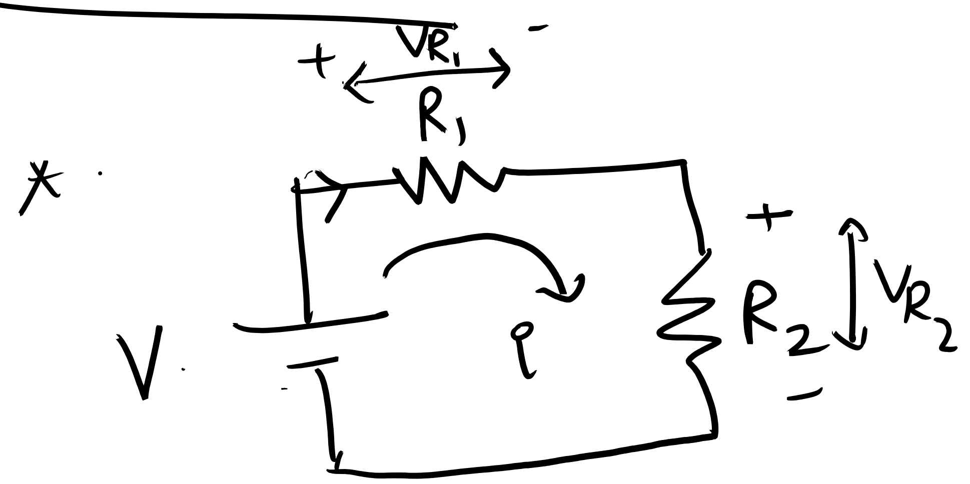
KVL ; KCL



Apply KVL;

$$-V + iR_1 + iR_2 = 0$$

$$i(R_1 + R_2) = V$$

$$i = \frac{V}{R_1 + R_2} \quad -①$$

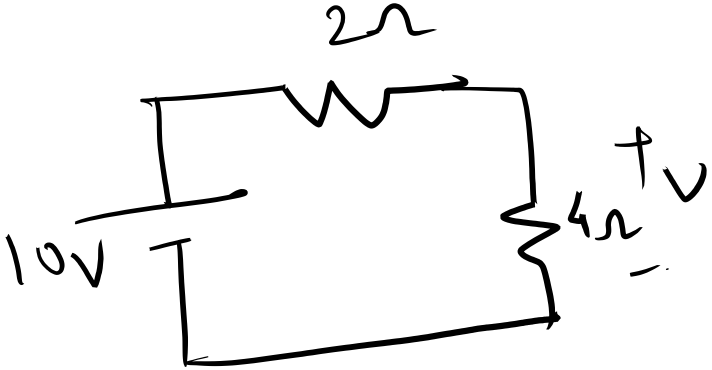
$$V_{R_1} = \underline{IR} = i \cdot R_1 = \frac{R_1 V}{R_1 + R_2} \quad -②$$

$$V_{R_2} = IR = iR_2 = \frac{R_2 V}{R_1 + R_2} \quad -③$$

Eq ② & ③ $\Longrightarrow$ <u>Voltage Division</u>

$$V_{R_1} = R_1 \frac{V}{(R_1 + R_2)}$$

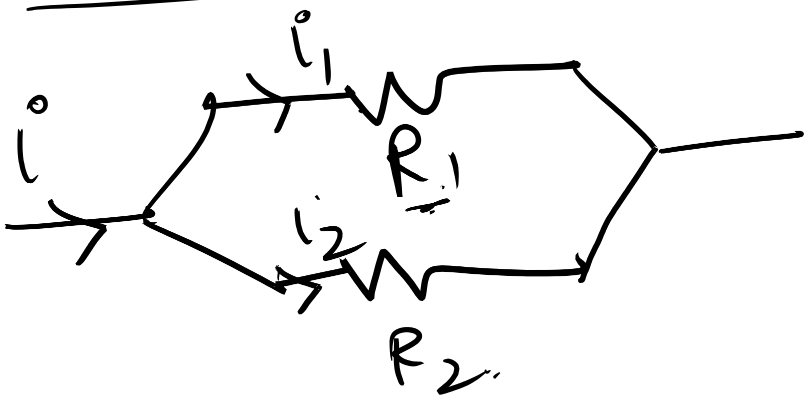
$$V_{R_2} = R_2 \frac{V}{(R_1 + R_2)}$$



$$V = 4 * \frac{10}{4+2} = \frac{40}{6} \text{ Volts}$$

Voltage Div. $\Rightarrow R \cdot \frac{V}{\text{Sum of R.}}$

* Current Division

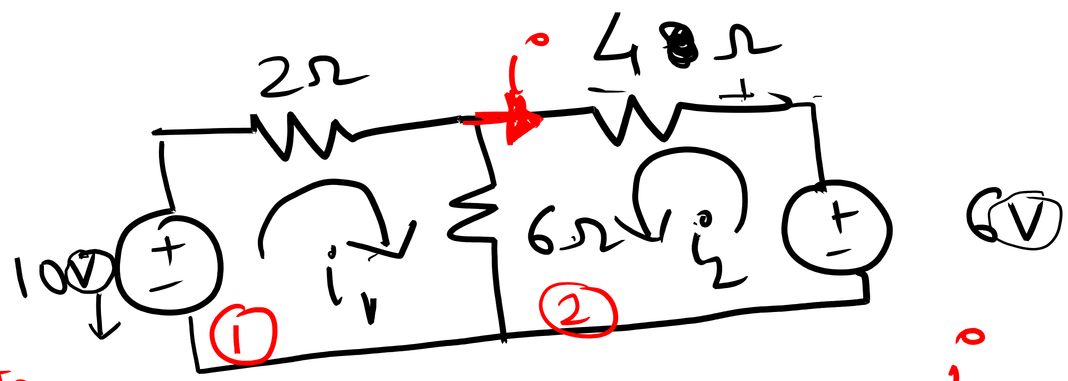


$$i_1 = \frac{i \cdot R_2}{R_1 + R_2}$$

$$i_2 = \frac{i\, R_1}{R_1 + R_2}$$

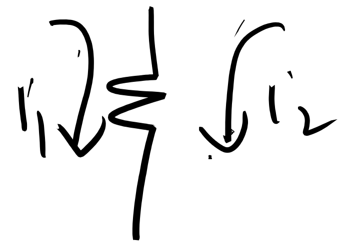
* Mesh Analysis

→ Identify Meshes & take some variables for mesh currents



$i_{1,2,3---n}$

→ Apply KVL in individual meshes.

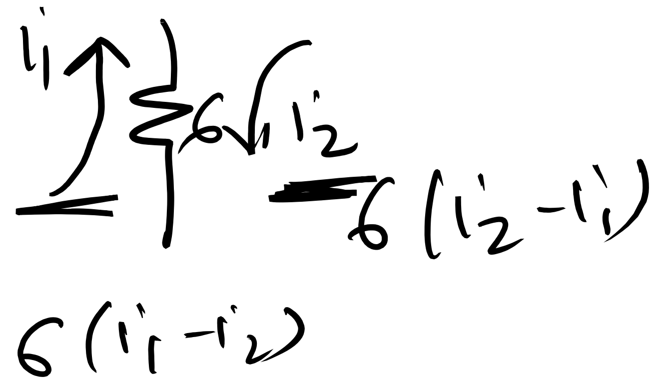


Mesh ①

$-10+2i_1+6(i_1+i_2)=0$ — ①

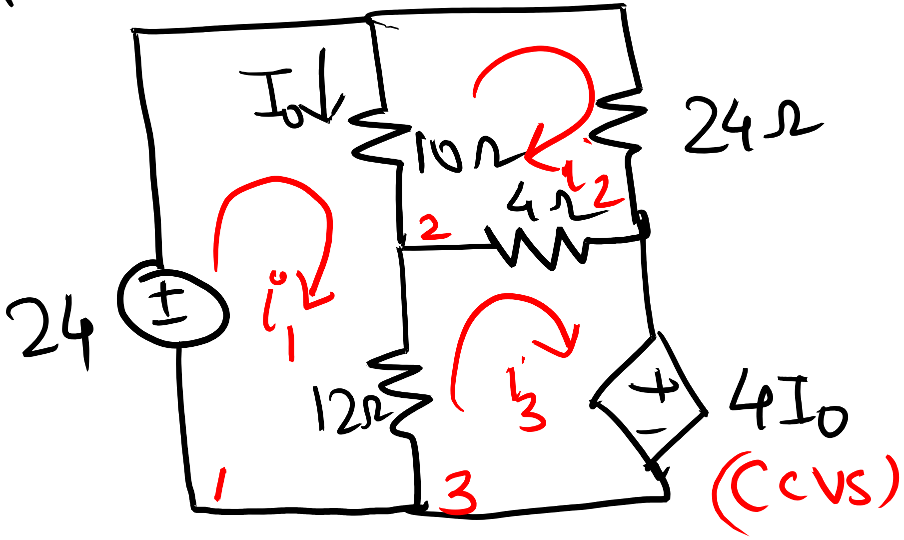
mesh ②

$+4i_2-6\cancel{8}+6(i_1+i_2)=0$ — ②



$i_1=\frac{16}{11}$ A ; $i_2=-\frac{3}{11}$ A

*



* **Mesh 1**

$$-24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0 \quad — (1)$$

* **Mesh 2**

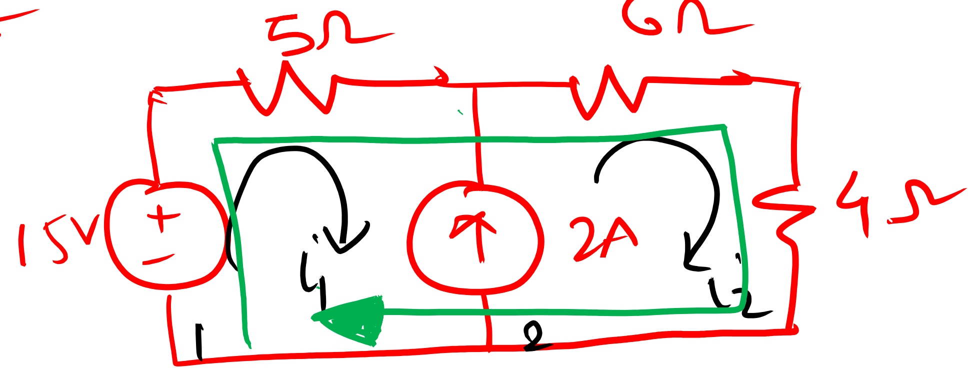
$$24 i_2 + 4(i_2 - i_3) + 10(i_2 - i_1) = 0 \quad — (2)$$

* **Mesh 3**

$$4(i_3 - i_2) + 4I_0 + 12(i_3 - i_1) = 0 \quad — (3)$$

$$I_0 = i_1 - i_2 \quad — (4)$$

*

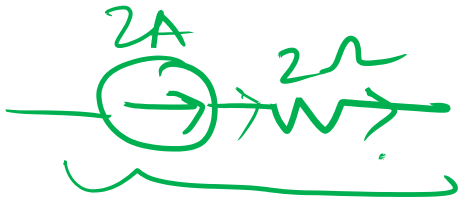


Mesh 1:

$$-15 + 5i_1 + ? = 0$$

Mesh 2:

$$6i_2 + 4i_2 + ? = 0$$

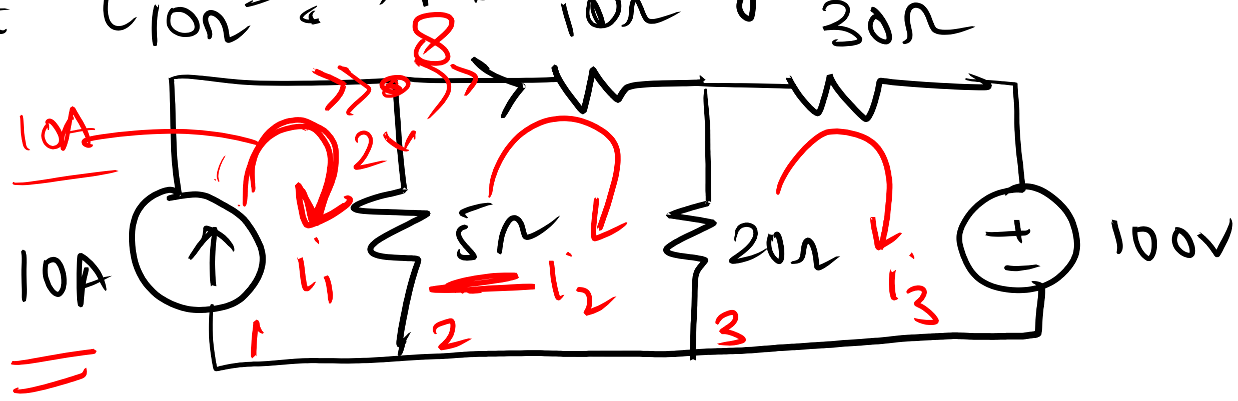


→ **Super Mesh**

$$-15 + 5i_1 + 6i_2 + 4i_2 = 0 \quad \text{—— (1)}$$

$$i_2 - i_1 = 2 \quad \text{—— (2)}$$

* $i_{10\Omega} = ?$ → Mesh Analysis



$5(i_2 - i_1)$

$5(12 - 10) =$

2A

Mesh 1: → $i_1 = 10$ → (1)

