First Semester Examination
2018/2019 Academic Session

December 2018/ January 2019

EEE 105 – CIRCUIT THEORY I
(TEORI LITAR I)

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **SIXTEEN (16)** pages and **SIX (6)** page of printed appendix material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat dan **ENAM (6)** muka surat lampiran yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instructions: This question paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions: **THREE (3)** from Section A and **TWO (2)** from Section B. All questions carry the same marks.

[***Arahan:*** *Kertas soalan ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan : **TIGA (3)** daripada Bahagian A dan **DUA (2)** daripada Bahagian B. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

SECTION A

BAHAGIAN A

1. (a) Answer the following questions:

Jawab soalan-soalan berikut:

(i) State the law of conservation of charge.
Nyatakan hukum pemuliharaan cas.

(5 marks/*markah*)

(ii) Two or more elements are in series if they _____ and _____.

Dua atau lebih elemen adalah dalam keadaan bersiri jika mereka _____ *dan* _____.

(8 marks/*markah*)

(iii) State and define two properties that constitute to linearity concept of circuit.
Nyata dan takrifkan dua ciri yang membentuk konsep kelelurusan litar.

(12 marks/*markah*)

(b) A model of circuitry that distributes power to a typical home is shown in Figure 1(b) with voltage polarities and current directions defined for all of the circuit components. The results of circuit analysis give the values for all of these voltages and currents, which are summarized in Table 1(b).

Satu model litar yang mengagihkan kuasa ke satu rumah tipikal ditunjukkan dalam Rajah 1(b) dengan polariti voltan dan arah arus diberikan kepada semua komponen litar. Keputusan analisa litar memberikan nilai untuk semua voltan dan arus, seperti yang diringkaskan dalam Jadual 1(b).

(i) Propose one analysis/method to determine whether or not the values given are correct.
Cadangkan satu analisa/kaedah untuk memastikan sama ada nilai-nilai yang diberikan adalah betul atau salah.

(5 marks/*markah*)

(ii) By using the proposed analysis/method in (i), determine whether or not the values given are correct.

Dengan menggunakan analisa/kaedah yang dicadangkan dalam (i), kenalpasti sama ada nilai-nilai yang diberikan adalah betul atau tidak.

(10 marks/ *markah*)

(iii) If there is incorrect value, identify **ONE** component that was possibly given with incorrect voltage polarities or current direction. Then, suggest a correct voltage polarities or current direction.

*Jika terdapat nilai yang salah, kenalpasti **SATU** komponen yang berkemungkinan diberikan polariti voltan atau arah arus yang salah. Kemudian, cadangkan polariti voltan atau arah arus yang betul.*

(10 marks/*markah*)

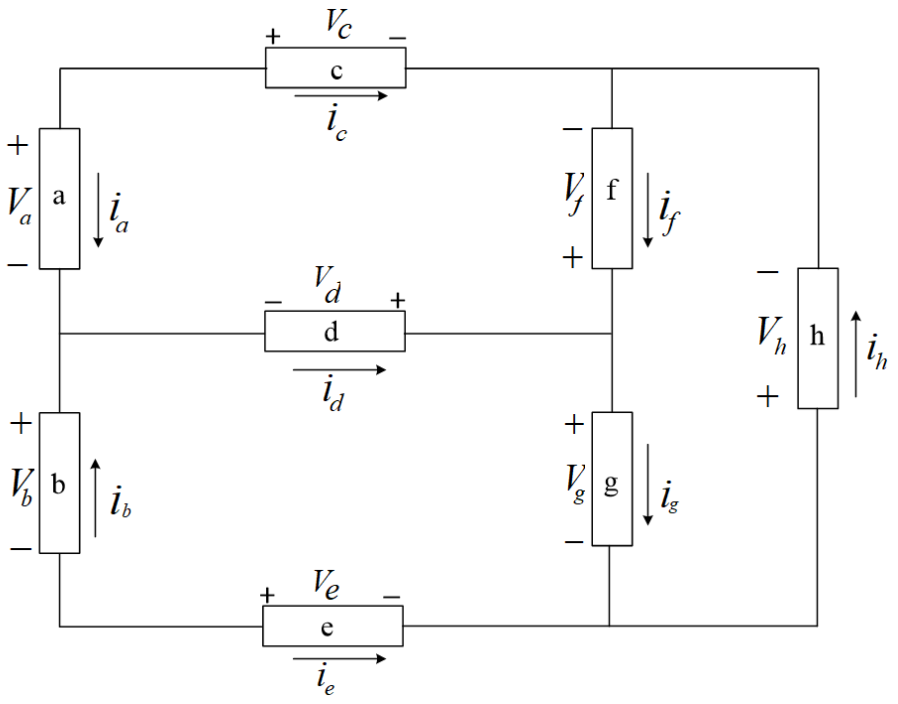


Figure 1(b)

Rajah 1(b)

Table 1(b)

Jadual 1(b)

Component ***Komponen***	**Voltage, v (V)** ***Voltan, v (V)***	**Current, i (A)** ***Arus, i (A)***
a	120	-10
b	120	9
c	10	10
d	10	1
e	-10	-9
f	-100	5
g	120	4
h	-220	-5

(c) Based on Figure 1(c), answer the following questions:

Berdasarkan Rajah 1(c), jawab soalan-soalan berikut:

(i) By using mesh analysis, find the values of all **two (2) mesh currents**. Then, determine v_a.

