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Internal Assessment Test 1 – Dec. 2021

Sub:	**Network Theory**				Sub Code:	18EC32	Branch:	ECE
Date:	16-12-2021	Duration:	90 Minutes	Max Marks: 50		Sem / Sec:	3/A, B,C,D	OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1	a. Determine the mesh currents in the given circuit Fig.1	[7]	CO1	L3

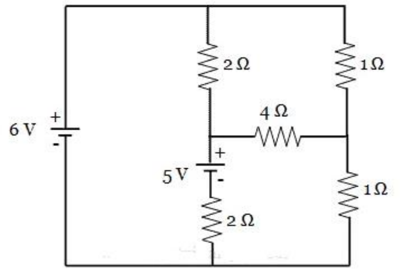
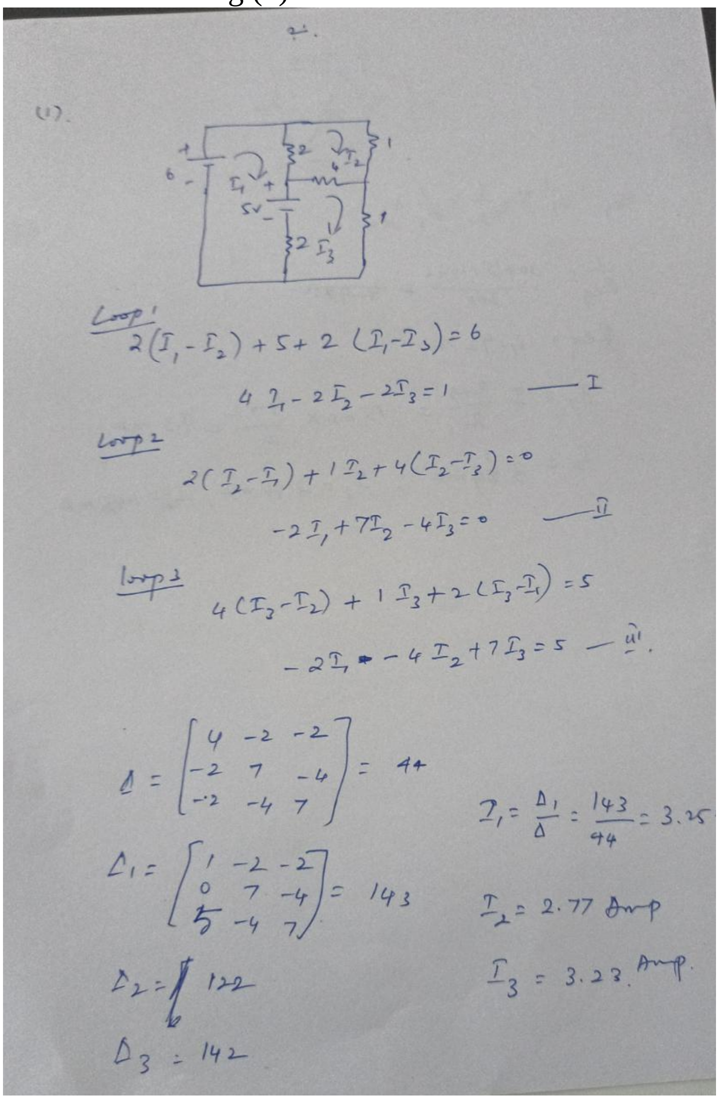


Fig (1)



Loop 1

$2(I_1 - I_2) + 5 + 2(I_1 - I_3) = 6$

$4I_1 - 2I_2 - 2I_3 = 1$ — I

Loop 2

$2(I_2 - I_1) + 1 I_2 + 4(I_2 - I_3) = 0$

$-2I_1 + 7I_2 - 4I_3 = 0$ — ii

Loop 3

$4(I_3 - I_2) + 1 I_3 + 2(I_3 - I_1) = 5$

$-2I_1 - 4I_2 + 7I_3 = 5$ — iii.