Mesh 2: $10 i_2 + 20(i_2 - i_3) + 5(i_2 - i_1) = 0$

$i_1 - 7 i_2 + 4 i_3 = 0$ → (2)

Mesh 3:

$30 i_3 + 100 + 20(i_3 - i_2) = 0$ → (3)

→ Mesh Analysis + SuperMesh

→ Nodal Analysis : (KCL)

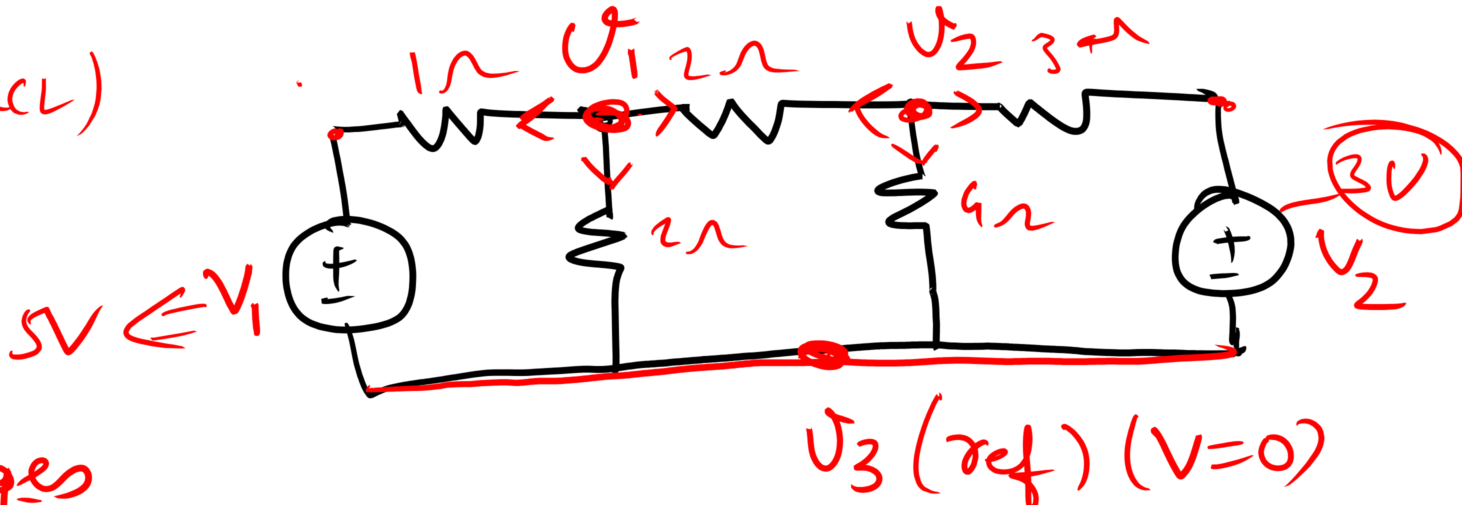
(1) Identify Nodes

(2) Mark the nodes with unknown voltages

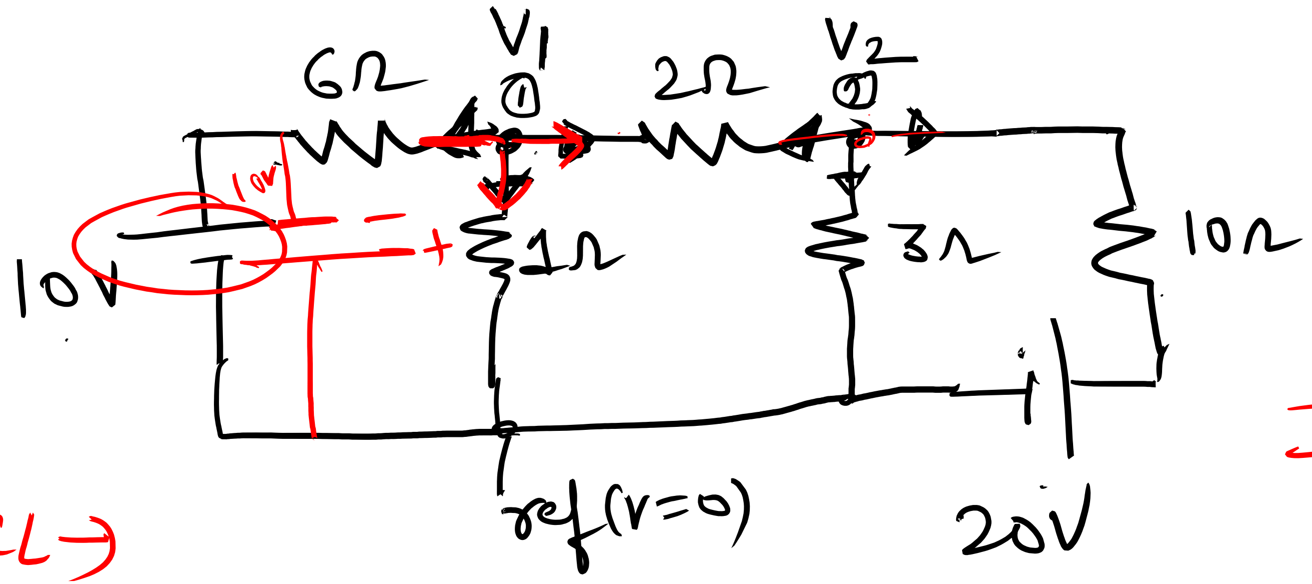
(3) Take one node as a ref with (V=0)

(4) Take currents on all node (outgoing current → +ive)

(5) Finally write KCL eq. on each node



Q



$$i = \frac{V}{R} = \frac{V_1 - V_2}{R}$$

$\Rightarrow$ Nodal Analysis

KCL $\rightarrow$

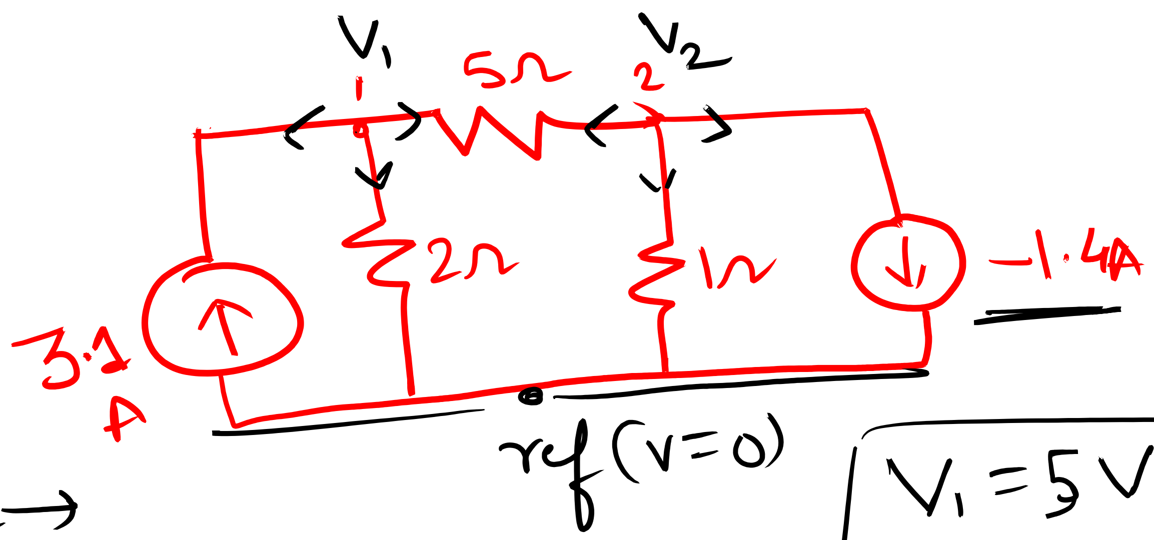
At node 1

$$\frac{V_1 - 10}{6} + \frac{V_1 - 0}{1} + \frac{V_1 - V_2}{2} = 0$$

KCL at Node 2

$$\frac{V_2 - V_1}{2} + \frac{V_2 - 0}{3} + \frac{V_2 - 20}{10} = 0$$

*



$$\boxed{\begin{aligned} V_1 &= 5V \\ V_2 &= 2V \end{aligned}}$$

KCL →

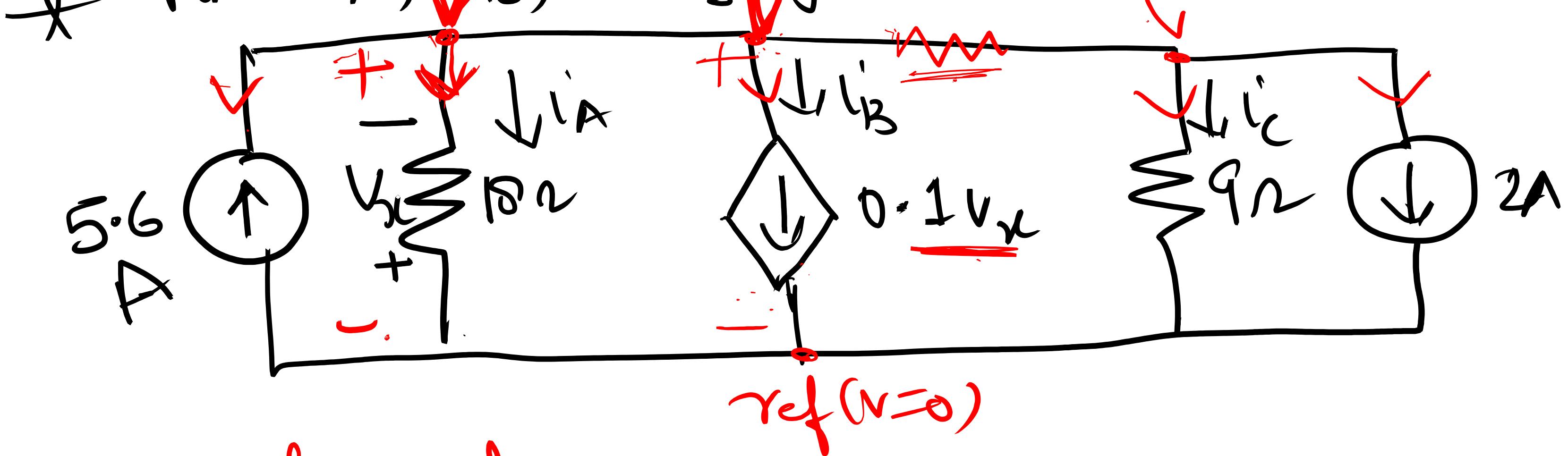
At node 1

$$-3.1 + \frac{V_1 - 0}{2} + \frac{V_1 - V_2}{5} = 0$$

KCL at node 2

$$\frac{V_2 - V_1}{5} + \frac{V_2 - 0}{1} + (-1.4) = 0$$

* Find i_A, i_B, i_C using Nodal

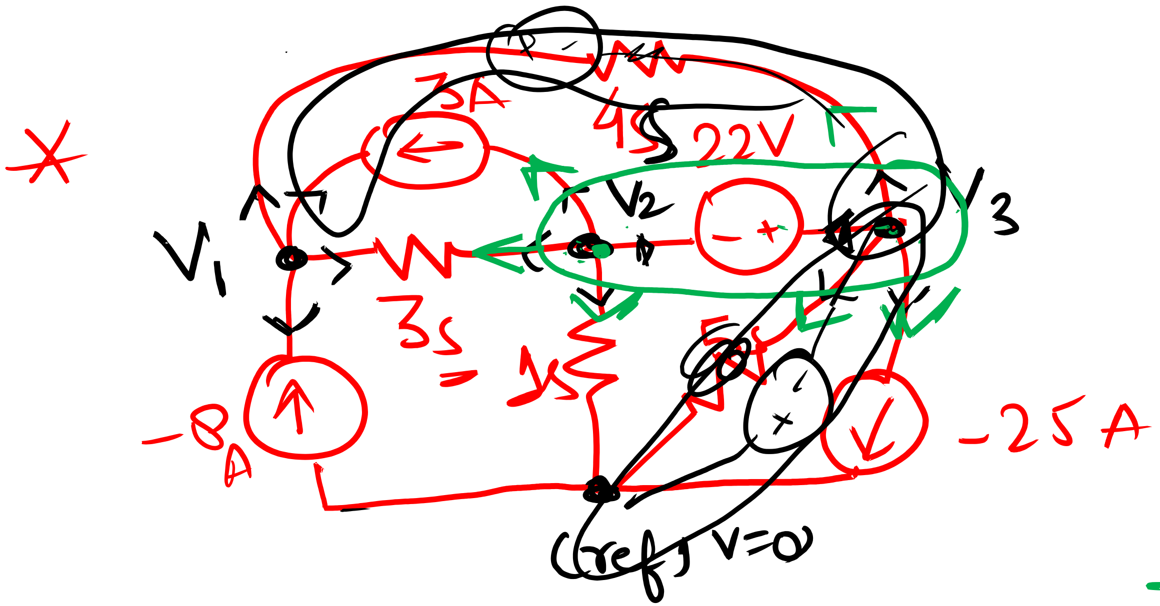


KCL eq for Node:

$$-5.6+\frac{V}{18}+0.1V_x+\frac{V}{9}+2=0 \quad \text{—(1)}$$

$$V_x=-18i_A \quad \text{—(2)}$$

$$\boxed{V_x=-V}$$



$R \to \frac{1}{R}$ = Conduct (Ω^{-1}) (S)