*Dengan menggunakan analisa jejaring, dapatkan nilai untuk semua **dua (2) arus jejaring**. Kemudian, dapatkan v_a.*

(20 marks/*markah*)

(ii) By using nodal analysis, find the values of all **seven (7) node voltages**. Then, determine v_a.

*Dengan menggunakan analisa nod, dapatkan nilai untuk semua **tujuh (7) voltan nod**. Kemudian, dapatkan v_a.*

(25 marks/*markah*)

(iii) Based on questions (i) and (ii), determine the best analysis to solve the problem. State your reason.
Berdasarkan soalan (i) dan (ii), kenalpasti analisa terbaik untuk menyelesaikan soalan tersebut. Nyatakan alasan anda.

(5 marks/*markah*)

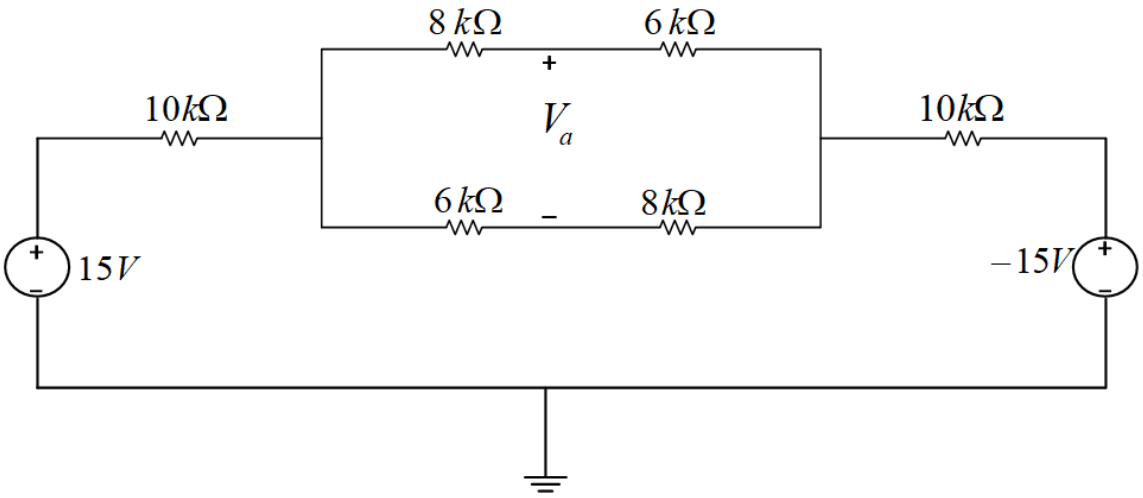


Figure 1(c)
Rajah 1(c)

2. (a) Objectives: To determine i and v_x of the circuit in Figure 2(a).
Objektif: Untuk menentukan i dan v_x bagi litar dalam Rajah 2(a).

Assumption: i(0) = 7 A.
Anggapan: i(0) = 7 A.

State your views on how you are going to achieve your objectives in terms of the circuit laws, circuit techniques and voltage expression for the inductor used. Then, use these laws, techniques and definition to analyse the circuit in Figure 2(a).

Nyatakan pandangan anda tentang bagaimana anda boleh mencapai objektif-objektif tersebut dari segi hukum litar, teknik litar dan persamaan voltan induktor yang digunakan. Kemudian, gunakan hukum, teknik dan definisi ini untuk menganalisa litar dalam Rajah 2(a).

(50 marks/*markah*)

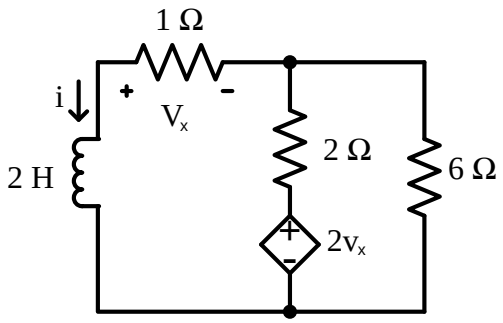


Figure 2(a)

Rajah 2(a)

(b) Objective: To determine i(t) for t > 0 for the circuit in Figure 2(b).
Objektif: Untuk menentukan i(t) bagi t > 0 bagi litar dalam Rajah 2(b).

