CMR
INSTITUTE OF
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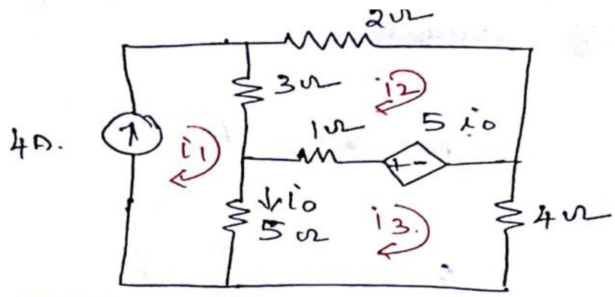
USN | | | | | | | | | | |

Internal Assesment Test - II

Sub:	Electric Circuit Analysis							Code:	18EE32
Date:	12/10/2019	Duration:	90 mins	Max Marks:	50	Sem:	3	Branch:	EEE
Solutions									

		Marks	OBE CO	OBE RBT
1	Use superposition theorem to find I_x of the network shown in fig1.	[10]	CO3	L4

(i) Consider 4A, short circuit 20V.



$$\boxed{i_1 = 4\,A}$$

KVL for Loop 2

$$2i_2 + 3(i_2 - i_1) + 1(i_2 - i_3) = 5\,i_o$$

$$i_1 - i_3 = i_o$$

$$-3i_1 + 6i_2 - i_3 = 5\,i_o \quad \text{--- (1)}$$

$$i_1 - i_3 = i_o$$

$$4 - i_3 = i_o$$

$$i_3 = 4 - i_o \; ; \quad i_1 = 4A$$

Sub in (1).

$$-3\times4 + 6\,i_2 - (4 - i_o) = 5\,i_o$$

$$-12 + 6i_2 - 4 + i_o = 5i_o$$

$$6\,i_2 - 16 = 4\,i_o$$

$$3\,i_2 - 2\,i_o = 8 \quad \text{--- (2)}$$

KVL for Loop 3.

$5(i_3 - i_1) + 1(i_3 - i_2) + 4\,i_3 = -5\,i_o$ — (3)

$i_1 = 4A\,;\quad i_3 = 4 - i_o.$

$5(i_3 - 4) + 1(i_3 - i_2) + 4\,i_3 = -5\,i_o.$

$10\,i_3 - 20 - i_2 = -5\,i_o.$

$i_3 = 4 - i_o$

$10(4 - i_o) - 20 - i_2 = -5\,i_o$

$40 - 10\,i_o - 20 + i_2 = -5\,i_o$

$-i_2 - 5\,i_o = -20$ — (4). $\boxed{i_2 + 5\,i_o = 20}$ — (4)

Solve (2) & (4)

(2) $\Rightarrow 3i_2 - 2i_o = \cancel{16}8$

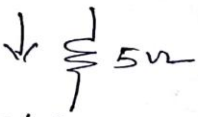
(4) × 3 $\Rightarrow 3i_2 + 15i_o = +60$

$-17\,i_o = -\cancel{52}$

~~$i_o = 3.384A$~~

$i_o = \frac{52}{17}.$

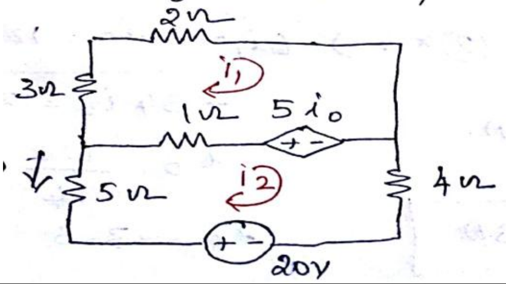
$\boxed{i_o = 3.06A}$



i_o
3.06A.

$\boxed{i_o' = 3.06A}$

(ii) Using 20V, Replace 4A.