$\Delta = \begin{vmatrix} 4 & -2 & -2 \\ -2 & 7 & -4 \\ -2 & -4 & 7 \end{vmatrix} = 44$

$\Delta_1 = \begin{vmatrix} 1 & -2 & -2 \\ 0 & 7 & -4 \\ 5 & -4 & 7 \end{vmatrix} = 143$

$\Delta_2 = 122$

$\Delta_3 = 142$

$I_1 = \frac{\Delta_1}{\Delta} = \frac{143}{44} = 3.25$

$I_2 = 2.77$ Amp

$I_3 = 3.23$ Amp.

		MARKS	CO	RBT
	b. Find the branch current in the given Fig 2.	[3]	CO1	L3

<table>
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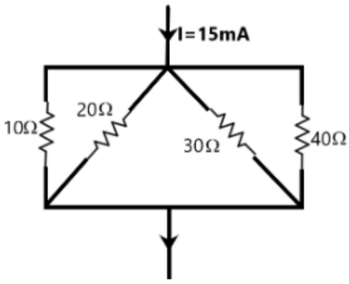
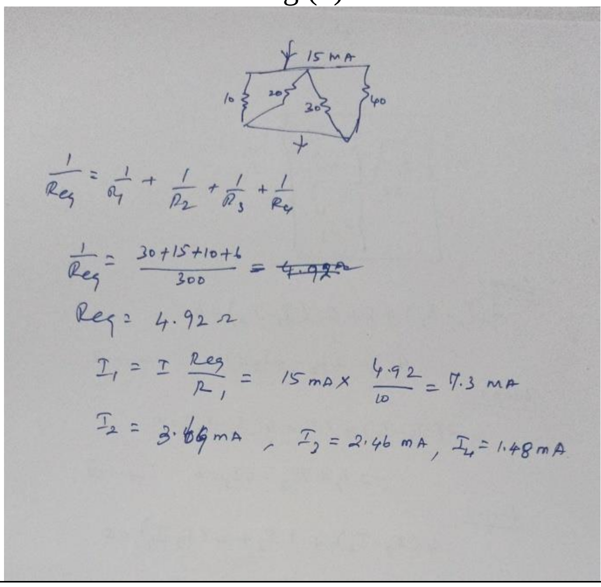


Fig (2)



$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$

$\frac{1}{R_{eq}} = \frac{30+15+10+6}{300} =$ ~~4.92Ω~~

$R_{eq} = 4.92\,\Omega$

$I_1 = I\frac{R_{eq}}{R_1} = 15\,mA \times \frac{4.92}{10} = 7.3\,mA$

$I_2 = 3.66\,mA$, $I_3 = 2.46\,mA$, $I_4 = 1.48\,mA$
</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>
Determine the nodal analysis to determine V_1, V_2 and in Fig.3.

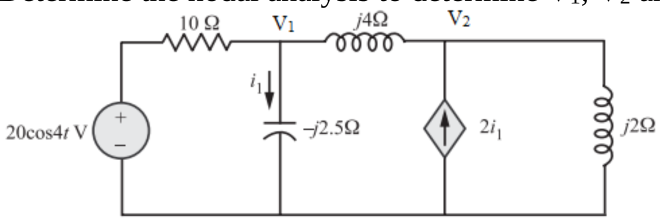


Fig.3

The phasor equivalent circuit is as shown in Fig. 1.88(a).

KCL at node $\mathbf{V}_1$:

$$\frac{\mathbf{V}_1 - 20\,\underline{/0^\circ}}{10} + \frac{\mathbf{V}_1}{-j2.5} + \frac{\mathbf{V}_1 - \mathbf{V}_2}{j4} = 0$$

$$\Rightarrow \qquad (1 + j1.5)\mathbf{V}_1 + j2.5\mathbf{V}_2 = 20$$

KCL at node $\mathbf{V}_2$:

$$\frac{\mathbf{V}_2 - \mathbf{V}_1}{j4} + \frac{\mathbf{V}_2}{j2} = 2\mathbf{I}_1$$

But $$\mathbf{I}_1 = \frac{\mathbf{V}_1}{-j2.5}$$
</td><td>[10]</td><td>CO1</td><td>L3</td></tr>
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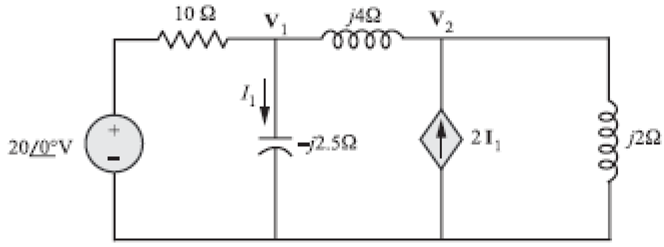