$\boxed{V_3 - V_2 = 22}$ — 3

$V_1 \xrightarrow{2S} V_2$

$(V_1 - V_2)\,2S$

KCL at Node 1

$$(V_1 - V_3)4 + (V_1 - V_2)3 - 3 - (-8) = 0 \quad \text{— } ①$$

⇒ Super Node

KCL at Node 2

$$(V_2 - V_1)3 + 3 + (V_2 - 0)1 + ? = 0$$

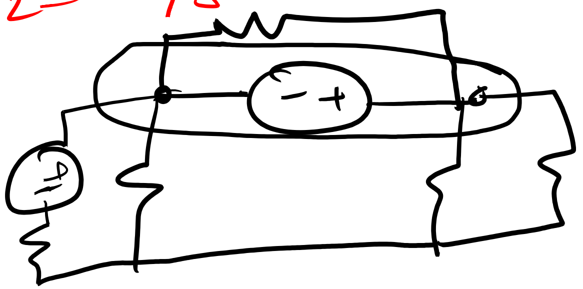
KCL at Node 3

$$+ ? = 0$$

$$(V_2 - V_1)3 + 3 + V_2 \cdot 1 + (V_3 - V_1)4 + (V_3 - 0)5 + (-25) = 0 \quad \text{— } ②$$

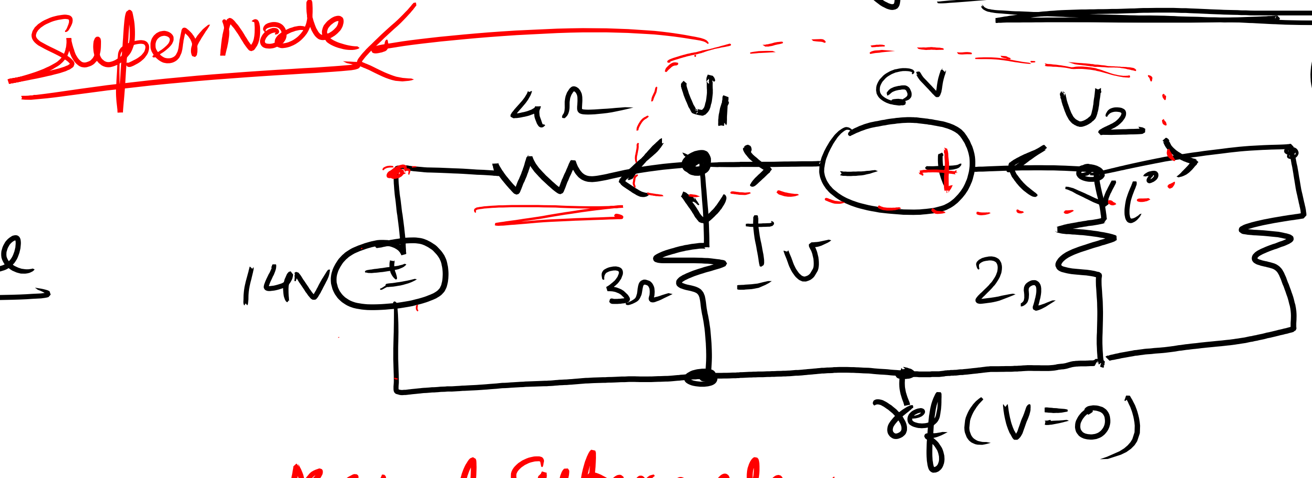
$V_1 = -8/15\ V$

$V_2 = 28/5\ V$



* Find v, i using $\boxed{\text{Nodal}}$ Analysis

(mesh)



$i = ?$ ⇒ SuperNode

(1) Identify Nodes

(2) Outgoing Currents

(3) Apply KCL at each node

$v = V_1$

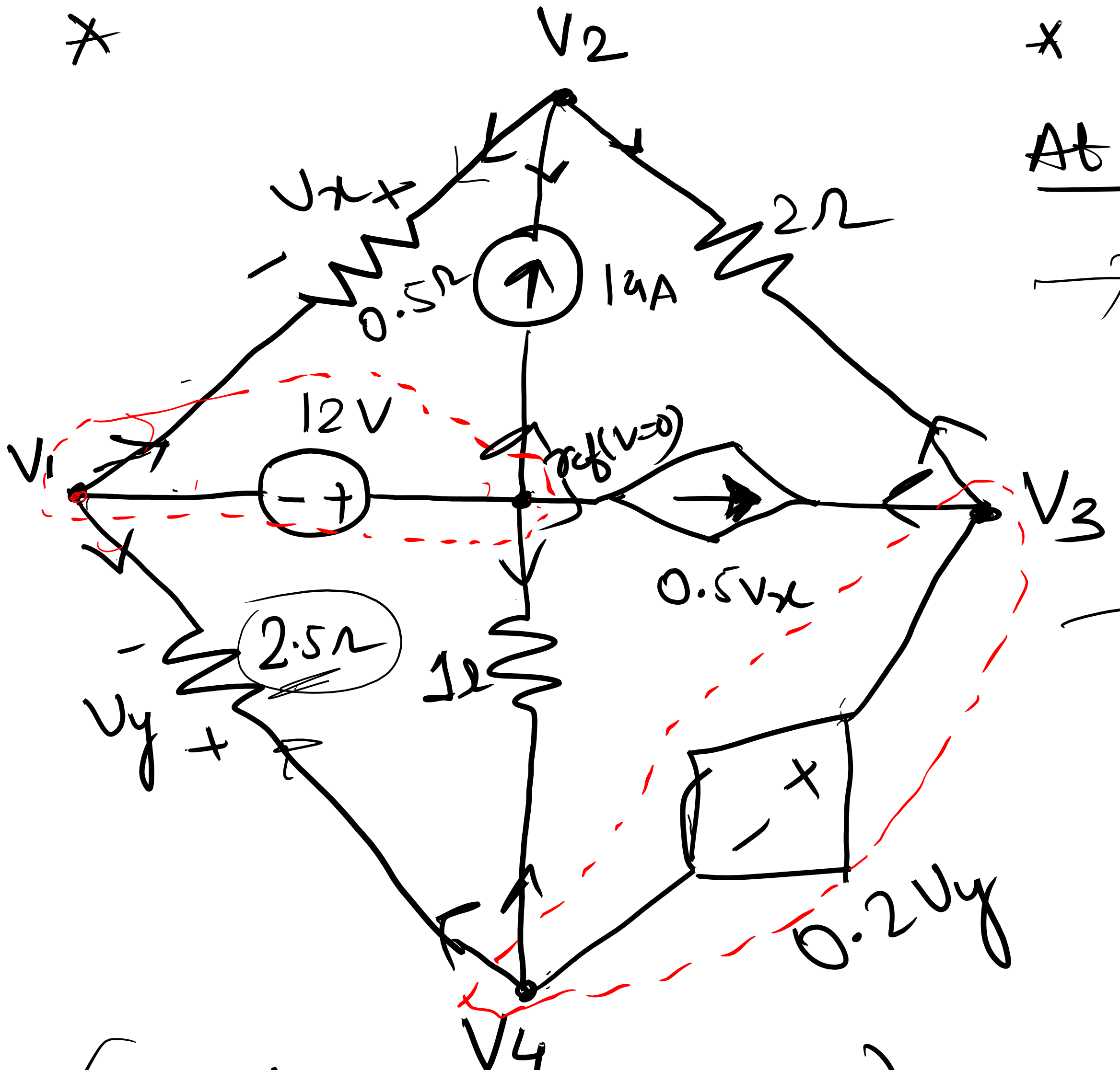
$i = \dfrac{V_2}{2}$

KCL at Supernode:

$$\frac{V_1 - 14}{4} + \frac{V_1}{3} + \frac{V_2}{6} + \frac{V_2}{2} = 0 \quad \text{— (i)}$$

$$V_2 - V_1 = 6 \quad \text{— (ii)}$$

- Consider super node as a single node with the node voltages as assumed in previous step & Apply KCL at supernode



$(V_1, V_2, V_3, V_4, V_x, V_y)$

$0 - V_1 = 12$

$V_1 = -12$

$V_1 = -12V$ —— (1)

At Node 2:

$\frac{V_2 - V_1}{0.5} - 14 + \frac{V_2 - V_3}{2} = 0$ —— (2)

At super Node 3–4:

$\frac{V_3 - V_2}{2} - 0.5V_x + \frac{V_4}{1} + \frac{V_4 - V_1}{2.5} = 0$ → (3)

$V_3 - V_4 = 0.2V_y$ → (4)

$V_2 - V_1 = V_x$ → (5)

$(V_4 - V_1) = V_y$ → (6)

→ KVL; KCL

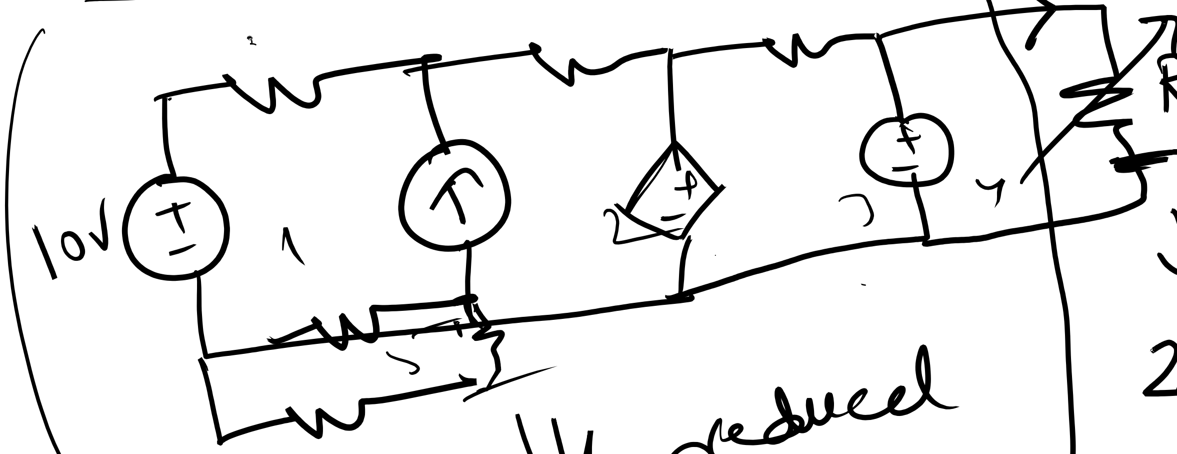
→ Mesh Analysis; Nodal Analysis (Super Node) → Most Powerful Technique to solve any electrical ckt

→ (Super Mesh)

→ **Network Theorems:**

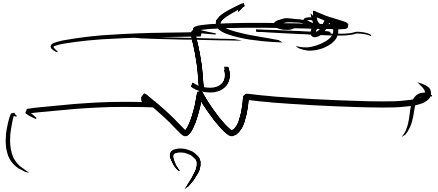
i Variable (POTentiometer)

*



⇓ reduced

large n/w



2Ω — 200Ω

(1Ω)