$i_o = -i_2.$

<u>KVL for Loop 1</u>

$2i_1 + 3i_1 + 1(i_1 - i_2) = 5 i_o.$

$6 i_1 - i_2 = 5 i_o$

$6 i_1 + i_o = 5 i_o$

$6 i_1 - 4 i_o = 0 \quad \text{—(1)}$

<u>KVL for loop 2.</u>

$1(i_2 - i_1) + 5 i_2 + 4 i_2 = 20 - 5 i_o.$

$10 i_2 - i_1 = 20 - 5 i_o.$

$i_2 = -i_o$

$-10 i_o - i_1 = 20 - 5 i_o$

$-i_1 + 5 i_o = 20. \quad \text{—(2)}.$

$\boxed{i_o = -3.53\text{ A}.}$

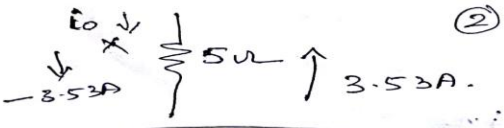
(1) $\Rightarrow 6 i_1 - 4 i_o = 0.$

(2) $\times 6 \Rightarrow -6 i_1 - 30 i_o = 120$

$-34 i_o = 120$

$i_o = \dfrac{120}{-34}$

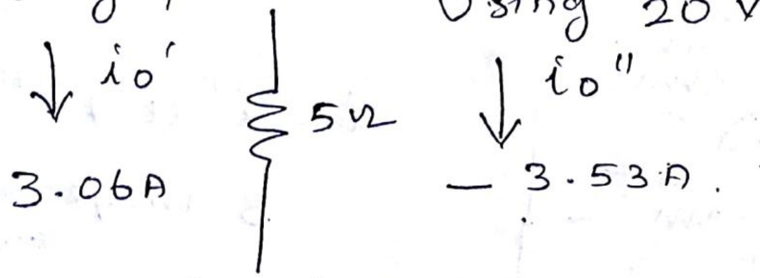
$i_o = -3.53\text{ A}.$



$\boxed{i_o'' = -3.53\text{A}}$

(iii) Algebraic Sum.

Using 4A. Using 20 V

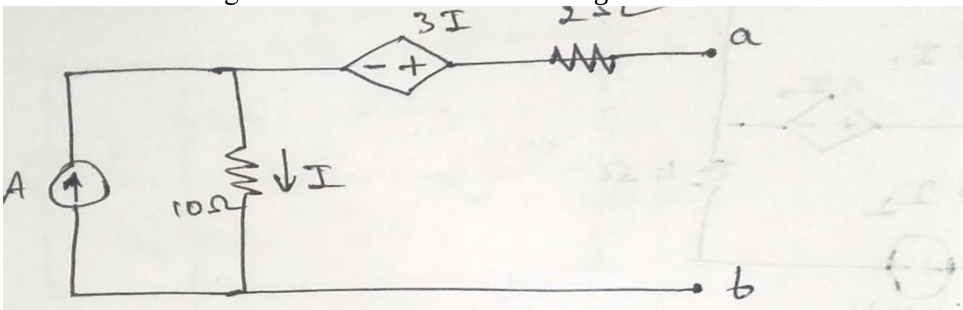


$i_o = i_o' + i_o''$

$= 3.06 - 3.53$

$\boxed{i_o = -0.47\text{ A}.}$

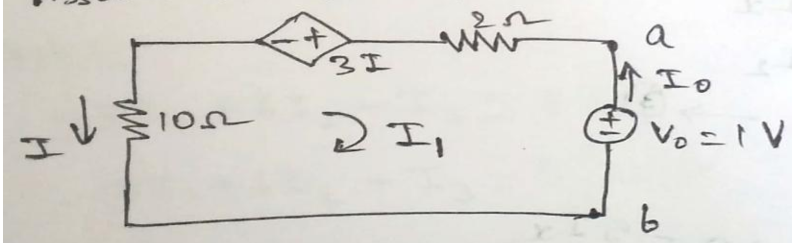
2	Find current I using Norton's theorem shown in fig2.	[10]	CO3	L4



To find R_{th}

Replace current source with open circuit

Assume Voltage $V_o = 1\ V$



$I = -I_1$

$I_o = -I_1$

$0 I_1 + 2I_1 = 3I - 1$

$12 I_1 = -3I_1 - 1$

$15 I_1 = -1$

$I_1 = -1/15\ A$

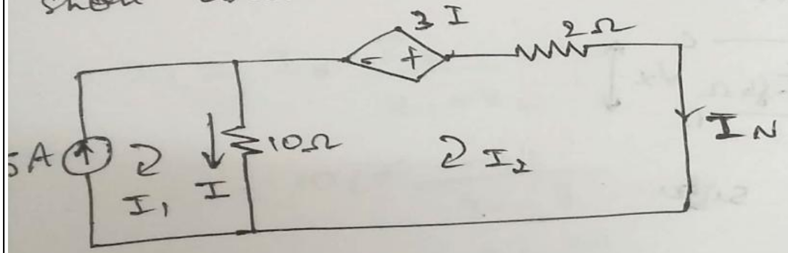
$$I_0 = -I_1$$
$$= \frac{1}{15} \text{ A}$$