Figure 1.88(a)

Hence, $$\frac{\mathbf{V}_2 - \mathbf{V}_1}{j4} + \frac{\mathbf{V}_2}{j2} = \frac{2\mathbf{V}_1}{-j2.5}$$

$$\Rightarrow \quad -j0.55\mathbf{V}_1 - j0.75\mathbf{V}_2 = 0$$

Multiplying throughout by $j20$, we get

$$11\mathbf{V}_1 + 15\mathbf{V}_2 = 0$$

Putting the two nodal equations in matrix form, we get

$$\begin{bmatrix} 1 + j1.5 & j2.5 \\ 11 & 15 \end{bmatrix} \begin{bmatrix} \mathbf{V}_1 \\ \mathbf{V}_2 \end{bmatrix} = \begin{bmatrix} 20 \\ 0 \end{bmatrix}$$

Solving the matrix equation, we get

$$\mathbf{V}_1 = 18.97 \underline{/18.43^\circ} \text{ V}$$
$$\mathbf{V}_2 = 13.91 \underline{/-161.56^\circ} \text{ V}$$

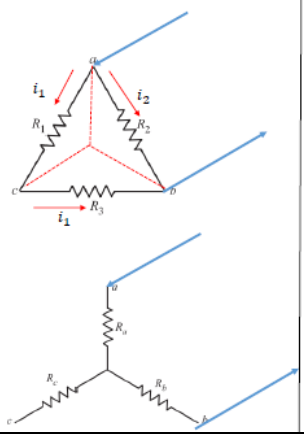
The current $$\mathbf{I}_1 = \frac{\mathbf{V}_1}{-j2.5} = 7.59 \underline{/108.4^\circ} \text{ A}$$

Transforming this to the time-domain, we get

$$i_1 = \mathbf{7.59\cos(4}t\mathbf{ + 108.4^\circ)\,A}$$

3	(a) Derive star to delta transformation.	[04] [06]	CO1 CO1	L2 L3

Delta to Star Conversion



Let us consider two terminal a-b in both network and calculate equivalent resistance of delta network

$R_{eq} = R_2||(R_1 + R_3)$

Similarly, for star network

$R_{eq} = R_a + R_b$

Terminal characteristics of delta network must be equivalent to that of a star network must

$R_2||(R_1 + R_3) = R_a + R_b$

$\frac{R_2(R_1 + R_3)}{R_1 + R_2 + R_3} = R_a + R_b$

$\frac{(R_1R_2 + R_2R_3)}{R_1 + R_2 + R_3} = R_a + R_b$ (1)

Let us consider two terminal a-c

$\frac{(R_1R_2 + R_1R_3)}{R_1 + R_2 + R_3} = R_a + R_c$ (2)

Let us consider two terminal b-c

$\frac{(R_1R_3 + R_2R_3)}{R_1 + R_2 + R_3} = R_b + R_c$ (3)

adding (1) (2) (3)

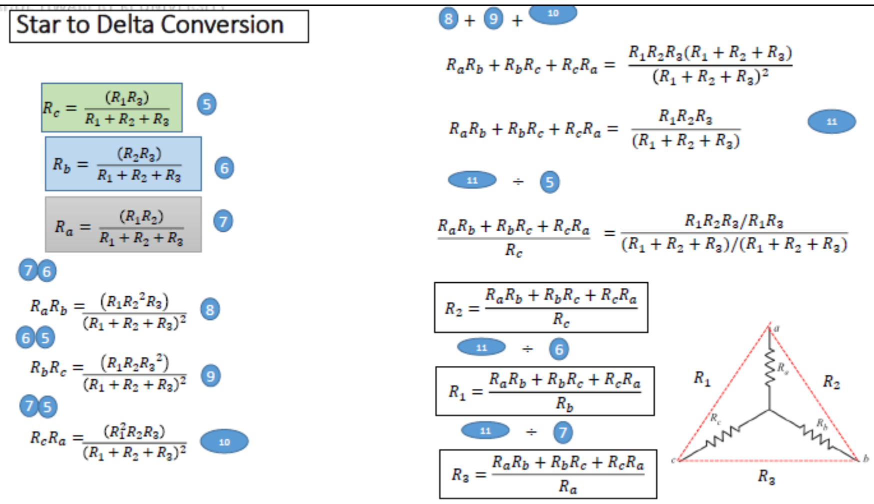
$\frac{2(R_1R_2 + R_2R_3 + R_1R_3)}{R_1 + R_2 + R_3} = 2(R_a + R_b + R_c)$