State your views on how you are going to achieve your objectives in terms of the circuit laws, circuit techniques and voltage definition for the inductor used. Then, use these laws, techniques and definition to analyse the circuit in Figure 2(b).
Nyatakan pandangan anda tentang bagaimana anda boleh mencapai objektif-objektif tersebut dari segi hukum litar, teknik litar dan definisi voltan induktor yang digunakan. Kemudian, gunakan hukum, teknik dan definisi ini untuk menganalisa litar dalam Rajah 2(b).

(50 marks/*markah*)

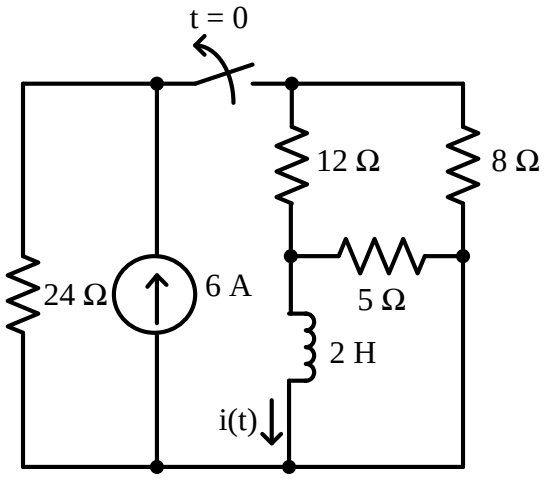


Figure 2(b)

Rajah 2(b)

3. (a) Answer the following questions:

Jawab soalan-soalan berikut:

(i) Note down the steps to analyze any A.C circuit.
Tuliskan langkah-langkah untuk menganalisis sebarang litar A.C.

(10 marks/*markah*)

(ii) Referring to the circuit shown in Figure 3.1 calculate the value of i_1 using Nodal Analysis method.
Merujuk kepada litar yang ditunjukkan dalam Rajah 3.1 kirakan nilai i_1 *dengan menggunakan kaedah Analisis Nodal.*

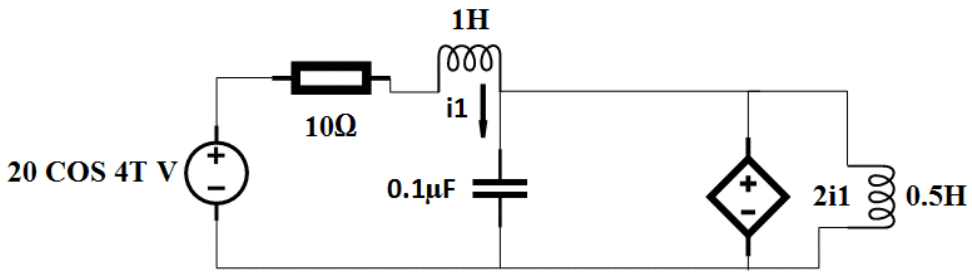


Figure 3.1
Rajah 3.1

(20 marks/*markah*)

(iii) Referring to circuit shown in Figure 3.2 calculate the value of I_x using mesh analysis.
Merujuk kepada litar yang ditunjukkan dalam Rajah 3.2 kirakan nilai I_x *dengan menggunakan analisis mesh.*

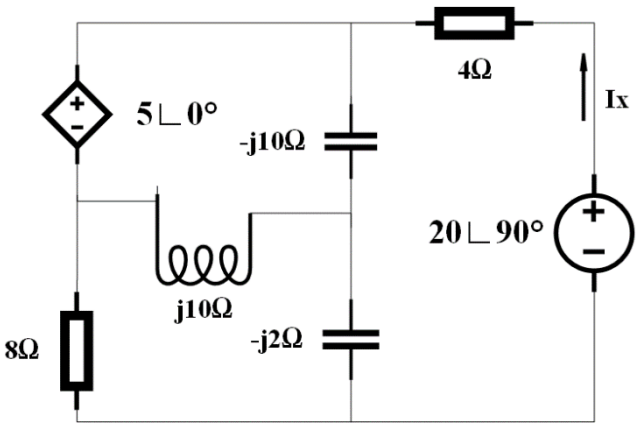


Figure 3.2
Rajah 3.2

(20 marks/*markah*)

(b) Answer the following questions:
Jawab soalan-soalan berikut:

(i) What is source transformation? Using neat and simple diagram demonstrate how voltage source in frequency domain is converted to current source.
Apakah transformasi sumber? Dengan menggunakan gambarajah yang ringkas dan mudah tunjukkan bagaimana sumber voltan di dalam domain kekerapan ditukarkan kepada sumber arus.

(25 marks/*markah*)

(ii) Referring to circuit shown in Figure 3.3 calculate voltage across 12 Ω resistor using source transformation method.
Merujuk kepada litar yang ditunjukkan di dalam Rajah 3.3 kirakan voltan merentasi perintang 12 Ω dengan menggunakan kaedah transformasi sumber.

