) i) Line to line voltages of a star-connected balanced three-phase supply are given as

$v_{AB} = 208\angle 90^0$ V, $v_{BC} = 208\angle 210^0$V, $v_{CA} = 208\angle -30^0$V.

Draw the phasor diagram showing the line to line voltages and phase voltages and hence determine the phase sequence of the supply.

ii) A delta connected balanced three-phase load draws a line current of I_1 from a balanced three-phase source. What will be the line current, if the same load is connected in wye configuration and supplied by the same three-phase source?

iii) In a balanced three-phase system, load consumes a total active power of 100 W and a total reactive power of 50 Var. If a capacitor bank is installed at the load end which can supply half of the reactive power requirement of the load, what will be the improved power factor of the system?

[4 Marks]

b) Figure Q4 shows a three-phase balanced wye-connected load supplied by a positive sequence balanced three-phase supply. The per-phase load impedance consists of a resistor and an inductor connected in parallel. The resistance of the resistor is 28.3 Ω and the reactance of the inductor is also 28.3 Ω. Line to line voltage across terminal A and B is $100\angle 120^0$ Vrms as shown in the figure.

i) Calculate the per-phase equivalent load impedance.

ii) Calculate the line current, I_A.

iii) What is the power factor of the load?

iv) Calculate the total active power, the total reactive power and the total apparent power drawn by the three-phase load.

v) Draw the phase voltages and phase currents in a phasor diagram for the above system.

[6 Marks]

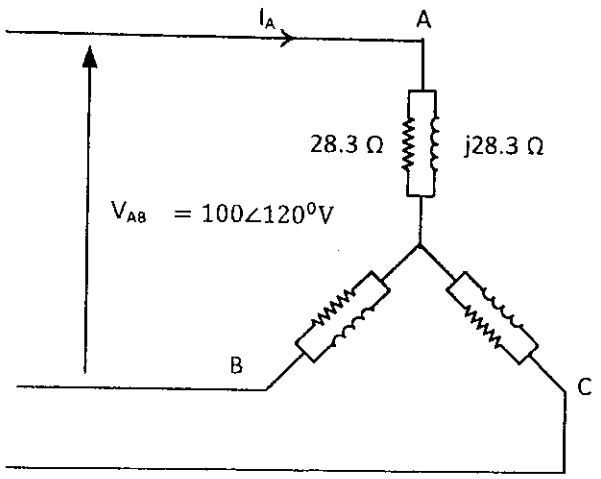

Figure Q4

Q5 a) i) What are the different types of dc electric motors available?

ii) Give an example for a dc electric motor application.

iii) What are the types of losses occur in an operating transformer?

iv) What are the measures taken during transformer construction in order to reduce the above losses?

[2 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 resistance is 0.4 Ω. 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 armature current.

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?

[4 Marks]

c) A 24 kVA, 7200/480 V single phase distribution transformer has the following resistances and reactances with their usual notations:

R_1	= 32 Ω	X_1	= 45 Ω	R_C	= 250 kΩ
R_2	= 0.05 Ω	X_2	= 0.06 Ω	X_m	= 30 kΩ

The excitation branch impedances are given referred to the high-voltage side of the transformer.

i) Find the approximated equivalent circuit of this transformer referred to the high-voltage side.

ii) Assume that the transformer is supplying rated load at 480 V and 0.8 power factor lagging. Calculate the input voltage of the transformer and its voltage regulation.

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

[4 Marks]

Q6 a) i) What are the basic types of analogue measuring instruments?

ii) Briefly explain how the deflecting torque and the controlling torque are realized in Permanent Magnet Moving Coil (PMMC) instrument.

iii) What are the advantages and disadvantages of PMMC instruments compared to other types of measuring instruments?

iv) Find the sizes of the resistors needed to convert a galvanometer with 100 μA full scale and 100 Ω internal resistance to a multi-range ammeter with 3 full scales of 10 mA, 100 mA and 1 A.

v) Find the sizes of the resistors needed to convert a galvanometer with 50 mV full scale and 500 Ω internal resistance to a multi-range voltmeter with 3 full scales of 5 V, 50 V and 250 V.

[6 Marks]

b) i) What is the standard guideline that should be followed in Sri Lanka when designing an electrical installation?

ii) State three most common types of faults occur in an electrical installation.

iii) Nowadays, fuses are replaced by MCB in domestic electrical installations. What are the advantages of a MCB over a fuse?

iv) Briefly explain the operation of a MCB during a short circuit and over loading faults.

v) Draw the circuit diagram of a RCCB and briefly explain the operation of the same during an earth leakage fault.

[4 Marks]