$\frac{(R_1R_2 + R_2R_3 + R_1R_3)}{R_1 + R_2 + R_3} = (R_a + R_b + R_c)$ (4)

(4) − (1) $R_c = \frac{(R_1R_3)}{R_1 + R_2 + R_3}$ (5)

(4) − (2) $R_b = \frac{(R_2R_3)}{R_1 + R_2 + R_3}$ (6)

(4) − (3) $R_a = \frac{(R_1R_2)}{R_1 + R_2 + R_3}$ (7)



(b) Find I_0 in the circuit shown in Fig.4 using source transformation.

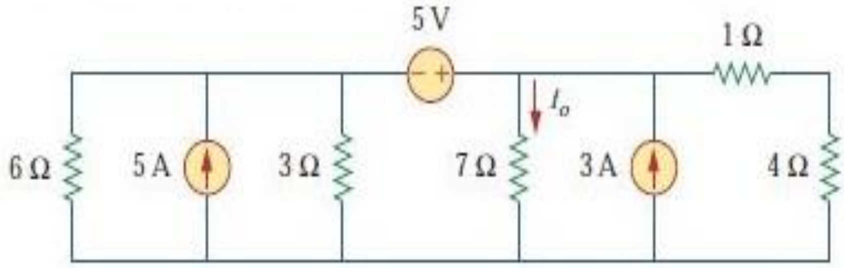


Fig. 4

4	The wheat stone bridge in the circuit shown in fig.5 is balanced when R_2=1200 Ω. If the galvanometer has a resistance of 30 Ω, how much current will be detected by it when the bridge is unbalanced by setting R_2 to 1204 Ω using Thevenin's theorem?	[10]	CO2	L3

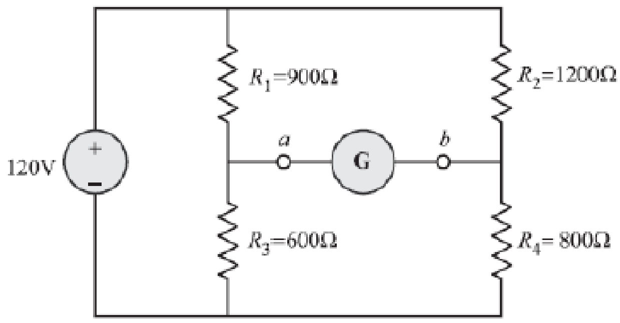
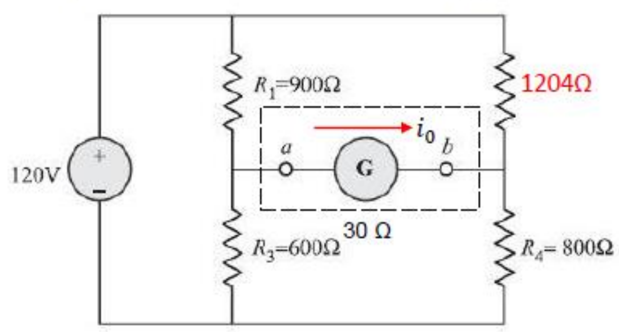
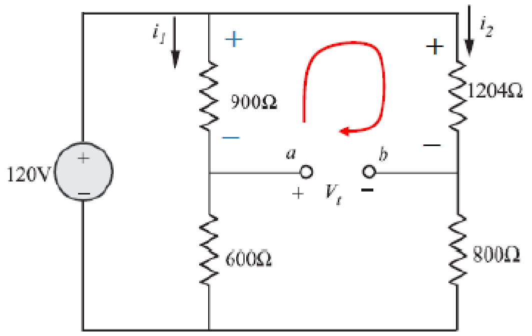