(25 marks/*markah*)

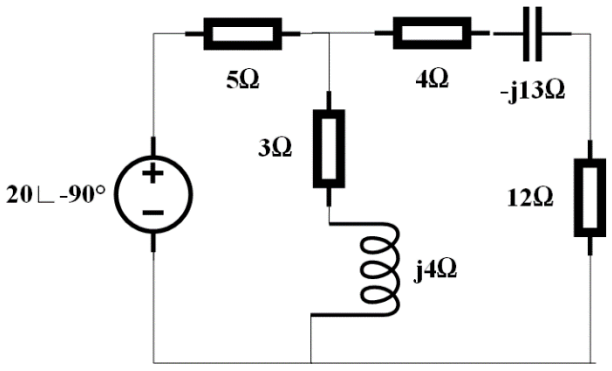


Figure 3.3
Rajah 3.3

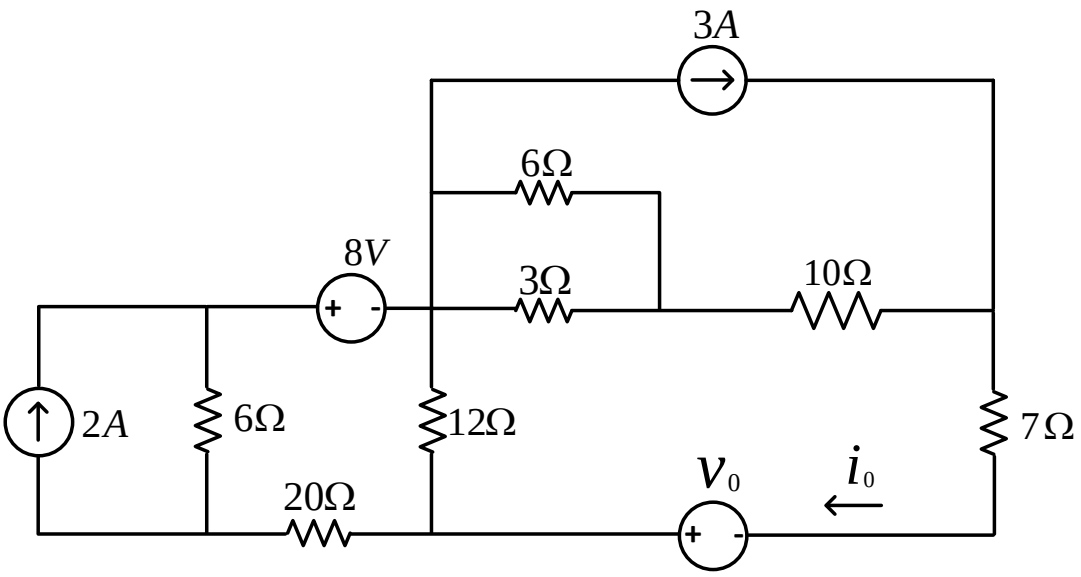
SECTION B

BAHAGIAN B

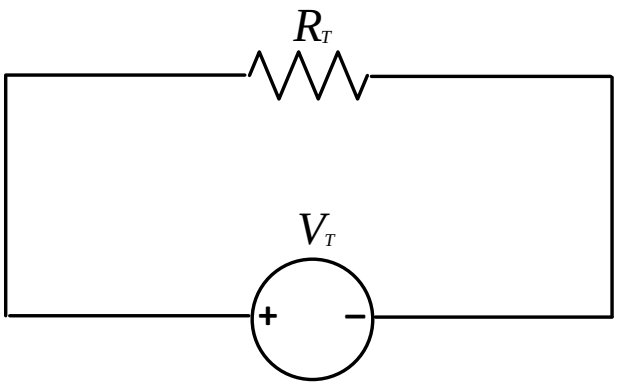
4. (a) **By using only source transformation method**, reduce the circuit shown in Figure 4(a)(i) to a single mesh circuit that contains one voltage source, v_T and one equivalent resistor, R_T as shown in Figure 4(a)(ii). Find the value of v_T and R_T. Then, determine the value of v_0 if $i_0 = 2.5$ A.

Dengan hanya menggunakan kaedah transformasi sumber*, ringkaskan litar yang ditunjukkan dalam Rajah 4(a)(i) kepada satu litar jejaring tunggal yang mempunyai satu sumber voltan,* v_T *dan satu perintang setara,* R_T *seperti yang ditunjukkan dalam Rajah 4(a)(ii). Dapatkan nilai* v_T dan R_T. *Kemudian, dapatkan nilai* v_0 *jika* $i_0 = 2.5$ *A.*

(50 marks/*markah*)



(i)



(ii)

Figure 4(a)

Rajah 4(a)

(b) Based on Figure 4(b), answer the following questions:

Berdasarkan Rajah 4(b), jawab soalan-soalan berikut:

(i) **By using only Ohm and Kirchhoff's Laws**, find the Norton current at terminal a-b.

***Dengan hanya menggunakan Hukum Ohm dan Kirchhoff**, dapatkan arus Norton pada terminal a-b.*

(15 marks/*markah*)

(ii) **By using only Ohm and Kirchhoff's Laws**, find the Thevenin voltage at terminal a-b.