$$R_{th} = \frac{V_0}{I_0} = \frac{1}{1/15} = 15\,\Omega$$

$$\boxed{R_{th} = 15\,\Omega}$$

To find I_N

short circuit the load resistor



$$I = I_1 - I_2$$

Mesh 1

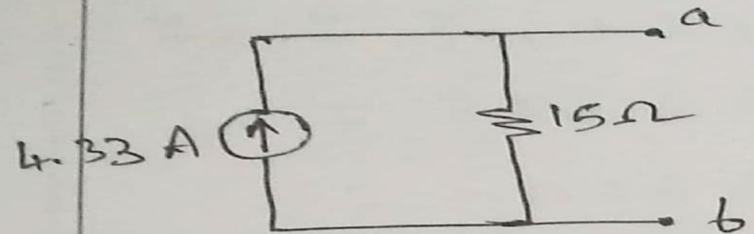
$$I_1 = 5\text{ A}$$

Mesh 2

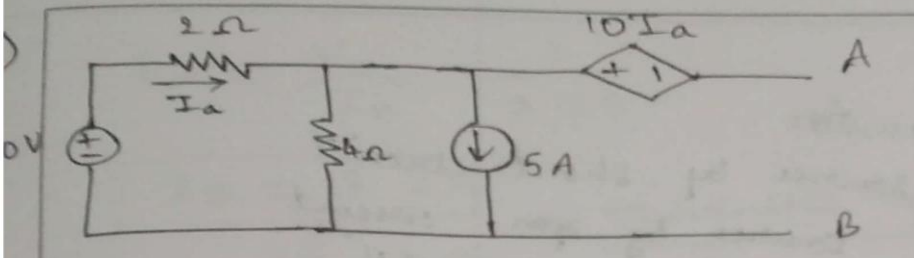
$$-10 I_1 + 12 I_2 = 3I$$
$$-10 I_1 + 12 I_2 = 3(I_1 - I_2)$$
$$15 I_2 = 13 I_1$$
$$I_2 = \frac{65}{15}$$
$$\boxed{I_N = I_2 = 4.333\text{ A}}$$

