**UNIVERSITY OF RUHUNA**

**Faculty of Engineering**

End-Semester 1 Examination in Engineering: October 2022

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

**[Three Hours]**

[Answer **all questions**. Each question carries **ten** marks]

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Q1 a) i) Compare the use of nodal analysis and mesh analysis for analyzing electric circuits.

ii) Find $v_0$ in the circuit shown in Figure Q1 (a) using mesh analysis. Select the mesh currents as shown in the figure.

iii) Find $v_0$ in the circuit shown in Figure Q1 (a) using nodal analysis. Select the node voltages as shown in the figure.

[5 Marks]

b) i) What is superposition theorem regard to electric circuit analysis.

ii) Use superposition theorem to find $v_0$ in the electric circuit shown in Figure Q1 (b).

[5 Marks]

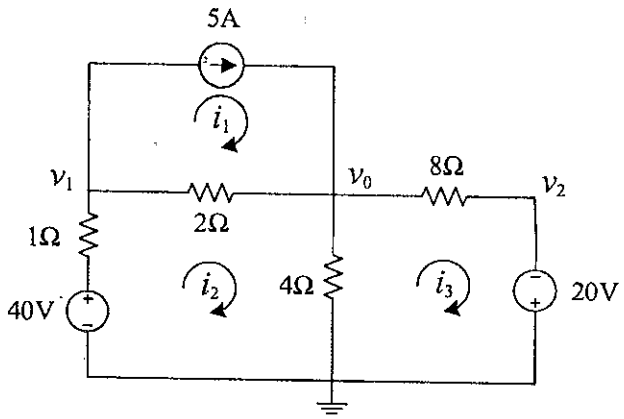



Figure Q1 (a)

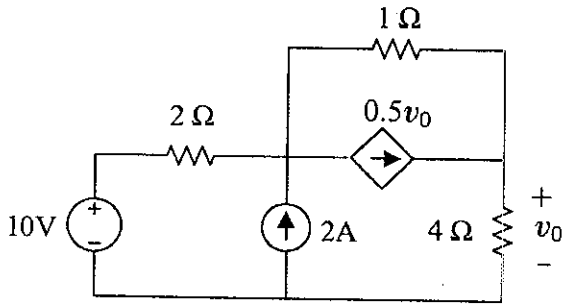



Figure Q1 (b)

Q2 a) i) Second order parallel RLC dc circuit shown in Figure Q2 (a). Obtain the second order differential equation of the inductor current in terms of the circuit parameters for $t \geq 0$.

ii) What are the four possible types of variations of the inductor current and on what conditions do they occur? Define any additional symbols used.

iii) Write the general expressions of the inductor current for the four possible types of variations identified above. Define any additional symbols used.

[4 Marks]

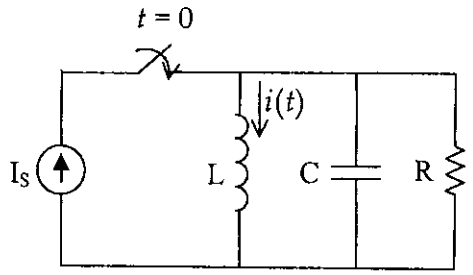



Figure Q2 (a)

b) The switch in the parallel RLC circuit shown in Figure Q2 (b) has been closed for a long time and it opens at $t = 0$.

i) Identify the type of variation of the inductor current $i(t)$ for $t \geq 0$.

ii) Find the complete response of the inductor current $i(t)$ for $t \geq 0$.

iii) Hence or otherwise find an expression for the voltage across the capacitor for $t \geq 0$.