***Dengan hanya menggunakan Hukum Ohm dan Kirchhoff**, dapatkan voltan Thevenin pada terminal a-b.*

(12 marks/*markah*)

(iii) **Without using the answers from (i) and (ii)**, find the Thevenin resistor at terminal a-b. **Use only Ohm and Kirchhoff's Laws** to solve the problem.

***Tanpa menggunakan jawapan dari (i) dan (ii)**, dapatkan rintangan Thevenin pada terminal a-b. **Hanya guna Hukum Ohm dan Kirchhoff** untuk menyelesaikan masalah ini.*

(15 marks/*markah*)

(iv) Find the Thevenin resistor at terminal a-b by using answer from (i) and (ii). Then, compare your answer with the one obtained in (iii).

Dapatkan rintangan Thevenin pada terminal a-b dengan menggunakan jawapan dari (i) dan (ii). Kemudian, bandingkan jawapan anda dengan jawapan yang diperolehi dalam (iii).

(4 marks/*markah*)

(v) Find the maximum power transferred to load resistor, R_L.
Dapatkan kuasa maksimum yang dihantar ke perintang beban, R_L.

(4 marks/*markah*)

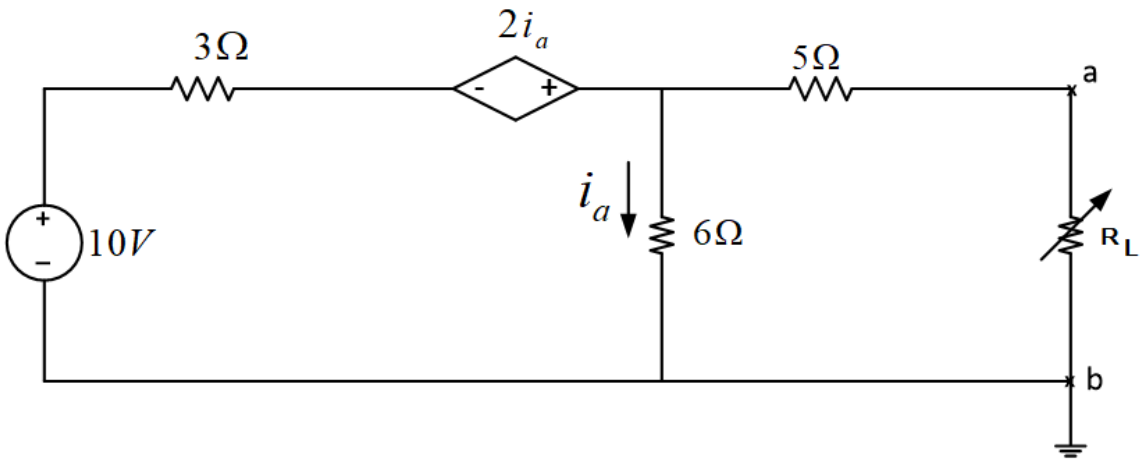


Figure 4(b)

Rajah 4(b)

5. (a) Find the voltage v(t) in a circuit described by the integrodifferential equation:
Tentukan voltan v(t) dalam litar yang digambarkan oleh persamaan pengamiran-pembeza:

$$2\frac{dv}{dt} + 5v + 10\int v\,dt = 50\cos(5t - 30°)$$

(25 marks/*markah*)

(b) Analyse the circuit in Figure 5(b) and determine v(t) and i(t).
Analisa litar dalam Rajah 5(b) dan tentukan v(t) dan i(t).

(30 marks/*markah*)

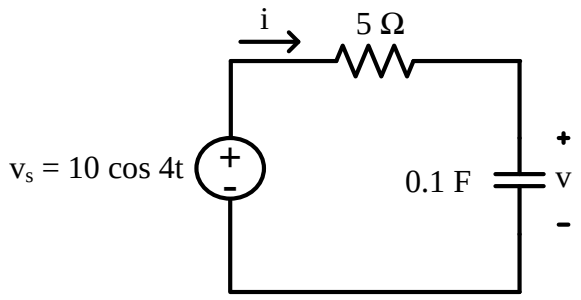


Figure 5(b)
Rajah 5(b)

(c) Analyse the circuit in Figure 5(c) and determine the input impedance, $\mathbf{Z}_{in}$, at ω = 20 rad/s.
Analisa litar dalam Rajah 5(c) dan tentukan impedan masukan, $\boldsymbol{Z}_{in}$, pada ω = 20 rad/s.

(20 marks/*markah*)

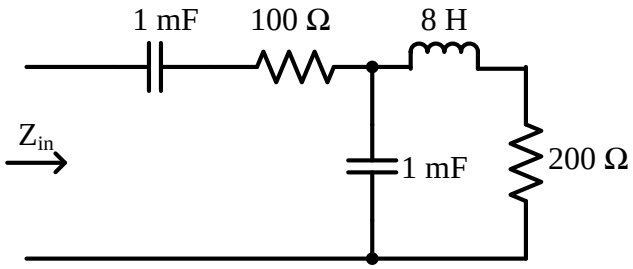


Figure 5(c)

Rajah 5(c)

(d) Analyse the circuit in Figure 5(d) and determine v_o.