Fig.5

Sol: i) We are interested in the galavanometer current



1)To find V_t



$$i_1 = \frac{120}{900+600} = \frac{120}{1500} A$$

$$i_2 = \frac{120}{1204+800} = \frac{120}{2004} A$$

Applying KVL in the outer loop

rent $-1204 i_2 = V_t + 900 i_1$

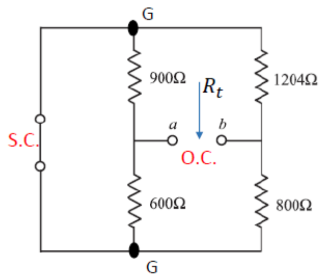
$$-V_t = -1204\left(\frac{120}{2004}\right) + 900\left(\frac{120}{1500}\right)$$

$$V_t = 1204\left(\frac{120}{2004}\right) - 900\left(\frac{120}{1500}\right)$$

$$V_t = 95.8mV$$

$V_t = 95.8mV$

ii)To find R_t deactivate all the sources



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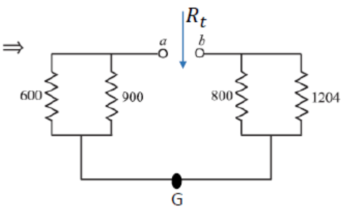


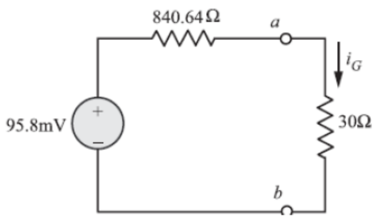
$R_t = (600||900) + (800||1204)$

$$R_t = \frac{600(900)}{600+900} + \frac{800(1204)}{800+1204}$$

$R_t = 840.64\Omega$

iii) Thevenin's equivalent circuit

Hence, the Thevenin equivalent circuit consists of the 95.8 mV source in series with 840.64Ω resistor.



$$i_G = \frac{95.8m}{840.64+30}$$

$i_G = 110.03\mu A$

5	a. List out the steps involved in the millman's theorem for circuit reduction. b. For the circuit shown in Fig. 6, find the load impedance Z_L that absorbs the maximum power. Calculate that maximum power.	[4] [6]	CO2 CO2	L2 L3

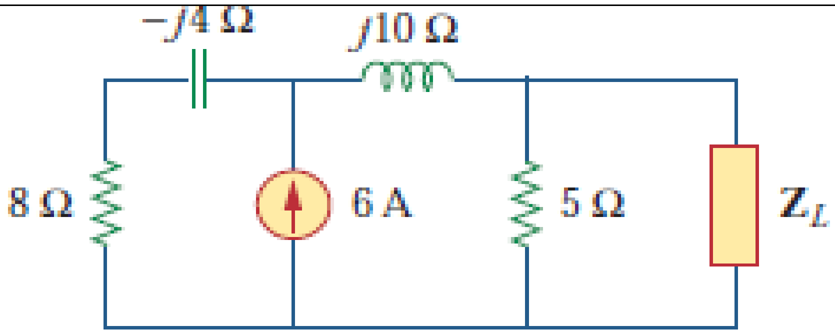
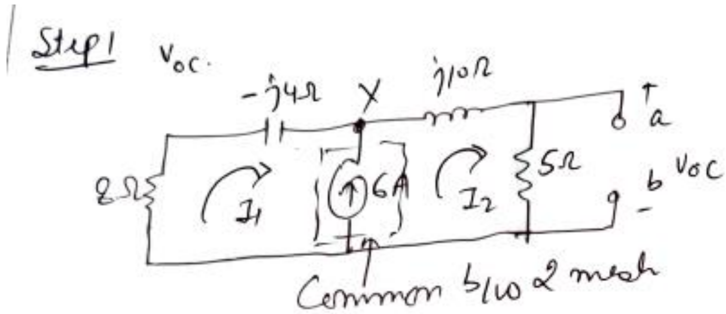


Fig.6

Solution:

Step 1 V_{oc}.