$$I = I_1 - I_2 = 5 - 4.333$$
$$\boxed{I = 0.666\text{ A}}$$

Nortons Eq. circuit

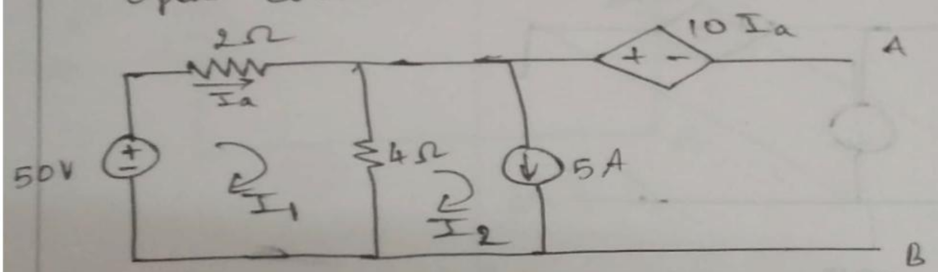


3	Find Thevenin's equivalent circuit across the terminal A-B of the network shown in fig3.	[10]	CO3	L4



To find V_{th}

Open circuit Load resistor



$I_a = I_1$

$6I_1 - 4I_2 = 50$ $\qquad$ $I_2 = 5A$

$6I_1 = 50 + 20$

$I_1 = 11.66\ A$

$V_{th} = -10 I_a + 4(I_1 - I_2)$

$= -10 \times 11.66 + 4(11.66 - 5)$

$\boxed{V_{th} = -89.96\ V}$

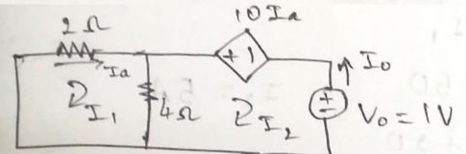
To find R_{th}

Remove load resistor

Replace voltage source by short circuit

current source by open circuit

Assume voltage $V_o = 1$ across AB



$I_o = -I_2$ $\qquad$ $I_a = I_1$

esh 1

$6I_1 - 4I_2 = 0 \rightarrow (1)$

esh 2

$-4I_1 + 4I_2 = -10I_a - 1$

$-4I_1 + 4I_2 = -10I_1 - 1$

$6I_1 + 4I_2 = -1 \rightarrow (2)$

$I_1 = -0.083\,A$

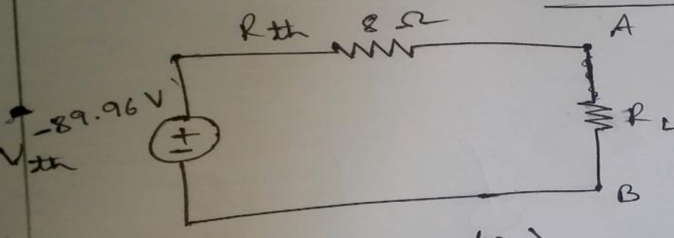
$I_2 = -0.125\,A$

$I_o = -I_2 = 0.125\,A$

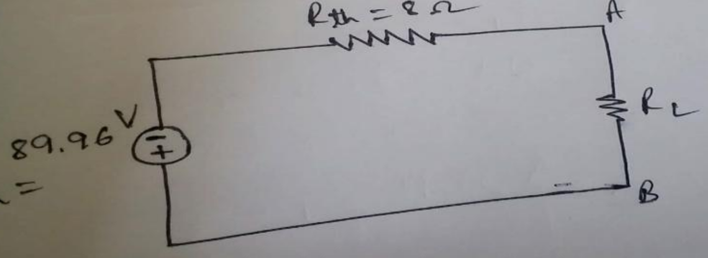
$$R_{th} = \frac{V_o}{I_o} = \frac{1}{0.125}$$

$\boxed{R_{th} = 8\ \Omega}$

Thevenin's equivalent circuit

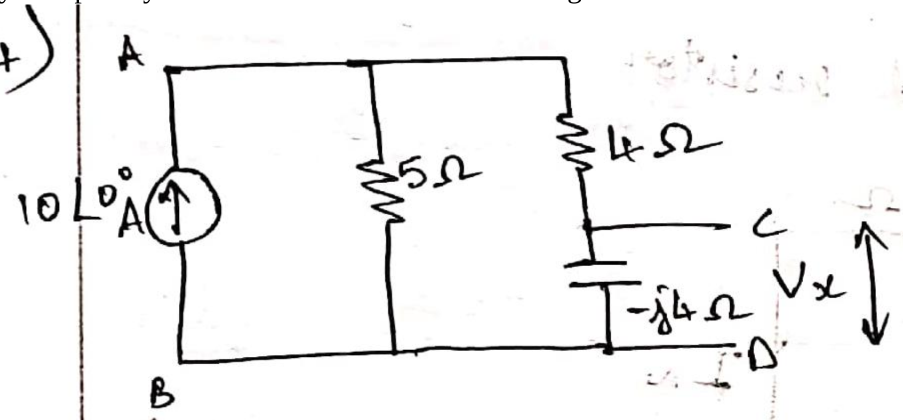


(or)

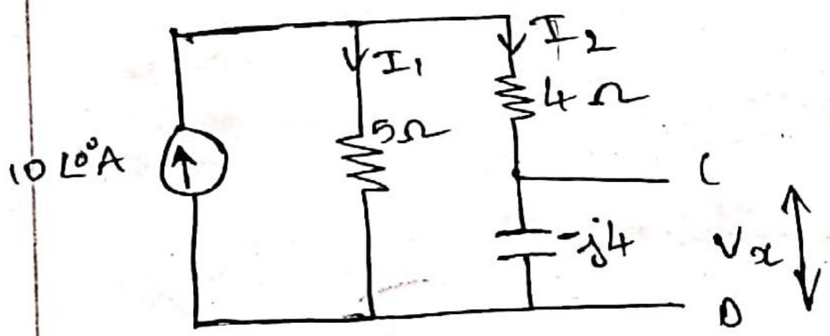


4	Verify Reciprocity theorem for the circuit shown in fig4.	[10]	CO3	L3

4)