Analisa litar dalam Rajah 5(d) dan tentukan v_o.

(25 marks/*markah*)

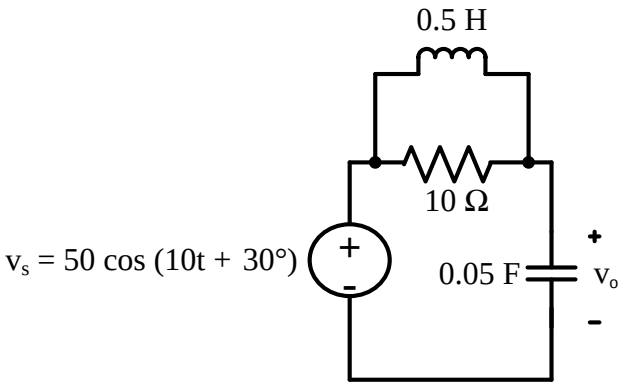


Figure 5(d)

Rajah 5(d)

6. (a) Answer the following questions:

Jawab soalan-soalan berikut:

(i) What is Apparent power and Power Factor. How can we improve the power factor of any electrical circuit, explain?

Apa itu Kuasa Ketara dan Faktor Kuasa. Bagaimanakah kita boleh meningkatkan faktor kuasa mana-mana litar elektrik, jelaskan?

(10 marks/*markah*)

(ii) The voltage across a load is $v(t) = 60\cos(\omega t - 10^{\bullet})$ V and current in the element in the direction of voltage drop is $^{*}i(t) = 1\cos(\omega t + 50^{\bullet})$ A, calculate the Complex power.

Voltan merentasi beban ialah $v(t) = 60\cos(\omega t - 10^{\bullet})$ *V dan arus dalam elemen ke arah penurunan voltan ialah* $^{*}i(t) = 1\cos(\omega t + 50^{\bullet})$ *A, Kirakan kuasa Kompleks.*

(20 marks/*markah*)

(iii) With aid of neat diagram explain the principle of operation of single-phase wattmeter. Why wattmeter is used?

Dengan bantuan rajah yang kemas jelaskan prinsip operasi wattmeter fasa tunggal. Mengapa wattmeter digunakan?

(20 marks/*markah*)

(b) Answer the following questions:
Jawab soalan-soalan berikut:

(i) In power grid what are the advantages of using 3-Ph system. In how many configurations can a 3-Ph voltage source be connected to a 3-Ph load, note them. Under what condition can Y-connection is said to be balanced?
Dalam grid kuasa apakah kelebihan menggunakan sistem 3-Ph. Berapa banyak konfigurasi boleh sumber voltan 3-Ph disambungkan kepada beban 3-Ph, tuliskan. Di bawah keadaan apakah sambungan Y dikatakan seimbang?

(20 marks/*markah*)

(ii) Referring to the circuit shown in Figure 6 state which configuration is used, referring to same circuit calculate the line currents.
Merujuk kepada litar yang ditunjukkan dalam Rajah 6 nyatakan konfigurasi yang digunakan, merujuk kepada litar yang sama kirakan arus-arus garis.

(30 marks/*markah*)

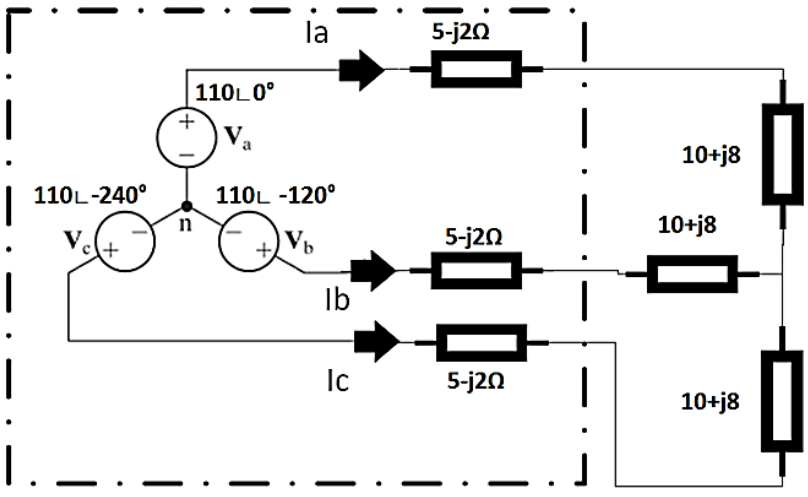


Figure 6
Rajah 6

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APPENDIX A
LAMPIRAN A

Mathematical Formulas

This appendix—by no means exhaustive—serves as a handy reference. It does contain all the formulas needed to solve circuit problems in this book.