[6 Marks]

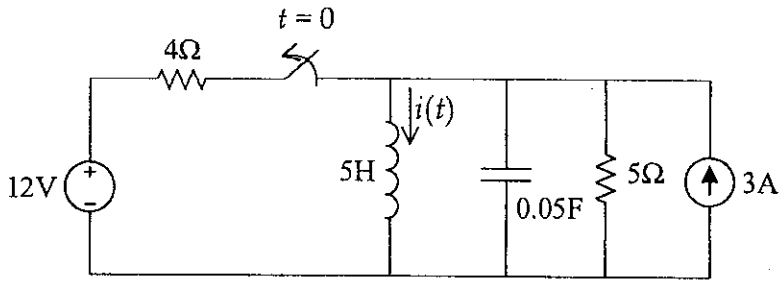



Figure Q2 (b)

Q3 a) Two currents flowing in two branches in a single-phase ac circuit are given by

$i_1(t) = 4\cos(377t + 30^0)$ A

$i_2(t) = 5\sin(377t - 20^0)$ A.

i) Determine the frequency of the given ac currents.

ii) Find the instantaneous values of $i_1(t)$ and $i_2(t)$ at 10 msec.

iii) Determine the phase angle difference between those two currents and which current is leading the other current.

iv) If $i_1(t)$ and $i_2(t)$ are added together, find the expression of the resultant current.

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 rms voltage and the frequency of the ac source are 100 V and 50 Hz respectively.

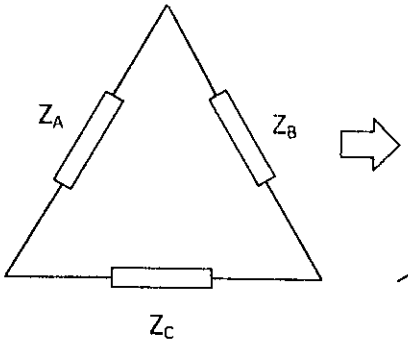
i) Determine the source current $I_S$ delivered by the source.
Hint: Convert the delta connected $abc$ network into equivalent star-connected network to simplify the network.

ii) Determine the active power, the reactive power and the apparent power delivered by the source.

iii) What is the operating power factor of the ac source?

[6 Marks]

Note: Delta-connected impedance network can be converted to equivalent star-connected impedance network as shown below.




$$Z_1 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$

$$Z_2 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_C Z_A}{Z_A + Z_B + Z_C}$$

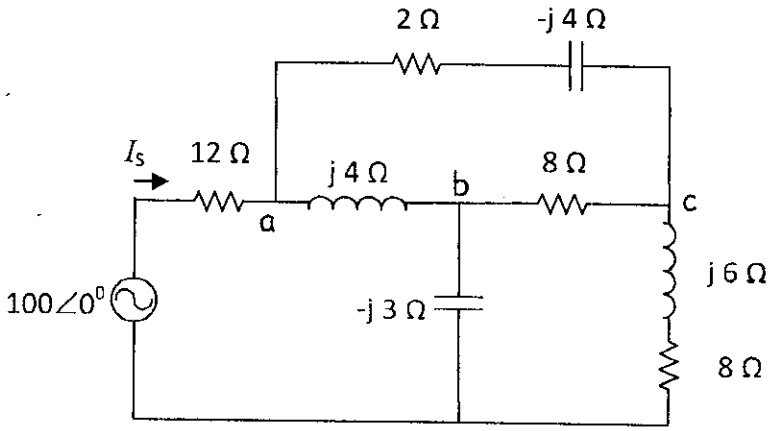



Figure Q3

Q4 a) i) If $v_{ab} = 400\angle 0^0$V in a balanced star-connected three phase generator, find the phase voltages assuming the phase sequence is

A) *abc* (+ve sequence)

B) *acb* (-ve sequence).

ii) Compare the relationships between the phase voltage to line voltage and phase currents to line currents of a star-connected balanced three-phase load with those of a delta-connected balanced three-phase load for a positive sequence supply.

[4 Marks]

b) A star - connected three - phase source is supplying two star - connected and delta - connected loads through a transmission line as shown in Figure Q4. The per phase source voltage, per phase load impedances and transmission line impedance are as shown in the figure.

i) Calculate the line current supplied by the three - phase source.

ii) What is the line-to-line voltage across the two loads?

iii) Calculate the real and reactive power supplied to each load.

iv) Calculate the voltage drop in the transmission line.