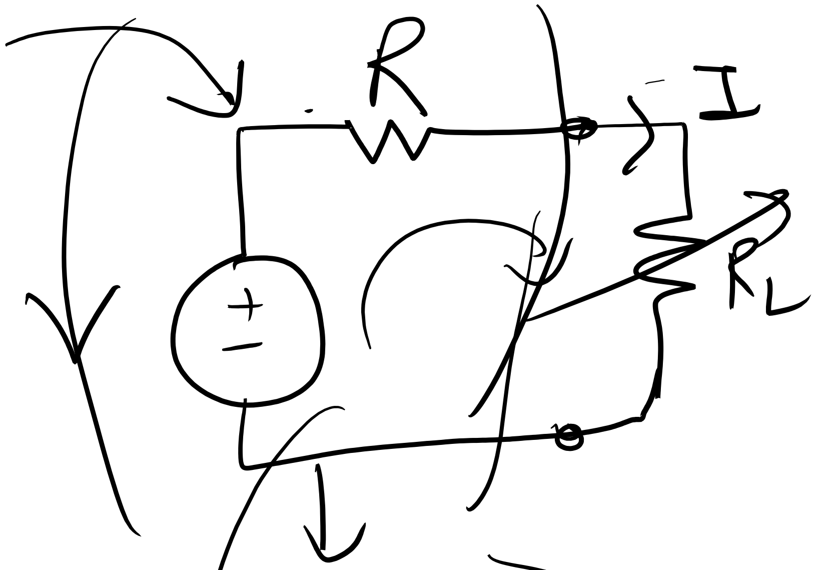
(2Ω, 3Ω 4Ω ----- 200Ω) →

→ ~19 elements

$i = (- - -)$

mesh

5 × 198



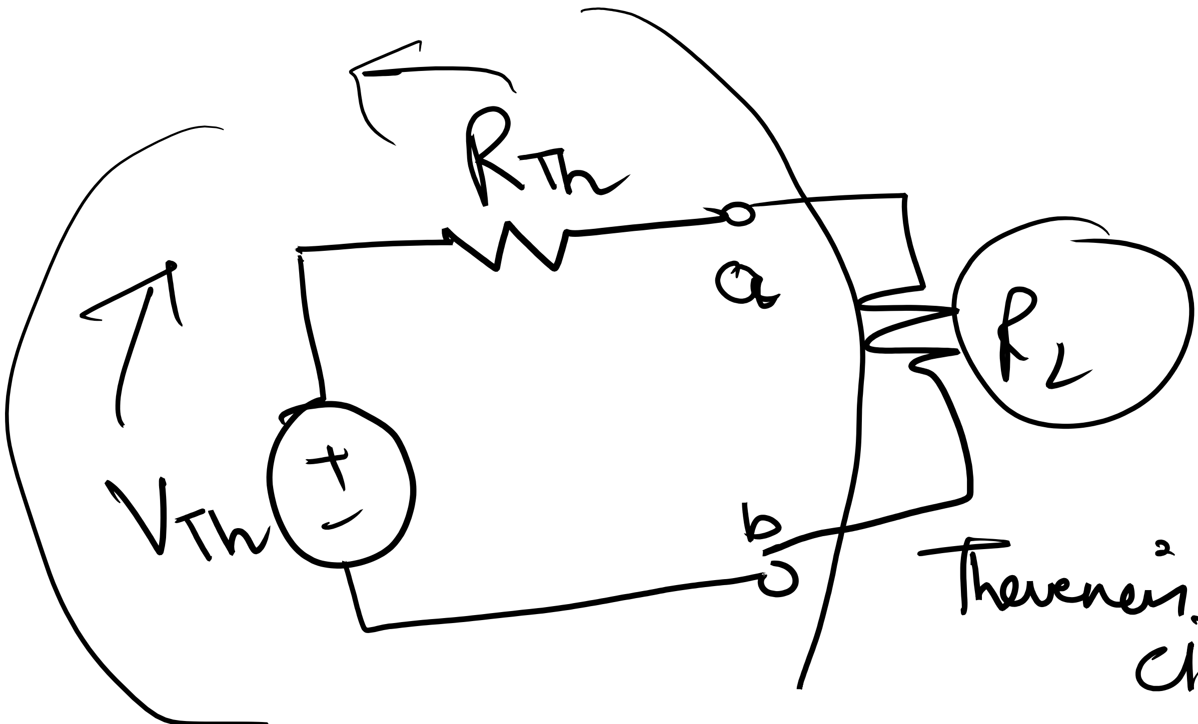
$$I = \frac{V}{R + R_L}$$

$2\Omega \rightarrow 200\Omega$

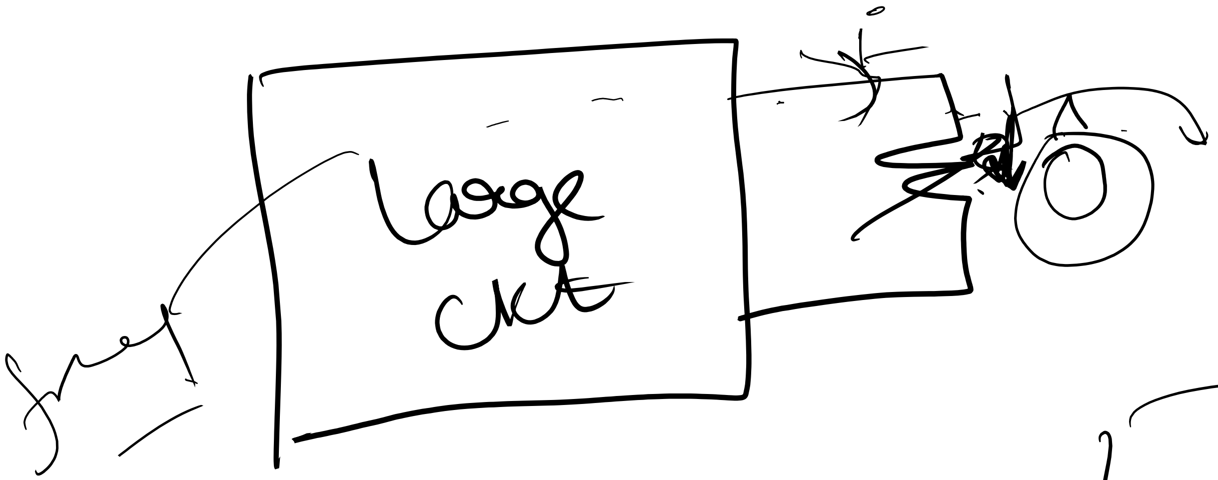
program for ___

Network Theorem

Thevenin's Theorem

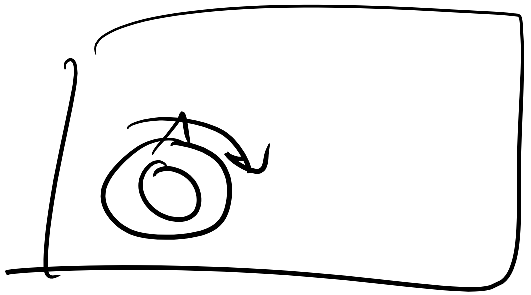


Thevenin's Equivalent circuit.



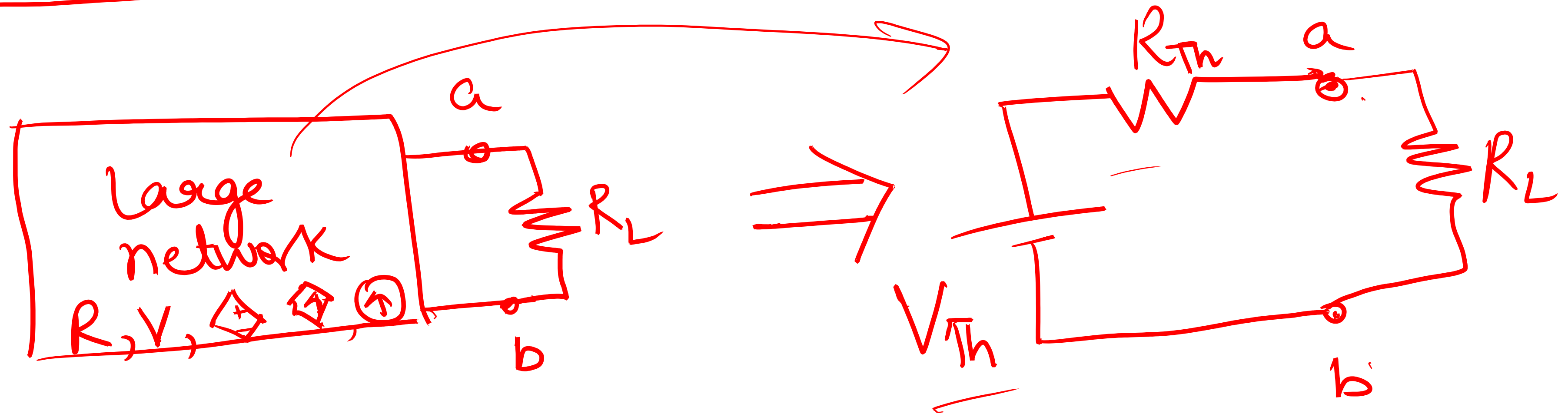
Amplifiers

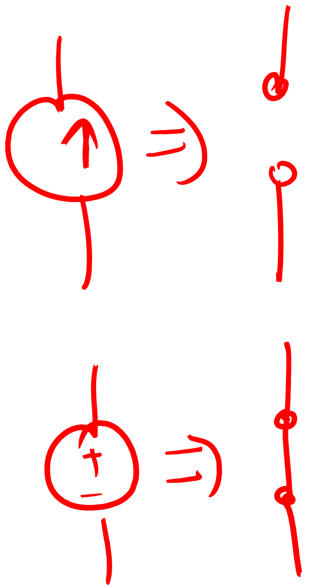
Ckt. Tuning



91.-- MHz

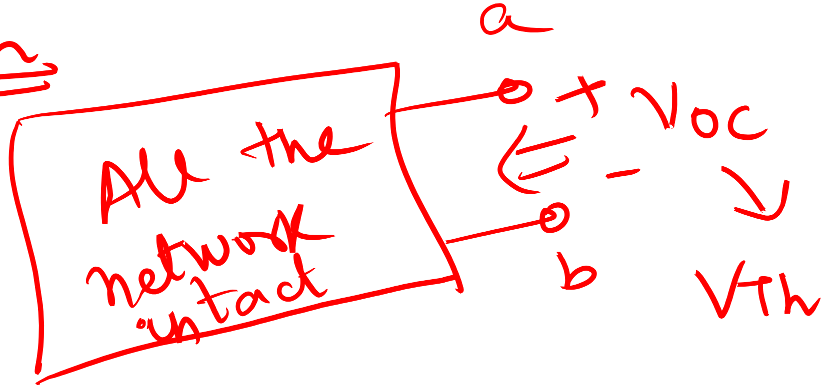
* Thevenin's Theorem



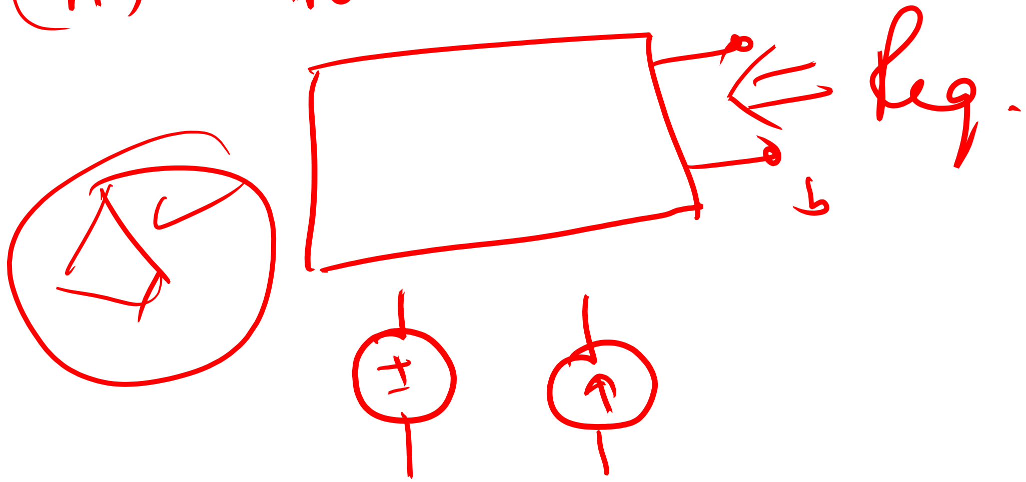


* Statement:

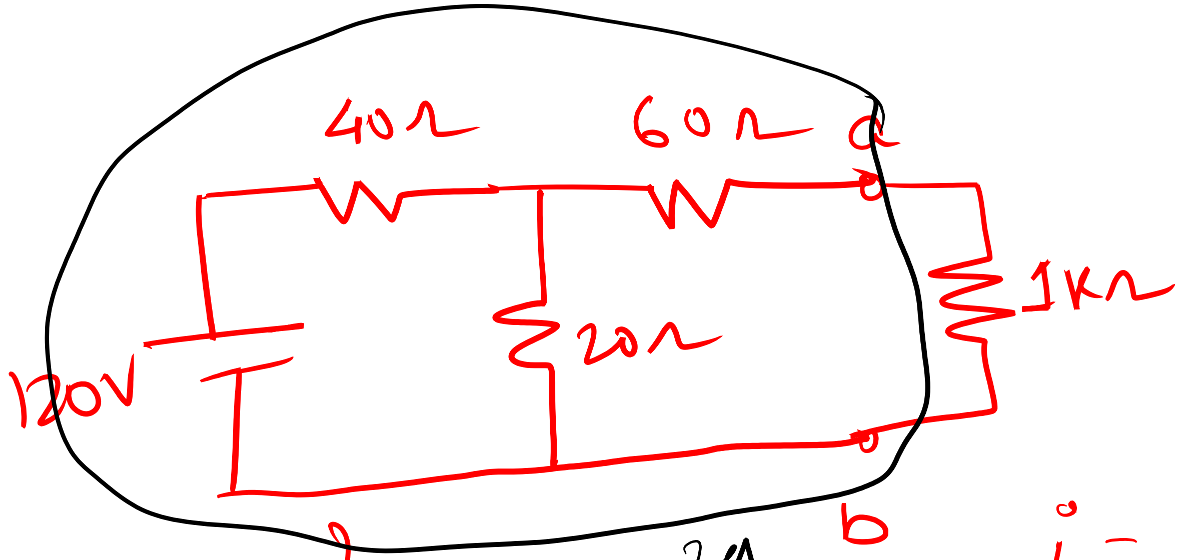
(i) V_{Th}



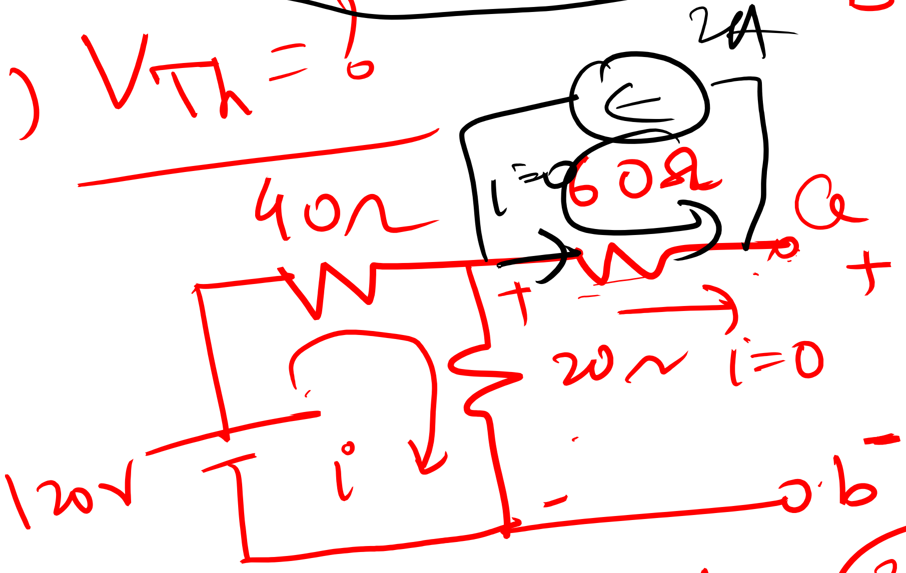
(ii) R_{Th}



*



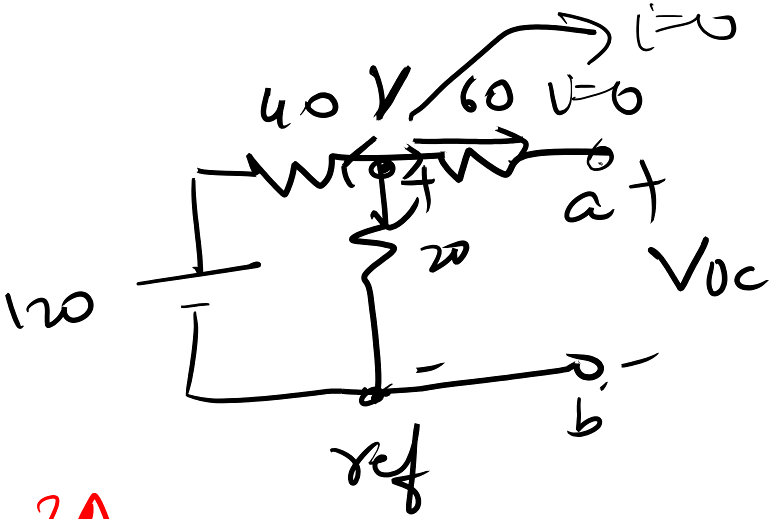
(i) $V_{Th} = ?$



$V_{Th} = \cancel{37.27V}$

$i = \frac{120}{60} = 2A$

$V_{oc} = V_{Th} = 40V$



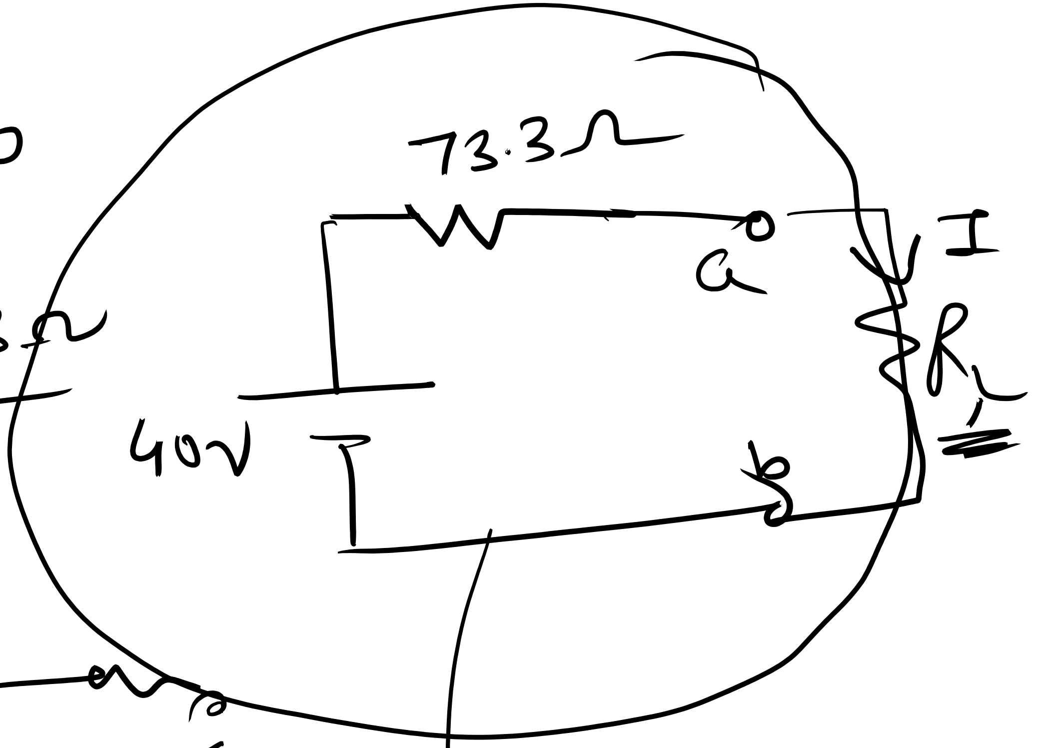
$$\frac{V-120}{40} + \frac{V-0}{20} = 0$$