Supermesh Eqn

$-8I_1 - (-j4)I_1 - j10I_2 - 5I_2 = 0$

$I_1(-8+j4) + I_2(-5-j10) = 0$ — (1)

KCL at X

$-I_1 - 6 + I_2 = 0$

$I_1 = I_2 - 6$ — (2)

from (1) & (2)

$(I_2-6)(-8+j4) + I_2(-5-j10) = 0$

$I_2(-8+j4) - 6(-8+j4) + I_2(-5-j10) = 0$

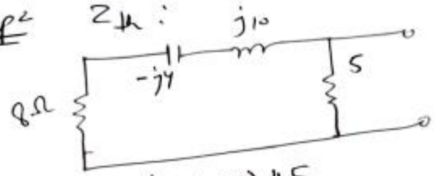
$I_2(-13-j6) = 6(-8+j4)$

~~$I_2 = 0.29 - 0.43$~~ $I_2 = 2.34 - 2.92j$ A

$V_{oc} = 5I_2$

$= 11.7 - 14.6j$ Volts

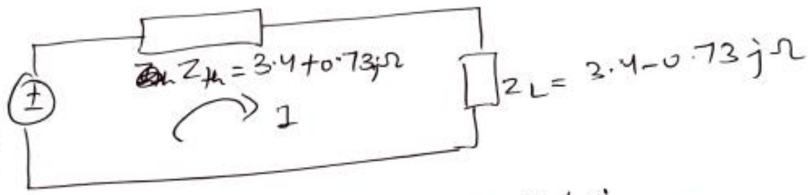
Step 2 Z_{th} :



$(8+j6) \parallel 5$

$$Z_{th} = \frac{(8+j6)5}{8+j6+5} = \frac{40+30j}{13+j6} = 3.4+0.73j\ \Omega$$

$$Z_L = Z_{th}^{*} = 3.4-0.73j\ \Omega$$



$$I = \frac{V_{oc}}{Z_{th}+Z_L} = \frac{11.7-14.6j}{3.4-0.73j+3.4+0.73j}$$

$$= 1.72-2.15j\ A$$

$$= 2.75\angle -51.3^{\circ}\ A$$

$$P_{max} = \frac{I^2}{2}.R_L$$

$$= \frac{(2.75)^2}{2}.(3.4) = 12.86\ \text{Watts}$$

Q. No.	Question	Marks	CO	Level
6	State Norton's theorem and explain its equivalent circuit. Find the Norton's equivalent circuit for the circuit in Fig. 7 with respect to terminals a-b.	[10]	CO2	L1,L3

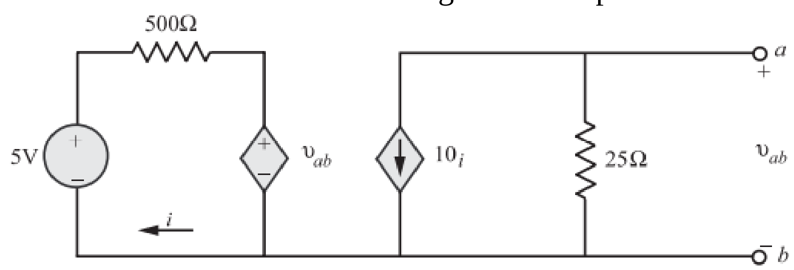


Fig.7

Solution:

Norton's theorem states that a linear two-terminal network can be replaced by an equivalent circuit consisting of a current source i_N in parallel with resistor R_N, where i_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent sources are turned off. If one does not wish to turn off the independent sources, then R_N is the ratio of open circuit voltage to short–circuit current at the terminal pair.

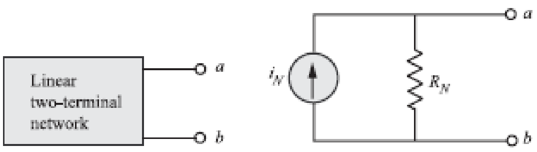


Figure 3.61(a) Original circuit Figure 3.61(b) Norton's equivalent circuit

Figure 3.61(b) shows Norton's equivalent circuit as seen from the terminals $a-b$ of the original circuit shown in Fig. 3.61(a). Since this is the dual of the Thevenin circuit, it is clear that $R_N = R_t$ and $i_N = \frac{v_{oc}}{R_t}$. In fact, source transformation of Thevenin equivalent circuit leads to Norton's equivalent circuit.