[6 Marks]

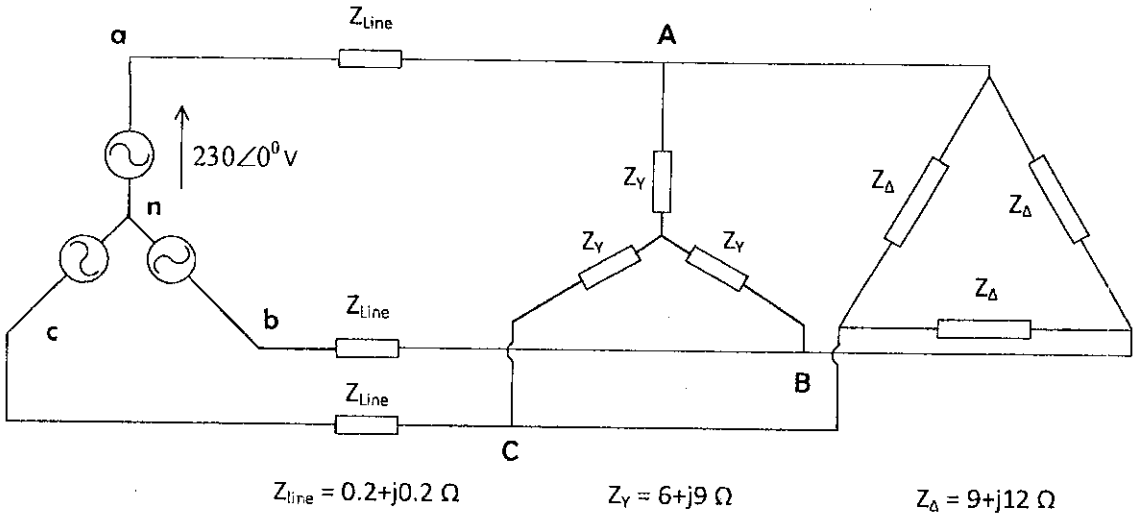



Figure Q4

Q5 a) i) What are the basic categories of oscilloscopes?

ii) For what purpose do you use an oscilloscope?

iii) What are the basic elements of an analogue Cathode Ray Oscilloscope (CRO)?

iv) Name three basic controls of an analogue CRO.

[2 Marks]

b) A two-channel analogue CRO and ac ammeter with an internal resistance ($R_1$) are used to analyze the single-phase ac circuit depicted in Figure Q5 (b) 1. Firstly, only $v_{ac}$ is connected to Channel-1 and the corresponding CRO display is shown in Figure Q5 (b) 2. Then, after adjusting the vertical position of the Channel-2 scan line to the same position as that of Channel-1, the source voltage ($v_s$) and $v_{ab}$ are connected to the Channel-1 and Channel-2, respectively. The CRO display is shown in Figure Q5 (b) 3. In both the cases, VOLT/DIV control and TIME/DIV control are set to 3V/Div and 2.5 ms/Div, respectively. The ammeter reading is 1.5 A.

i) Calculate the frequency of the source voltage ($v_s$).

ii) Calculate the values of the resistance ($R_2$) and inductance (L).

iii) Calculate the internal resistance of the ammeter.

iv) Obtain $v_s$ in $V_{sm} \sin \omega t$ and the current in $I_m \sin(\omega t + \theta)$ forms.

[6 Marks]

c) i) State the most common types of faults occur in a domestic electrical installation.

ii) What is the most suitable protective device for each fault, you mentioned in Part c) (i)?