Quadratic Formula

The roots of the quadratic equation $ax^2 + bx + c = 0$ are

$$x_1, x_2 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometric Identities

$$\sin(-x) = -\sin x$$
$$\cos(-x) = \cos x$$
$$\sec x = \frac{1}{\cos x}, \qquad \csc x = \frac{1}{\sin x}$$
$$\tan x = \frac{\sin x}{\cos x}, \qquad \cot x = \frac{1}{\tan x}$$
$$\sin(x \pm 90°) = \pm \cos x$$
$$\cos(x \pm 90°) = \mp \sin x$$
$$\sin(x \pm 180°) = -\sin x$$
$$\cos(x \pm 180°) = -\cos x$$
$$\cos^2 x + \sin^2 x = 1$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \qquad \text{(law of sines)}$$

$$a^2 = b^2 + c^2 - 2bc \cos A \qquad \text{(law of cosines)}$$

$$\frac{\tan \frac{1}{2}(A - B)}{\tan \frac{1}{2}(A + B)} = \frac{a - b}{a + b} \qquad \text{(law of tangents)}$$

$$\sin(x \pm y) = \sin x \cos y \pm \cos x \sin y$$
$$\cos(x \pm y) = \cos x \cos y \mp \sin x \sin y$$
$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \mp \tan x \tan y}$$
$$2 \sin x \sin y = \cos(x - y) - \cos(x + y)$$
$$2 \sin x \cos y = \sin(x + y) + \sin(x - y)$$
$$2 \cos x \cos y = \cos(x + y) + \cos(x - y)$$
$$\sin 2x = 2 \sin x \cos x$$

$$\cos 2x = \cos^2 x - \sin^2 x = 2\cos^2 x - 1 = 1 - 2\sin^2 x$$

$$\tan 2x = \frac{2\tan x}{1 - \tan^2 x}$$

$$\sin^2 x = \frac{1}{2}(1 - \cos 2x)$$

$$\cos^2 x = \frac{1}{2}(1 + \cos 2x)$$

$$K_1 \cos x + K_2 \sin x = \sqrt{K_1^2 + K_2^2}\cos\left(x + \tan^{-1}\frac{-K_2}{K_1}\right)$$

$$e^{jx} = \cos x + j\sin x \qquad \text{(Euler's formula)}$$

$$\cos x = \frac{e^{jx} + e^{-jx}}{2}$$

$$\sin x = \frac{e^{jx} - e^{-jx}}{2j}$$

$$1 \text{ rad} = 57.296^\circ$$

Hyperbolic Functions

$$\sinh x = \frac{1}{2}(e^x - e^{-x})$$

$$\cosh x = \frac{1}{2}(e^x + e^{-x})$$

$$\tanh x = \frac{\sinh x}{\cosh x}$$

$$\coth x = \frac{1}{\tanh x}$$

$$\operatorname{csch} x = \frac{1}{\sinh x}$$

$$\operatorname{sech} x = \frac{1}{\cosh x}$$

$$\sinh(x \pm y) = \sinh x \cosh y \pm \cosh x \sinh y$$

$$\cosh(x \pm y) = \cosh x \cosh y \pm \sinh x \sinh y$$

Derivatives

If $U = U(x)$, $V = V(x)$, and $a =$ constant,

$$\frac{d}{dx}(aU) = a\frac{dU}{dx}$$

$$\frac{d}{dx}(UV) = U\frac{dV}{dx} + V\frac{dU}{dx}$$

$$\frac{d}{dx}\left(\frac{U}{V}\right) = \frac{V\frac{dU}{dx} - U\frac{dV}{dx}}{V^2}$$

$$\frac{d}{dx}(aU^n) = naU^{n-1}$$

$$\frac{d}{dx}(a^U) = a^U \ln a \frac{dU}{dx}$$

$$\frac{d}{dx}(e^U) = e^U\frac{dU}{dx}$$

$$\frac{d}{dx}(\sin U) = \cos U\frac{dU}{dx}$$

$$\frac{d}{dx}(\cos U) = -\sin U\frac{dU}{dx}$$

Indefinite Integrals

If $U = U(x)$, $V = V(x)$, and $a =$ constant,

$$\int a\,dx = ax + C$$

$$\int U\,dV = UV - \int V\,dU \quad \text{(integration by parts)}$$

$$\int U^n\,dU = \frac{U^{n+1}}{n+1} + C, \quad n \neq 1$$

$$\int \frac{dU}{U} = \ln U + C$$

$$\int a^U\,dU = \frac{a^U}{\ln a} + C, \quad a > 0, a \neq 1$$

$$\int e^{ax}\,dx = \frac{1}{a}e^{ax} + C$$

$$\int xe^{ax}\,dx = \frac{e^{ax}}{a^2}(ax - 1) + C$$

$$\int x^2e^{ax}\,dx = \frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2) + C$$