Procedure for finding Norton's equivalent circuit:

(1) If the network contains resistors and independent sources, follow the instructions below:

(a) Deactivate the sources and find R_N by circuit reduction techniques.

(b) Find i_N with sources activated.

(2) If the network contains resistors, independent and dependent sources, follow the steps given below:

(a) Determine the short-circuit current i_N with all sources activated.

(b) Find the open-circuit voltage v_{oc}.

(c) $R_t = R_N = \frac{v_{oc}}{i_N}$

(3) If the network contains only resistors and dependent sources, follow the procedure described below:

(a) Note that $i_N = 0$.

(b) Connect 1A current source to the terminals $a-b$ and find v_{ab}.

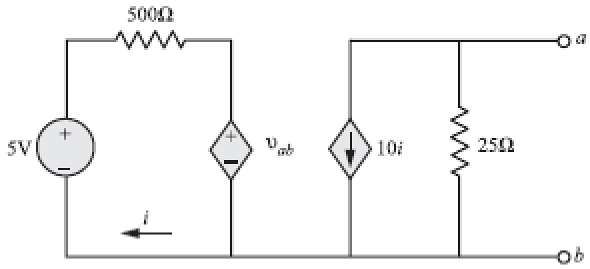
(c) $R_t = \frac{v_{ab}}{1}$

Note: Also, since $v_t = v_{oc}$ and $i_N = i_{sc}$

$$R_t = \frac{v_{oc}}{i_{sc}} = R_N$$

The open–circuit and short–circuit test are sufficient to find any Thevenin or Norton equivalent.

To find R_N or R_t :



Writing the KVL equations for the left-hand mesh, we get

$$-5 + 500i + v_{ab} = 0 \tag{3.15}$$

Also for the right-hand mesh, we get

$$v_{ab} = -25(10i) = -250i$$

Therefore $$i = \frac{-v_{ab}}{250}$$

Substituting i into the mesh equation (3.15), we get

$$-5 + 500\left(\frac{-v_{ab}}{250}\right) + v_{ab} = 0$$

$$\Rightarrow \quad v_{ab} = -5 \text{ V}$$

$$R_N = R_t \triangleq \frac{v_{oc}}{i_{sc}} = \frac{v_{ab}}{i_{sc}} = \frac{-5}{-0.1} = 50\ \Omega$$

The Norton equivalent circuit is shown in Fig 3.77 (a).

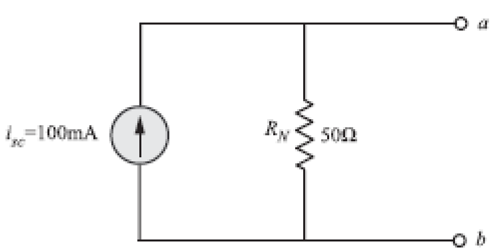
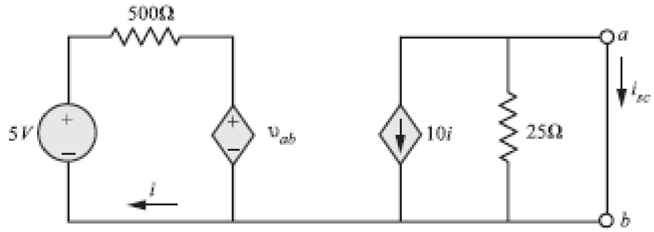
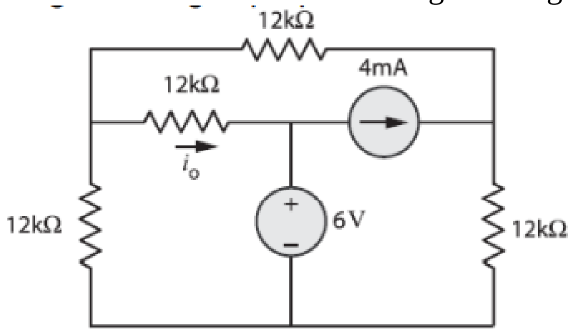
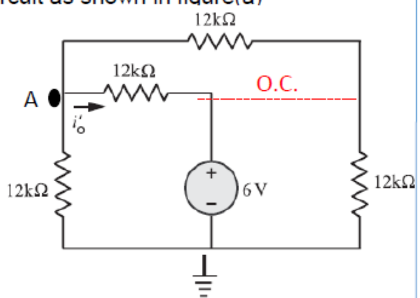