case i) considering AB side



$$I_2 = 10\angle 0^\circ \; \frac{5}{9-j4}$$

$$= 10\angle 0^\circ \; \frac{5\angle 0^\circ}{9.84\angle -23.96}$$

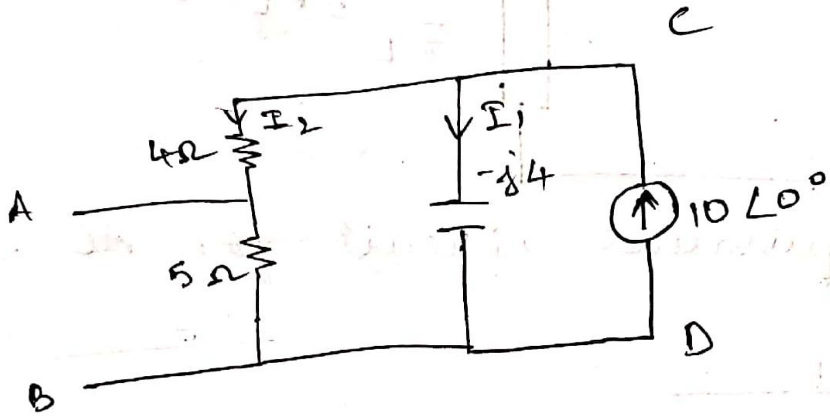
$$= 5.08\angle 23.96 \text{ A}$$

$$V_x = -j4\,(5.08\angle 23.96)$$

$$= 4\angle -90 \,.\, (5.08\angle 23.96)$$

$$\boxed{V_{CD} = V_x = 20.32\angle -66.04 \text{ V}}$$

case ii) considering CD side



$$I_2 = I \cdot \frac{Z_1}{Z_1+Z_2}$$

$$= 10\angle 0^\circ \frac{-j4}{9-j4}$$

$$= 10\angle 0^\circ \frac{4\angle -90}{9.84\angle -23.96}$$

$$I_2 = 4.065\angle -66.04 \text{ A}$$

$$V_{AB} = V_x = 5\,(4.065\angle -66.04)$$

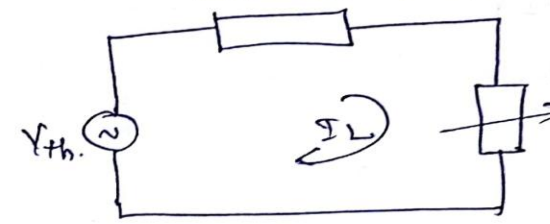
$$\boxed{V_{AB} = 20.32\angle -66.04 \text{ V}}$$

From case (i) & (ii)

$$\boxed{V_{AB} = V_{CD} = 20.32\angle -66.04 \text{ V}}$$

5a Obtain the condition for an alternating voltage source to transfer maximum power to the load when the load impedance is the complex conjugate of the source impedance. [5] CO3 L3

$Z_{th} = R_{th} + jX_{th}$



$$I_L = \frac{V_{th}}{Z_{th} + Z_L} = \frac{V_{th}}{(R_{th} + jX_{th}) + (R_L + jX_L)}$$

$$I_L = \frac{V_{th}}{(R_{th} + R_L) + j(X_{th} + X_L)}$$

$$\frac{dP_L}{dX_L} \Rightarrow 0\,(V) - 2((R_{th}+R_L) + 2j(X_{th}+X_L))\frac{V_{th}^2 R_L}{n} = 0$$