[2 Marks]

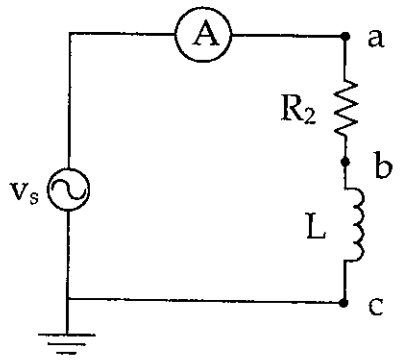



Figure Q5 (b) 1

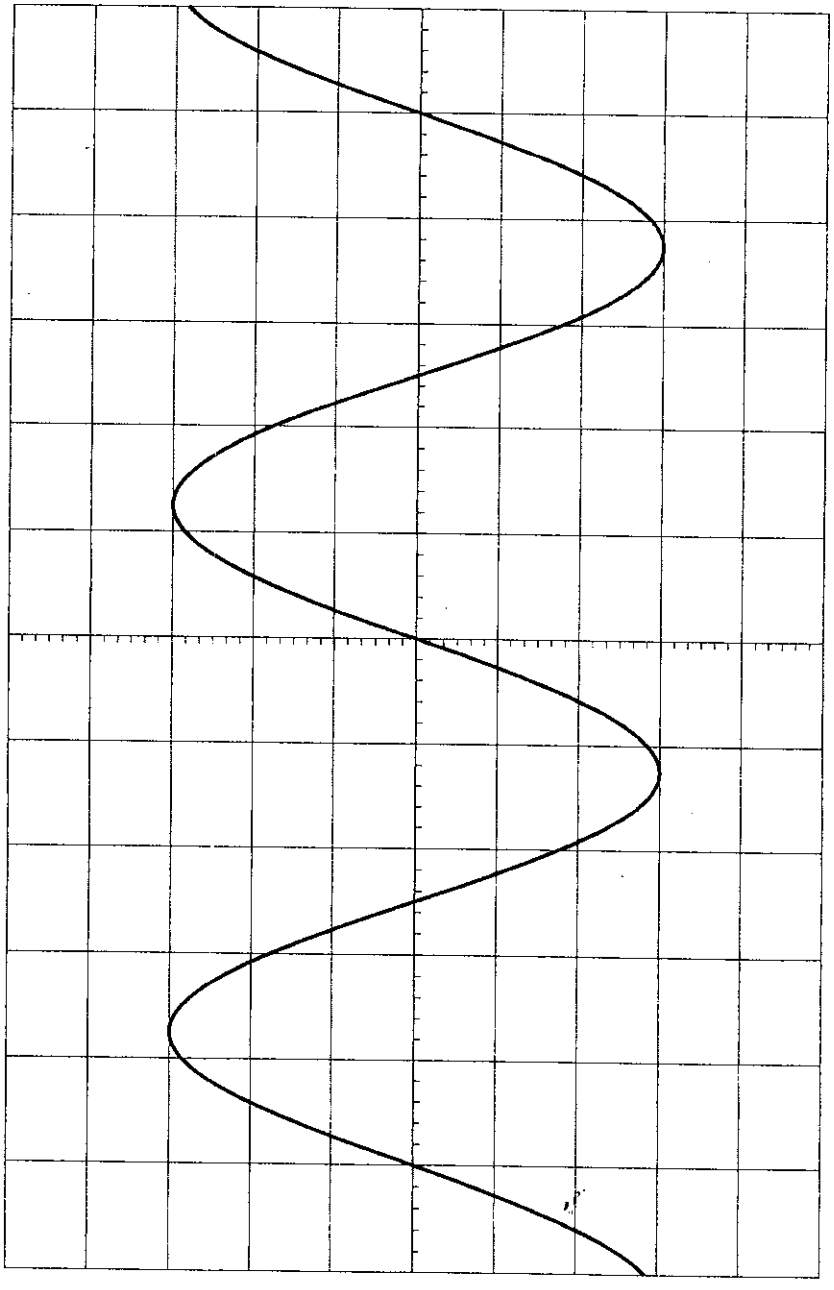