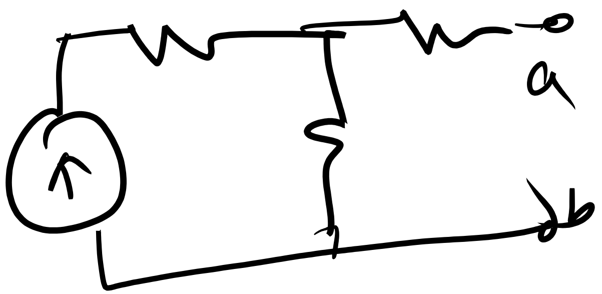
$$\boxed{V \Rightarrow V_{oc}}$$

(2) R_{Th}

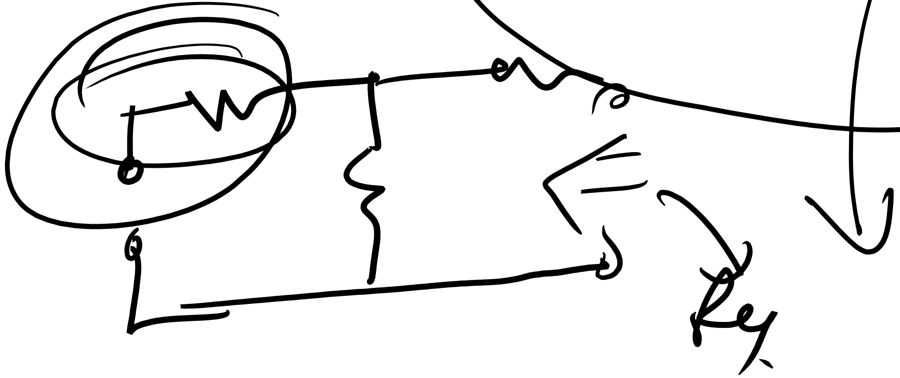
$(40 \| 20) + 60$

$R_{eq} = 73.3\Omega$

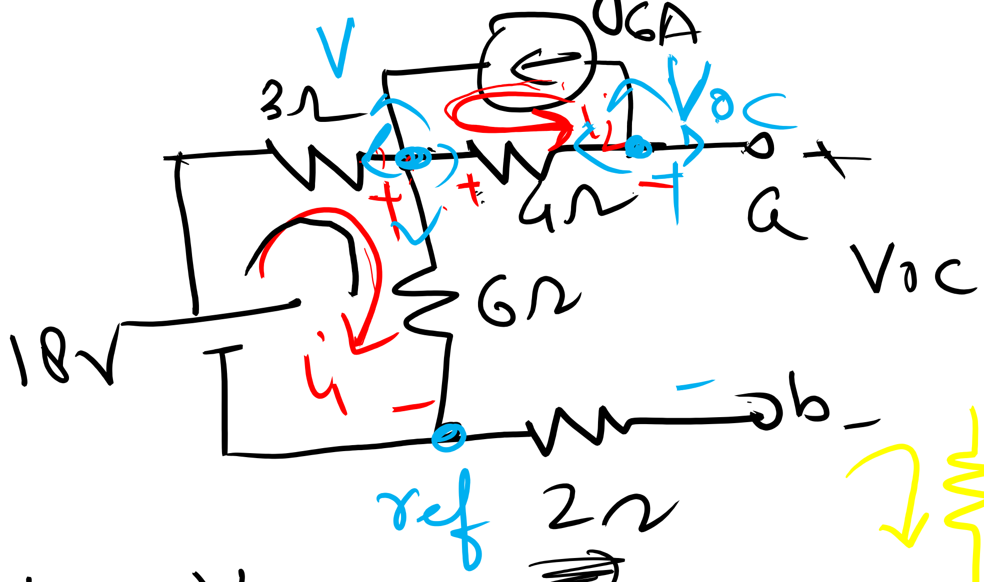




$\Rightarrow$



* Thevenize the given ckt across a-b



(i) $V_{Th} = V_{oc}$

$$\frac{V-18}{3} + \frac{V}{6} + \frac{V-V_{oc}}{4} - 6 = 0$$

$$\frac{V_{oc}-V}{4} + 6 = 0$$

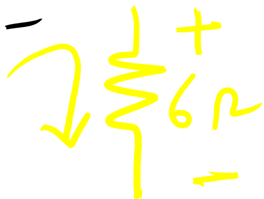
$$\boxed{V_{oc} = -12V}$$

$i_2 = 6A$

$-18 + 3i_1 + 6i_1 = 0$

$9i_1 = 18$

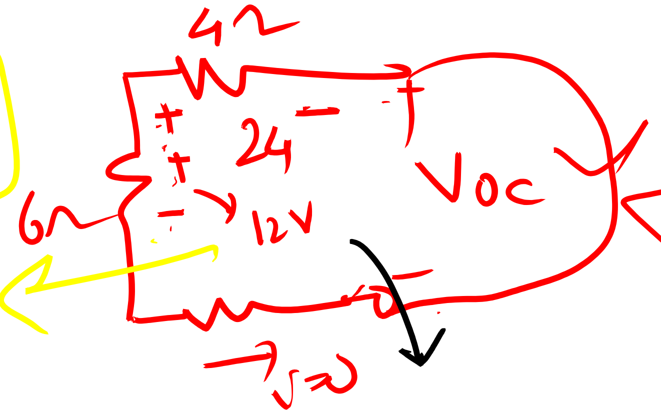
$i_1 = 2A$



$V_{6\Omega} \Rightarrow 6*2 = 12V$

$V_{4\Omega} = 6*4 = 24V$

$$\boxed{-12 + 24 + V_{oc} = 0}$$

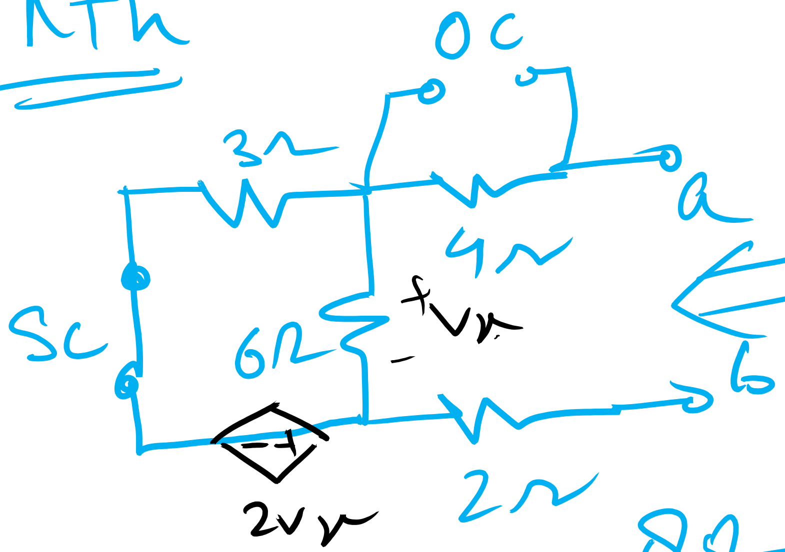


$$\boxed{-12 + 24 + V_{oc} = 0}$$

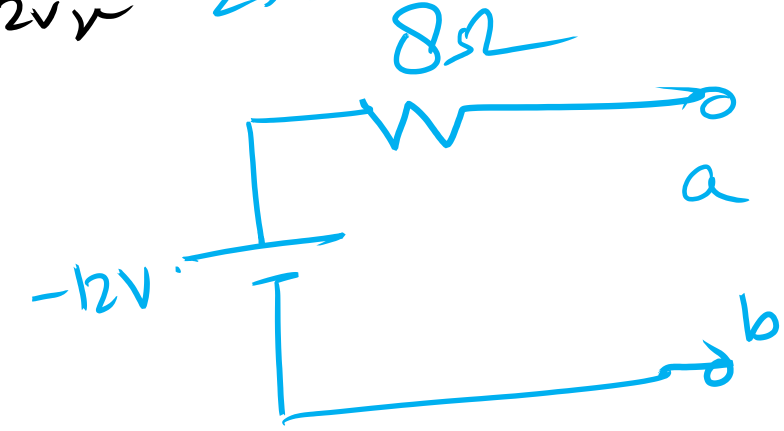
$V_{oc} + 12 = 0$

$$\boxed{V_{oc} = -12V}$$

(ii) R_{Th}

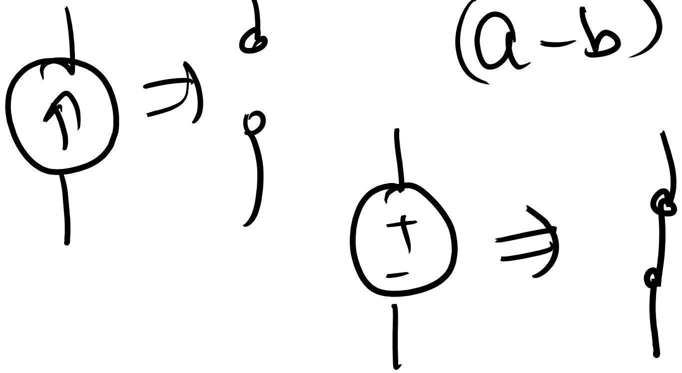


$\Leftarrow R_{eq} = 8\Omega = R_{Th}$



(i) $V_{Th} \Rightarrow V_{oc}$
(a-b)

(ii) R_{Th}
(a-b)



*

Thevenin Theorem

Independent sources only

(1) $V_{Th} \Rightarrow V_{oc}$

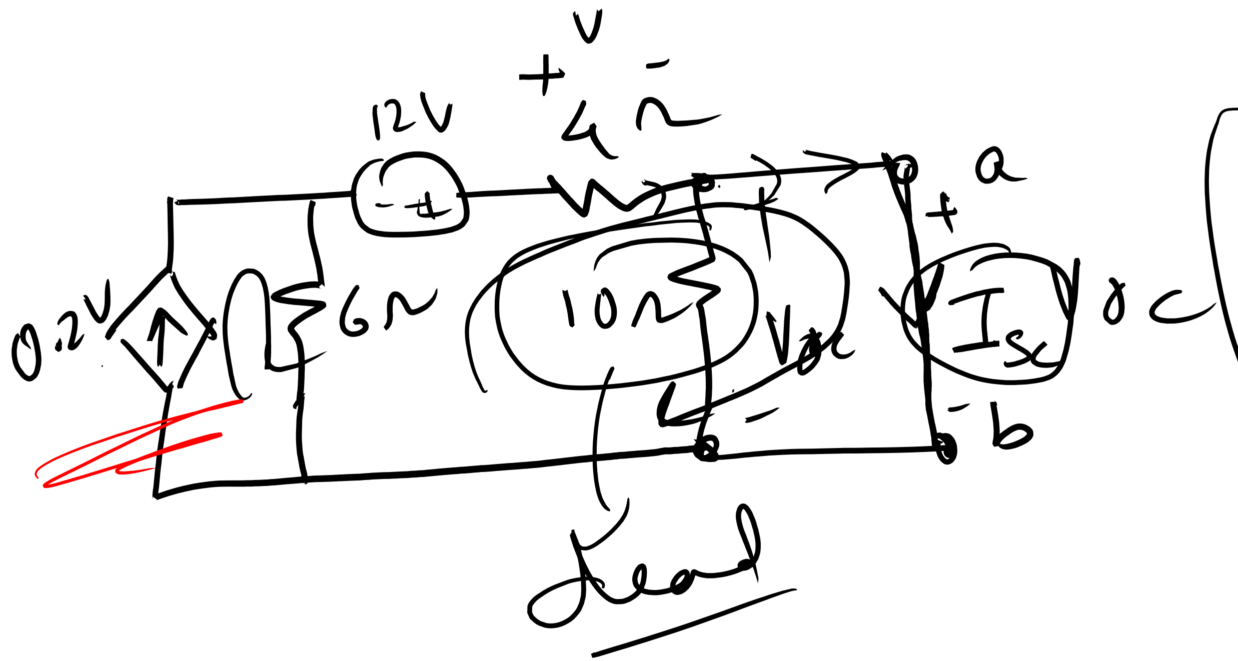
(2) $R_{Th} \Rightarrow R_{eq}$ after killing indep. (power sources)

[Dependent + Independent sources]

(1) $V_{Th} \Rightarrow V_{oc}(a-b)$

(2) $I_{sc} \Rightarrow$ shorting terminals (a-b)

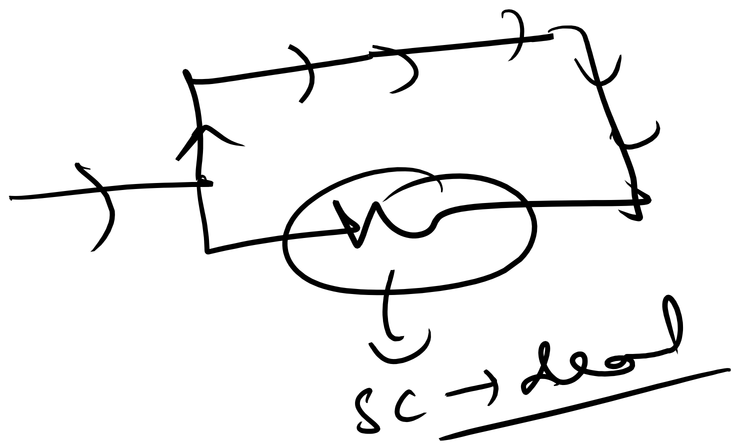
(3) $R_{Th} = \frac{V_{oc}}{I_{sc}}\ \Omega$



(1) $V_{Th} = V_{oc}$

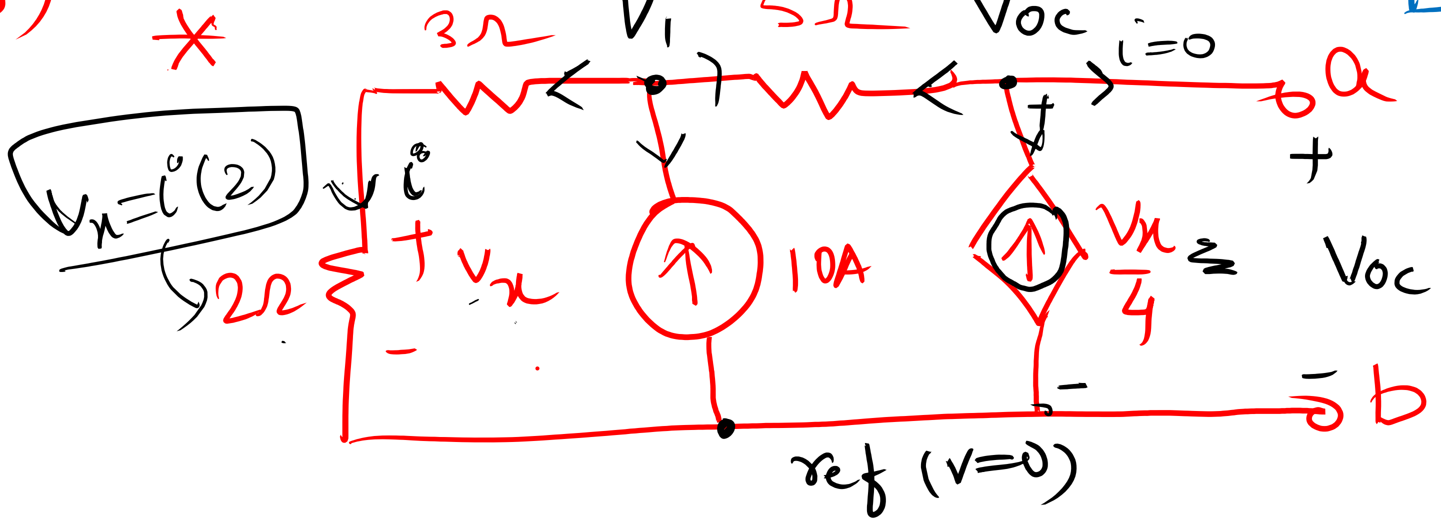
(2) $I_{sc} = a$ Amp

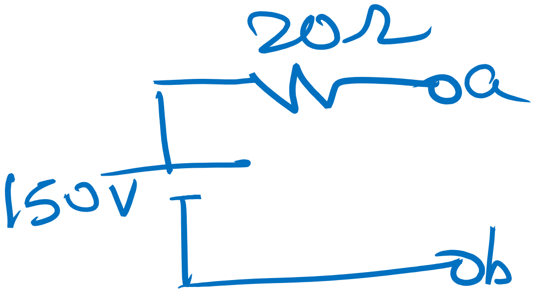
(3) $R_{Th} = \frac{V_{oc}}{a}$



Thevenin Equivalent (Dependent Sources)

- V_{Th}
- I_{sc}
- $R_{Th} = \dfrac{V_{Th}}{I_{sc}}$





① $V_{Th}(V_{oc})$

$$\frac{V_1}{5} = i$$

KCL at Node 1: $\dfrac{V_1}{3+2} - 10 + \dfrac{V_1 - V_{oc}}{5} = 0$ — ①

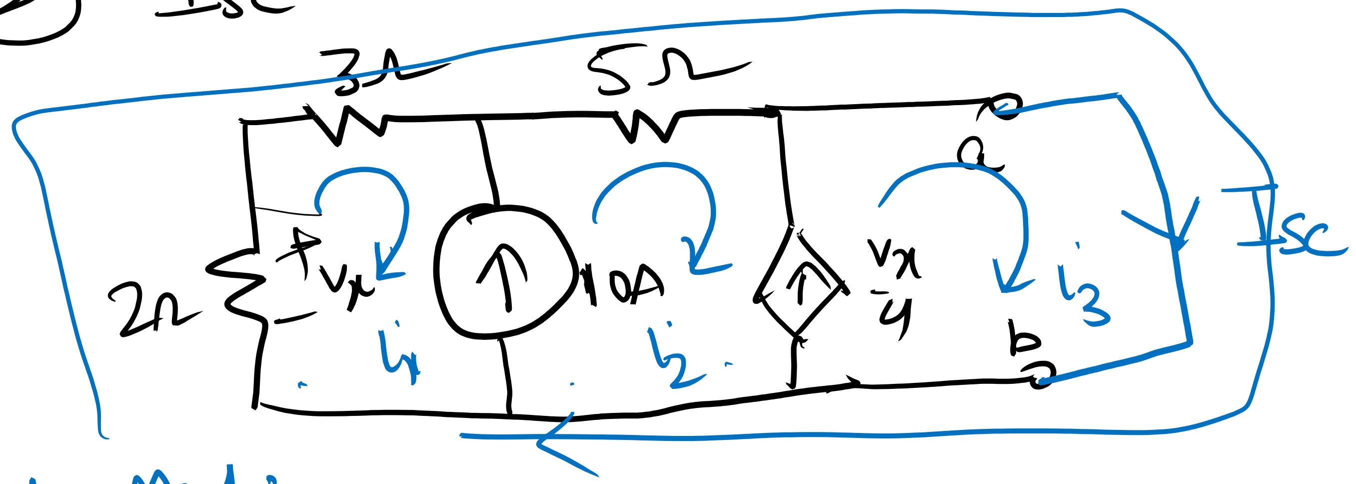
$$V_x = 2\left(\frac{V_1}{5}\right)$$

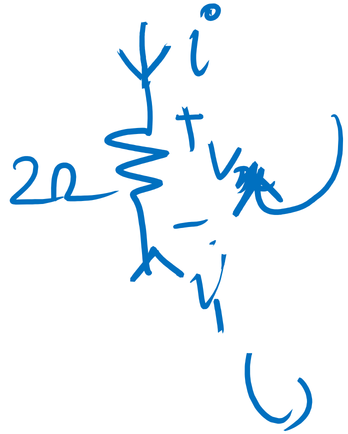
Node 2: $\dfrac{V_{oc} - V_1}{5} - \dfrac{V_x}{4} = 0$ — ②