$$2j(X_{th} + X_L) = 0$$

$$-X_{th} = X_L$$

$$\boxed{X_L = -X_{th}}$$

$$\frac{dP_L}{dR_L} = 0 ;\ X_L = -X_{th}$$

$$\frac{d}{dR_L}P_L = V_{th}^2 (R_{th}+R_L)^2 - 2(R_{th}+R_L)R = 0$$

$$R_L = R_{th}. \quad (R_{th}+R_L)^2 = 2(R_{th}+R_L)R_L$$

$$R_{th} + R_L = 2R_L$$

$$\boxed{R_{th} = R_L}$$

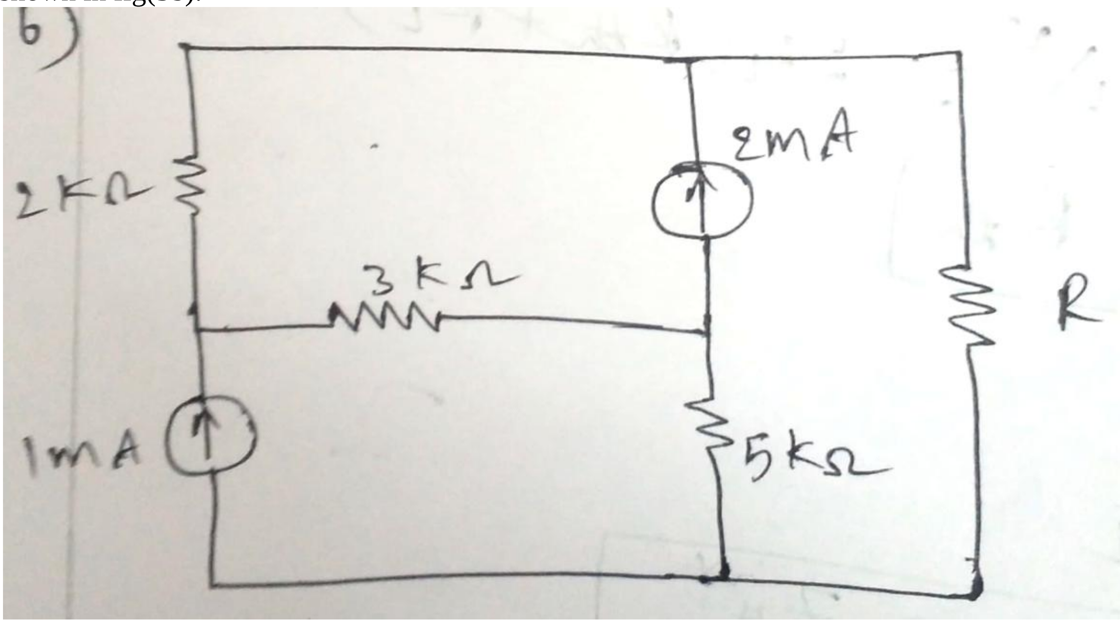
$$Z_L = R_L + jX_L$$

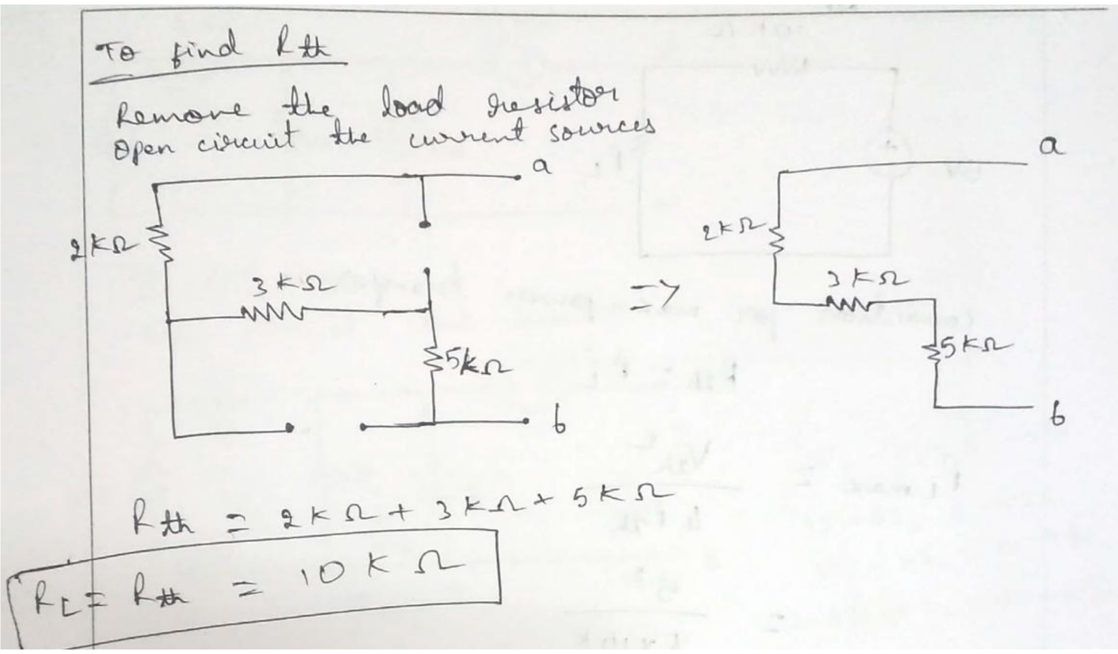
$$\boxed{Z_L = R_{th} - jX_{th} = Z_{th}^*}$$