$$\int \ln x\,dx = x\ln x - x + C$$

$$\int \sin ax\,dx = -\frac{1}{a}\cos ax + C$$

$$\int \cos ax\,dx = \frac{1}{a}\sin ax + C$$

$$\int \sin^2 ax\,dx = \frac{x}{2} - \frac{\sin 2ax}{4a} + C$$

$$\int \cos^2 ax\,dx = \frac{x}{2} + \frac{\sin 2ax}{4a} + C$$

$$\int x\sin ax\,dx = \frac{1}{a^2}(\sin ax - ax\cos ax) + C$$

$$\int x\cos ax\,dx = \frac{1}{a^2}(\cos ax + ax\sin ax) + C$$

$$\int x^2\sin ax\,dx = \frac{1}{a^3}(2ax\sin ax + 2\cos ax - a^2x^2\cos ax) + C$$

$$\int x^2\cos ax\,dx = \frac{1}{a^3}(2ax\cos ax - 2\sin ax + a^2x^2\sin ax) + C$$

$$\int e^{ax}\sin bx\,dx = \frac{e^{ax}}{a^2+b^2}(a\sin bx - b\cos bx) + C$$

$$\int e^{ax}\cos bx\,dx = \frac{e^{ax}}{a^2+b^2}(a\cos bx + b\sin bx) + C$$

$$\int \sin ax\sin bx\,dx = \frac{\sin(a-b)x}{2(a-b)} - \frac{\sin(a+b)x}{2(a+b)} + C, \qquad a^2 \neq b^2$$

$$\int \sin ax\cos bx\,dx = -\frac{\cos(a-b)x}{2(a-b)} - \frac{\cos(a+b)x}{2(a+b)} + C, \qquad a^2 \neq b^2$$

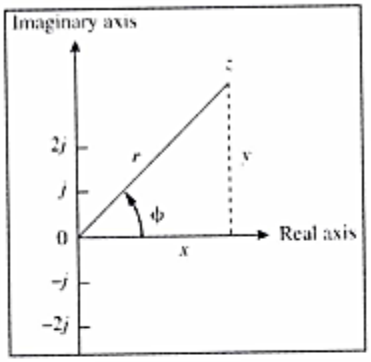
$$\int \cos ax\cos bx\,dx = \frac{\sin(a-b)x}{2(a-b)} + \frac{\sin(a+b)x}{2(a+b)} + C, \qquad a^2 \neq b^2$$

$$\int \frac{dx}{a^2+x^2} = \frac{1}{a}\tan^{-1}\frac{x}{a} + C$$

$$\int \frac{x^2\,dx}{a^2+x^2} = x - a\tan^{-1}\frac{x}{a} + C$$

$$\int \frac{dx}{(a^2+x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2+a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right) + C$$

Graph relating the complex number elements:



Complex number in rectangular form:

$$z = x + jy$$

$$r = \sqrt{x^2 + y^2}$$

$$\emptyset = \tan^{-1}\frac{y}{x}$$

$$z = r(\cos\phi + j\sin\phi)$$

$$\frac{1}{j} = -j \text{ and } \quad j = 1\angle 90°$$

Complex number in polar form:

$$z = r\angle\phi$$

Complex number in exponential form:

$$z = re^{j\phi}$$

Sinusoid-phasor transformation:

$$V_m \cos(\omega t + \phi) \leftrightarrow V_m \angle\phi$$
$$V_m \sin(\omega t + \phi) \leftrightarrow V_m \angle\phi\text{-}90°$$
$$I_m \cos(\omega t + \theta) \leftrightarrow I_m \angle\theta$$
$$I_m \sin(\omega t + \theta) \leftrightarrow I_m \angle\theta\text{-}90°$$

Trigonometric identities:

$$\sin(A \pm B) = \sin A\cos B \pm \cos A\sin B$$

$$\cos(A \pm B) = \cos A\cos B \mp \sin A\sin B$$

$$\sin(\omega t \pm 180^\circ) = -\sin\omega t$$

$$\sin(\omega t \pm 90^\circ) = \pm\cos\omega t$$

$$\cos(\omega t \pm 180^\circ) = -\cos\omega t$$

$$\cos(\omega t \pm 90^\circ) = \mp\sin\omega t$$

Mathematic operation of complex number:

Addition	$z_1 + z_2 = (x_1 + x_2) + j(y_1 + y_2)$
Subtraction	$z_1 - z_2 = (x_1 - x_2) + j(y_1 - y_2)$
Multiplication	$z_1 z_2 = r_1 r_2 \angle\phi_1 + \phi_2$
Division	$\frac{z_1}{z_2} = \frac{r_1}{r_2} \angle\phi_1 - \phi_2$
Reciprocal	$\frac{1}{z} = \frac{1}{r} \angle -\phi$
Square root	$\sqrt{z} = \sqrt{r} \angle\phi/2$
Complex conjugate	$z^* = x - jy = r\angle -\phi = re^{-j\phi}$
Euler's identity	$e^{\pm j\phi} = \cos\phi \pm j\sin\phi$