$V_x = \dfrac{2V_1}{5}$ → ③

$$\boxed{V_{oc} = 150V}$$

② I_{sc}





$V_x = 2i^\circ$

$V_x = -2i_1$

Supermesh:

$2i_1 + 3i_1 + 5i_2 = 0$ — ①

$i_2 - i_1 = 10$ — ②

$i_3 - i_2 = \frac{V_x}{4}$ — ③

$\boxed{V_x = -2i_1}$ — ④

$\boxed{i_3 = 7.5 = I_{sc}}$

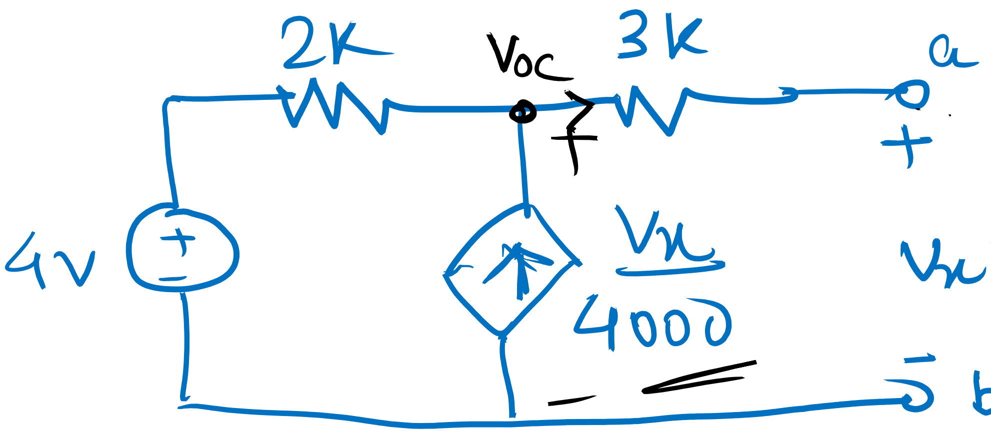
③ $R_{Th} = \frac{V_{oc}}{I_{sc}}$

$= \frac{150}{7.5}$

$= 20\Omega$

* Obtain Thevenin Eq:

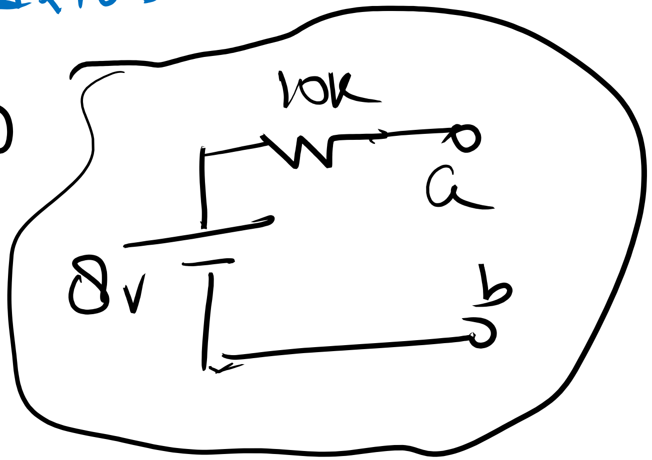
$1K = \text{kiloohm} = 1\times10^3\,\Omega$

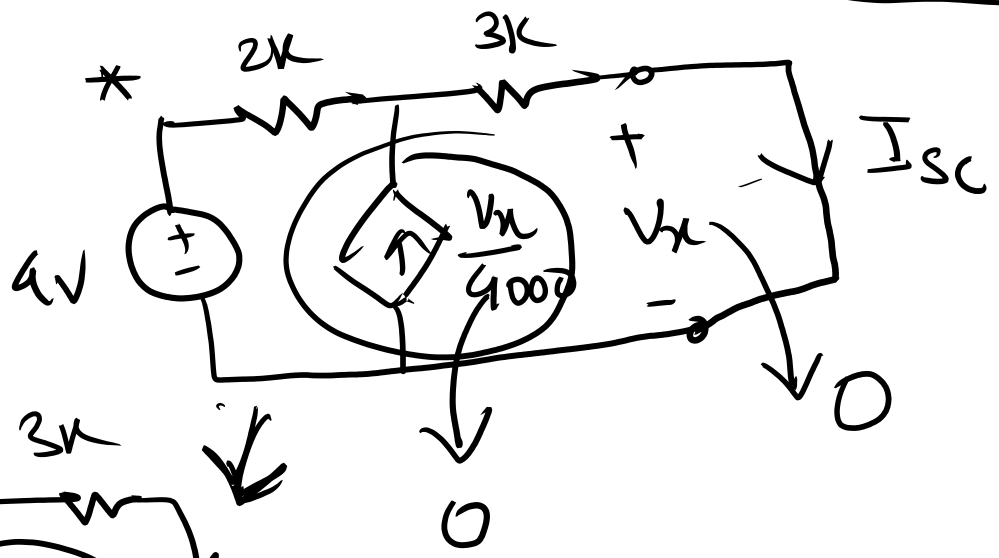


$V_x = V_{oc}$

$$\frac{V_{oc}-4}{2000} - \frac{V_x}{4000} = 0$$

$V_{oc} = V_x$

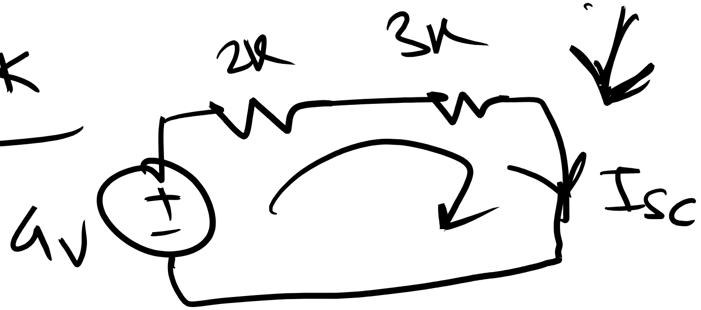




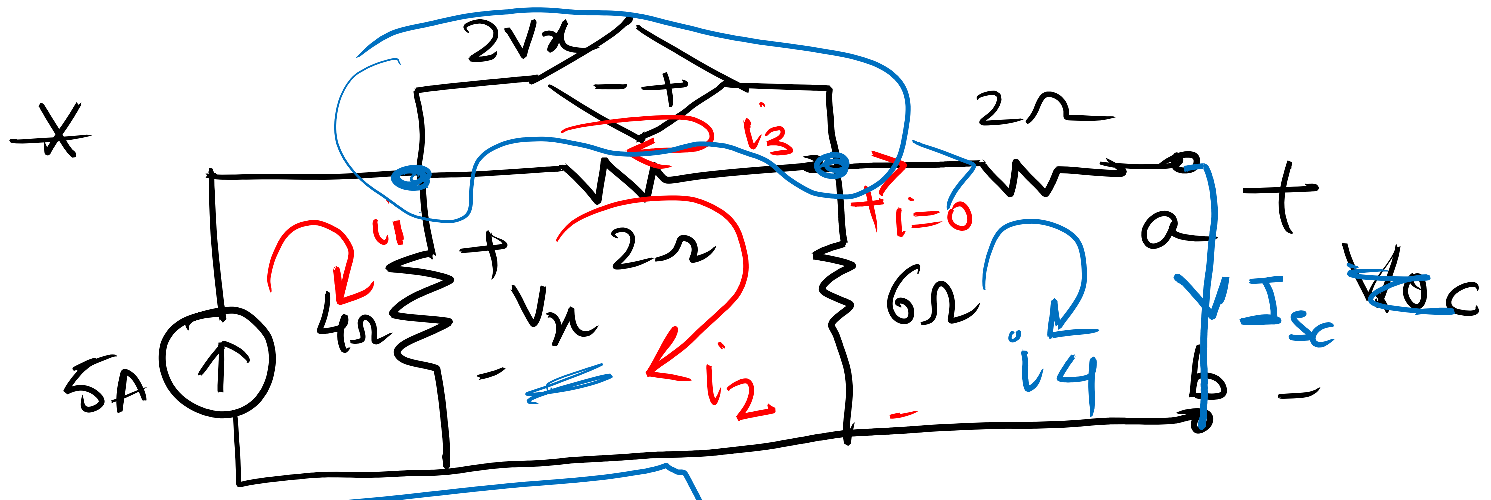
$V_{oc} = 8V$

$I_{sc} = \frac{4}{5000} = 0.80mA$

$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{8}{0.8\times10^{-3}} = 10K$



*



(i) $\boxed{V_{oc}\,(V_{Th}) = 20V}$

$4(i_2 - i_1) + 2(i_2 - i_3) + 6i_2 = 0$ — ①

$-2V_x + 2(i_3 - i_2) = 0$ — ②

$i_1 = 5$ — ③

$V_x = 4(i_1 - i_2)$ — ④

(2) $i_1 = 5$ — ①

$-2V_x + 2(i_3 - i_2) = 0$ — ②

$4(i_2 - i_1) + 2(i_2 - i_3) + 6(i_2 - i_4) = 0$ — ③

$6(i_4 - i_2) + 2i_4 = 0$ — ④

$V_x = 4(i_1 - i_2)$ → ⑤

$\boxed{i_4 = I_{sc} = 10A}$

$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{20}{10} = \underline{\underline{2\Omega}}$