Maximum Power will be transformed from source to load in AC circuits, when load impedance is complex conjugate of Thevenin's impedance.

$$\boxed{Z_L = Z_{th}^*}$$

5b	Find the value of load resistance R when maximum power is transfer across it in the network shown in fig(5b).	[5]	CO3	L3



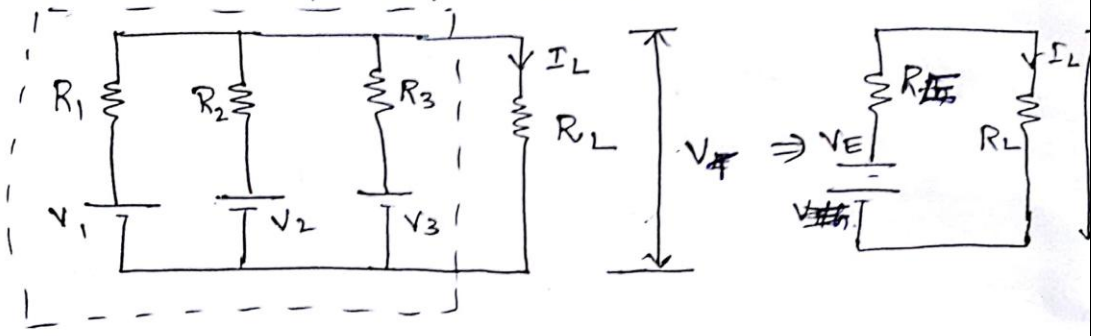


6a	State and prove Millman's theorem.	[4]	CO3	L3

Millman's Theorem

* It is otherwise called as "Parallel Generator Theorem".
* This is combination of Norton's theorem and Thevenin theorem.

Circuit with Voltage Sources.



* V_1, V_2, V_3 are voltages of 1st, 2nd & 3rd branch
* R_1, R_2, R_3 are respective resistances.
* I_L, R_L, V_T → Load current, load resistance and Terminal voltage.
* This can be converted into single voltage source and resistance.

Where V_E = Equivalent voltage ⇒ Thevenin's voltage

$$V_E = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{\Sigma \frac{V}{R}}{\Sigma \frac{1}{R}}.$$

R_{th} ⇒ Thevenin's resistance

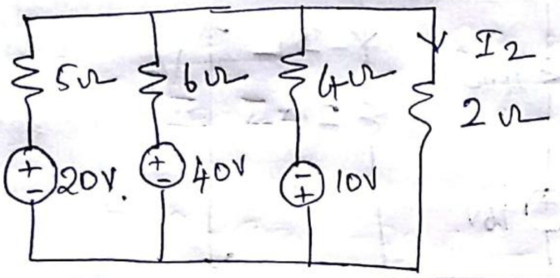
$$\boxed{R_E = \frac{1}{1/R_1 + \frac{1}{R_2} + \frac{1}{R_3}}}$$

Load current $I_L = \frac{V_{th}}{R_{th} + R_L}$

Terminal Voltage $V_T = I_L R_L$.

[6] CO3 L3

6b. Determine the current I by applying Millman's theorem shown in fig(6b).



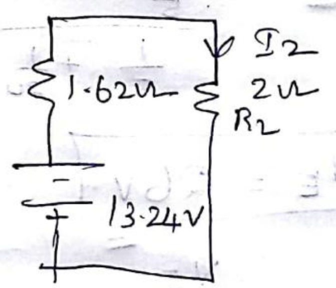
$$R_E = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = \frac{1}{\frac{1}{5}+\frac{1}{6}+\frac{1}{4}} = \frac{1}{0.2+0.167+0.25} = \frac{1}{0.617}$$

$$\boxed{R_E = 1.62\,\Omega}$$

$$V_E = \frac{\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = \frac{\frac{20}{5}+\frac{40}{6}-\frac{10}{4}}{\frac{1}{5}+\frac{1}{6}+\frac{1}{4}}$$

$$= \frac{4+6.67-2.5}{0.617}$$

$$\boxed{V_E = 13.24\,V}$$



$$I_2 = I_L = \frac{V_E}{R_E+R_L}$$

$$I_2 = \frac{13.24}{1.62+2} = 3.66\,A.$$

$$\boxed{I_2 = 3.66\,A}$$