UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE : EFB1013 - CIRCUIT THEORY

DATE : 19 APRIL 2025 (SATURDAY)

TIME : 9.00 AM - 12.00 NOON (3 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **FIVE (5)** pages in this Question Booklet including the cover page .

ii. **DOUBLE-SIDED** Question Booklet.

1. Kirchoff's laws and Thevenin/Norton theorems are techniques that can be used to analyze complex circuits.

a. A complex circuit is shown in **FIGURE Q1a**.

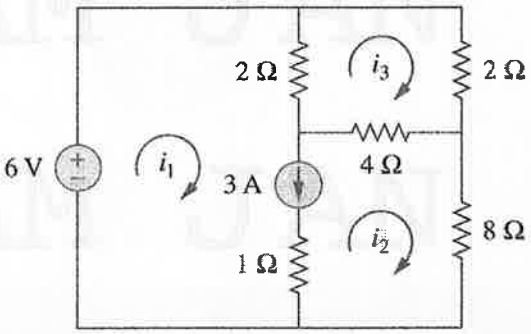

FIGURE Q1a

i. State the condition for super-mesh and write down the mesh equations for the circuit using Kirchoff's voltage law.

[10 marks]

ii. Determine all the mesh currents.

[8 marks]

b. It is often desirable to ensure maximum power is transferred to the load (for example, a motor), as shown in **FIGURE Q1b**.

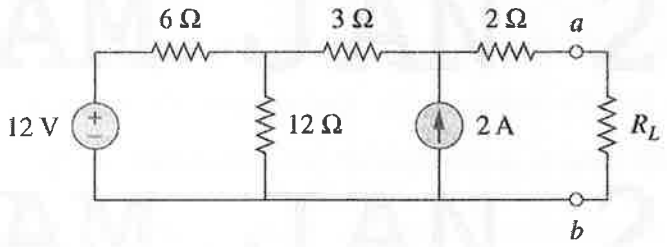

FIGURE Q1b

i. Using Thevenin's theorem, find the equivalent circuit (R_{Th} and V_{Th}) to the left of the terminals a-b.

[8 marks]

ii. Hence, state the value of R_L for maximum power transfer and determine the maximum power.

[4 marks]

2. Inductors are one of the important circuit elements that can store electrical energy in a magnetic field.

a. The current through a 0.1H inductor is $10te^{-5t}$ A. Find the voltage and the energy stored in it.

[7 marks]

b. The switch in the circuit shown in **FIGURE Q2** has been open for a long time. At $t = 0$, the switch is closed.

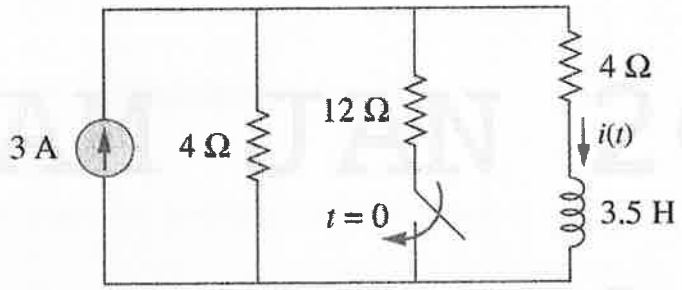

FIGURE Q2

i. With the switch opened, determine the inductor's initial current, $i(0)$.

[4 marks]

ii. With the switch closed, determine the inductor's final current, $i(\infty)$ and the time constant.

[8 marks]

iii. Evaluate whether the circuit is a source-free or step response circuit. Hence, determine the inductor's current, $i(t)$ for $t > 0$.

[6 marks]

iv. Discuss how the values of the current source and resistors in the circuit, affect the inductor's current, $i(t)$.

[5 marks]

3. The operational amplifier is an active circuit element that can be designed to perform mathematical operations. An op-amp circuit is shown in **FIGURE Q3**.

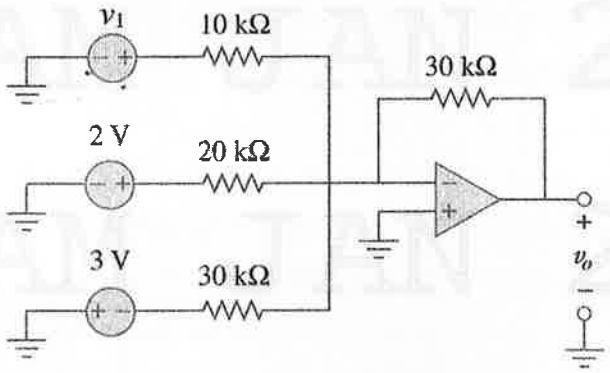

FIGURE Q3

a. Identify the type of amplifier circuit and determine the output voltage, v_o, if v_1 = 1 V.

[10 marks]

b. In order to obtain an output voltage, v_o = 12 V, what should be the new value of v_1 ?

[5 marks]

c. If the resistance of the 30-kΩ feedback resistor is doubled, discuss how this affects the output voltage, v_o.

[5 marks]

4. Phasors are an important tool for analyzing AC power circuits.

a. Consider the circuit shown in **FIGURE Q4**.

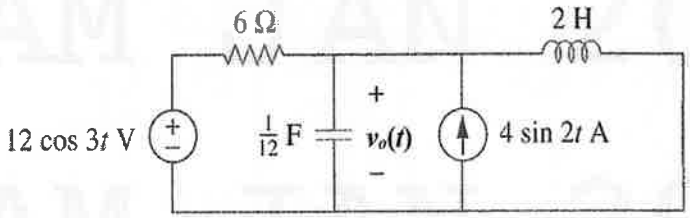

FIGURE Q4

i. Construct the equivalent circuit for each frequency in phasor domain.

[4 marks]

ii. Determine $v_o(t)$ using superposition theorem.

[8 marks]

b. The voltage and current phasors, across a load is given as follows:-

$$\mathbf{V} = 110 \angle 85° \text{ V rms}, \mathbf{I} = 0.4 \angle 15° \text{ A rms}$$

Calculate the complex power, apparent power, real power, and reactive power.

[8 marks]

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