Figure Q5 (b) 2

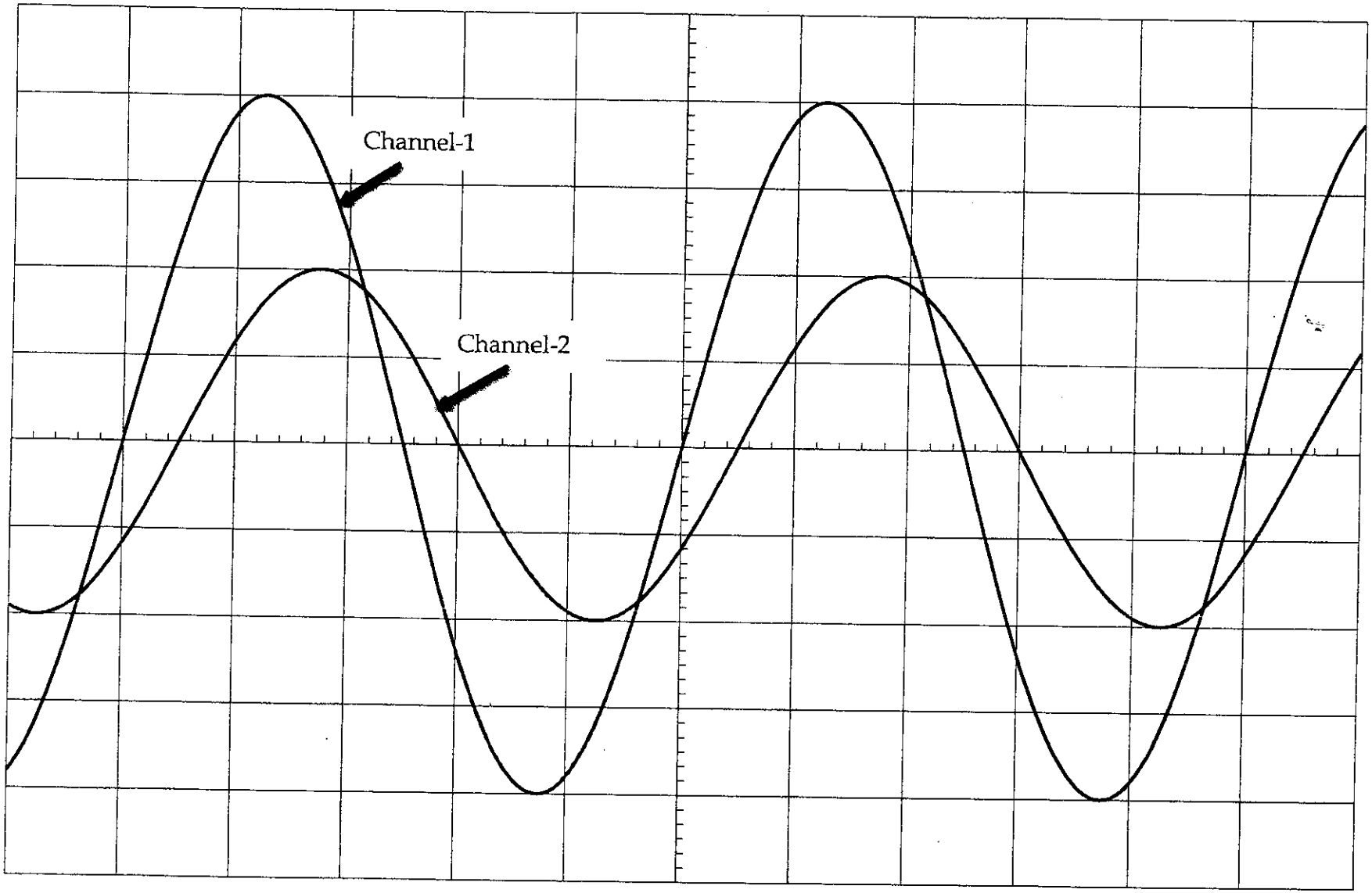



Figure Q5 (b) 3