Figure 3.77 (a)

	To find i_{sc}:  Note that $v_{ab} = 0$ when the terminals $a - b$ are short-circuited. Then $i = \frac{5}{500} = 10$ mA Therefore, for the right–hand portion of the circuit, $i_{sc} = -10i = -100$ mA.			
7	Find i_o in the network shown in figure using superposition  Solution: **Sol:** As a first step, set the current source to zero. That is, the current source appears as an open Circuit as shown in figure(a)  figure(a)	[10]	CO2	L3

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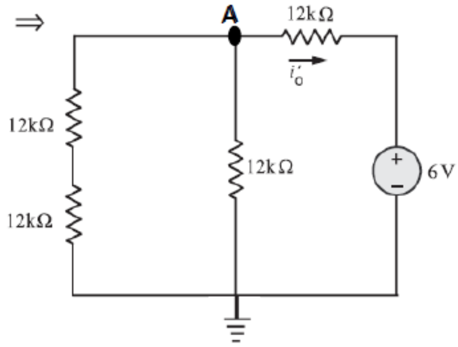

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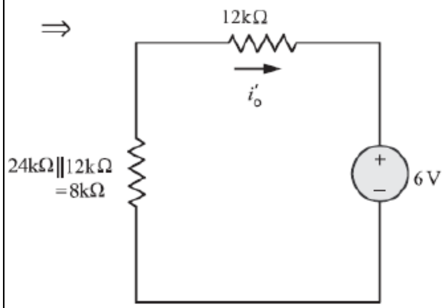


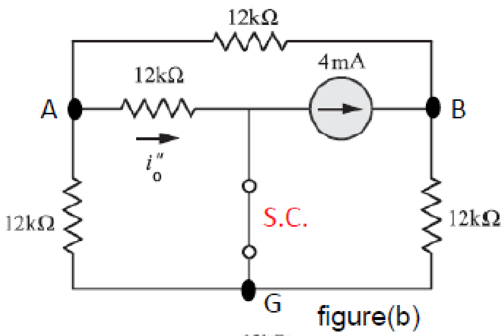
$$-(8k)i'_0 - (12k)i'_0 - 6 = 0$$

$$-i'_0 = \frac{6}{8k + 12k}$$

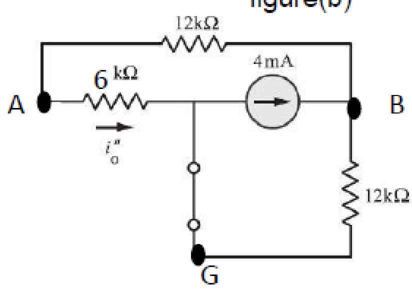
$$-i'_0 = 0.3mA$$

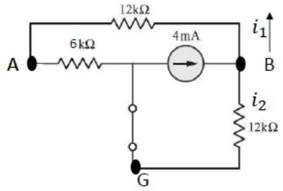
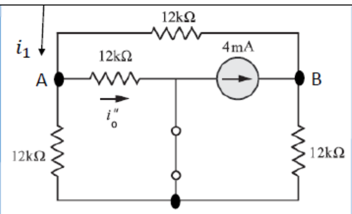
$$\boxed{i'_0 = -0.3mA}$$

As a second step, set the voltage source to zero. This means the voltage source is replaced by a short circuit as shown in Figure(b).,



figure(b)



	 Using current division principle $i_1 = (4m)\left(\frac{12k}{12k + 12k + 6k}\right)$ $\boxed{i_1 = 1.6mA}$	 Using current division principle $\boxed{i''_0 = 0.8mA}$	According to superposition theorem $i_0 = i'_0 + i''_0$ $\boxed{i_0 = -0.3m + 0.8m = 0.5mA}$			