* Steps for Thevenin

1. Identify a-b & remove any R_L
2. Find V_{oc} at a-b keeping ckt intact

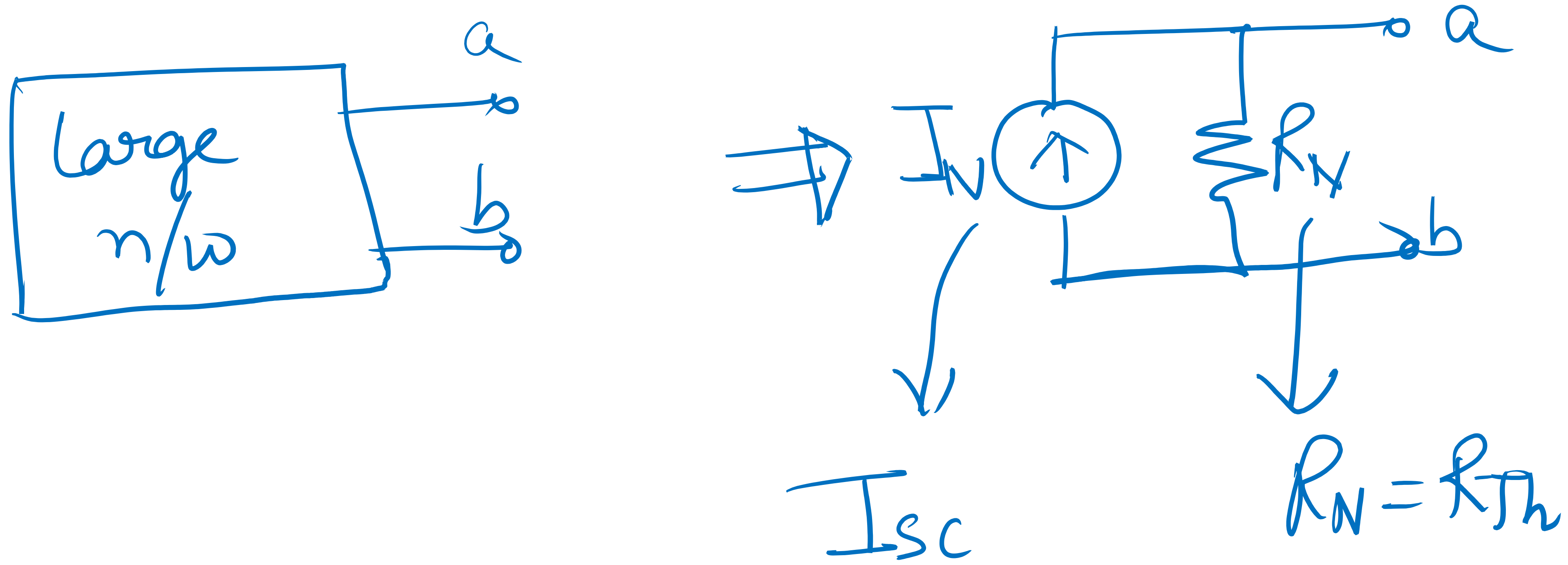
Depen Sour

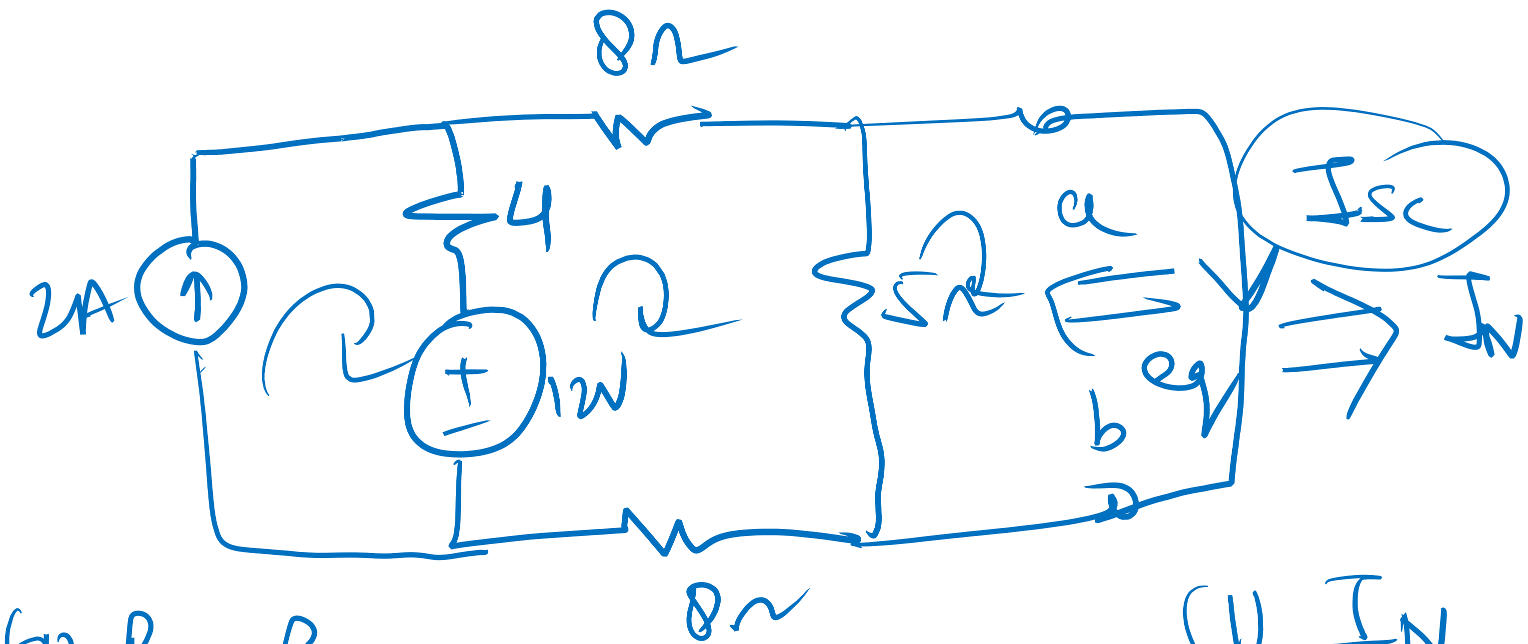
NO → Find R_{Th} by killing all independent sources.

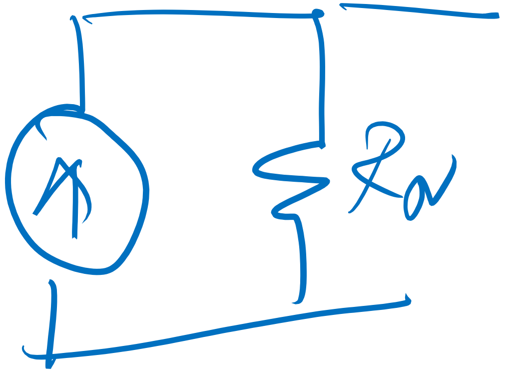
Yes → 1. Find I_{sc}

2. $R_{Th} = \dfrac{V_{oc}}{I_{sc}}$

* Norton's Theorem

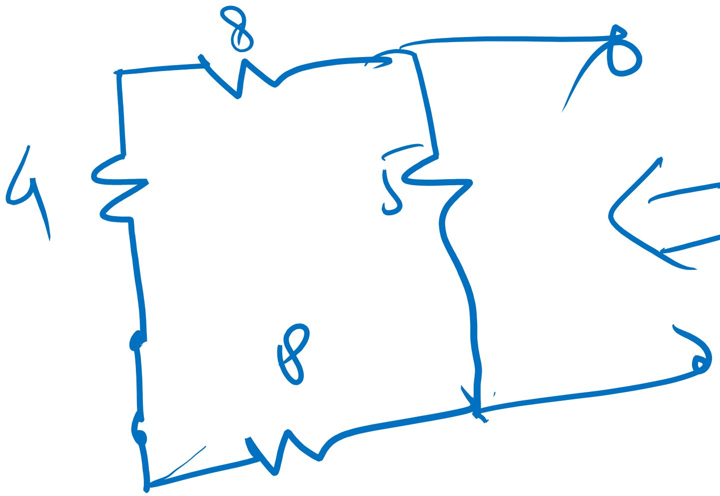






(2) $R_N = R_{Th}$

(1) I_N



$\Leftarrow R_{eq} = 4\Omega = R_N$

$\rightarrow V_{OC}$

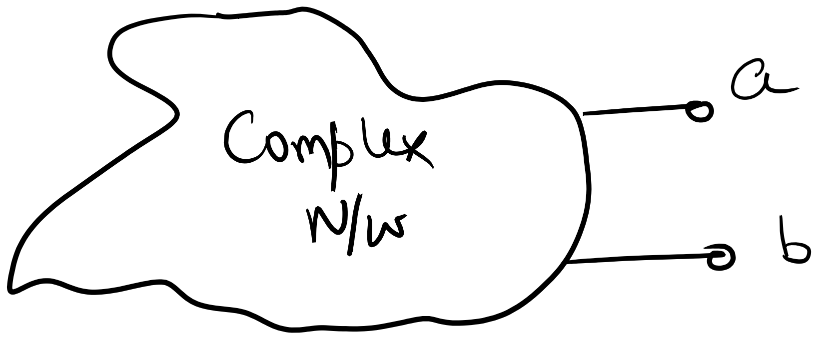
$\rightarrow I_{sc} = I_N$

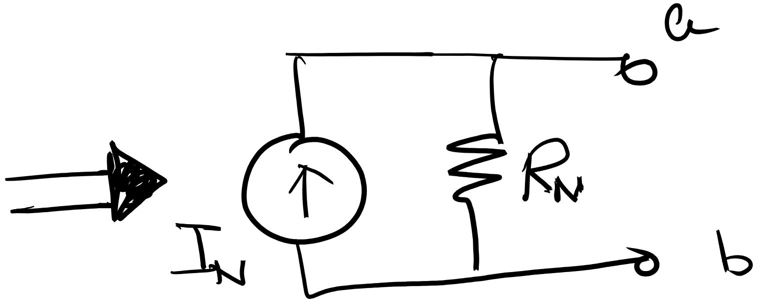
$\rightarrow R_N = \dfrac{V_{OC}}{I_{sc}}$

→ Norton's Theorem

$R_N = R_{Th}$

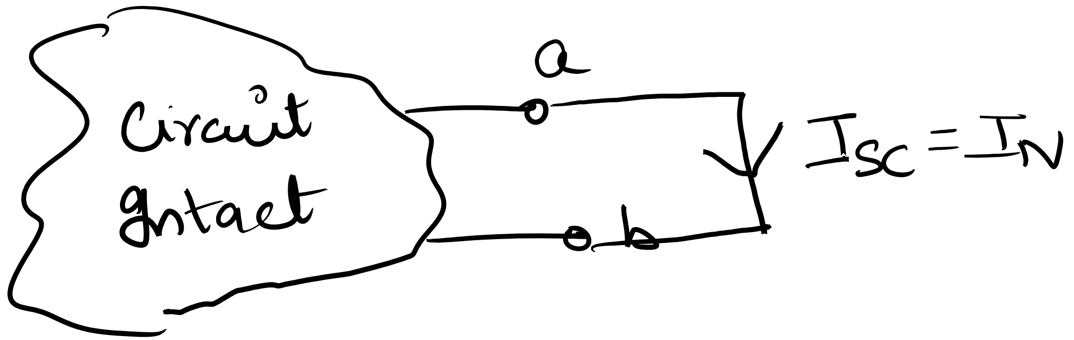
$I_N = I_{SC}$





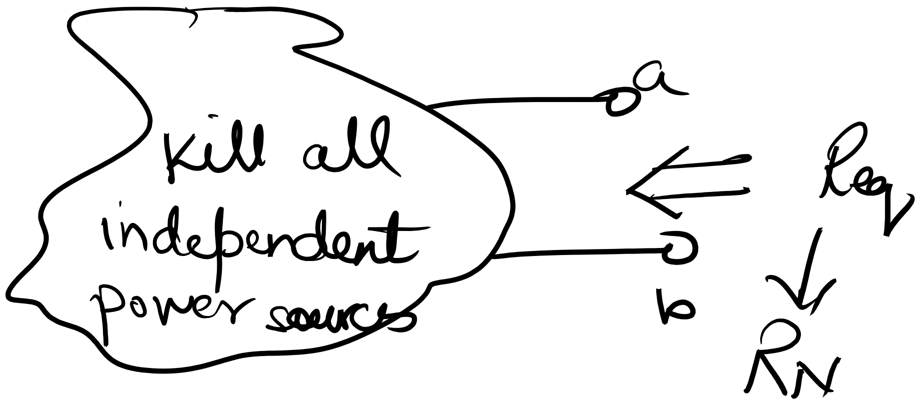
* Statement :

(1) I_N

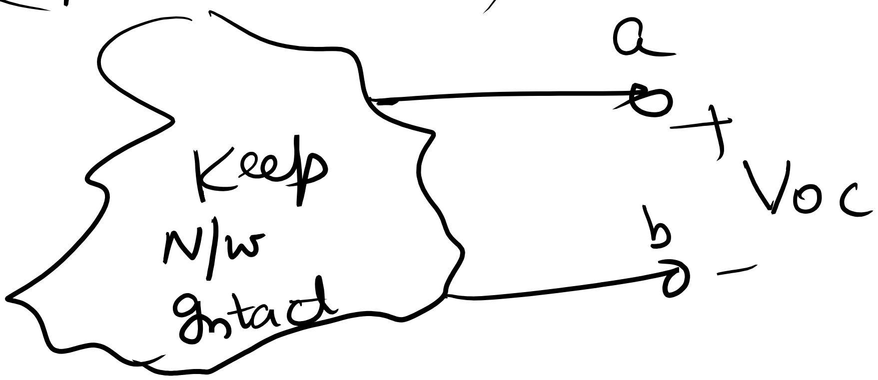


(2) R_N

(No dependent source)



(Dependent sources)



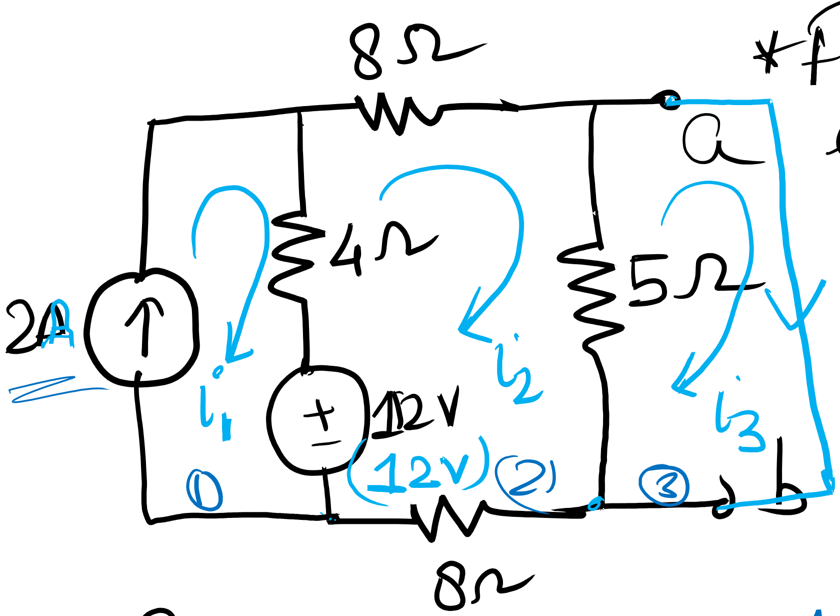
$I_{sc} = I_N = \underline{?}$

$$\boxed{R_N = \frac{V_{oc}}{I_{sc}}}$$

$i_1 = 2$

$i_2 = i_3$

*

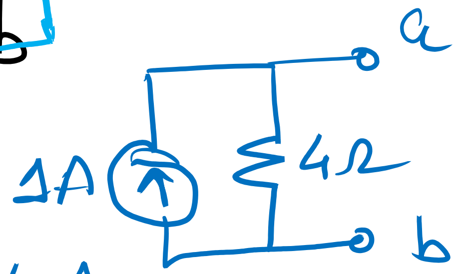


*Find Norton's equivalent across a-b

$I_{sc} = I_N$

$R_N = 4\Omega$

$I_N = \cancel{4A}$ $\underline{5.33A}$; $-\underline{1/5\,A}$

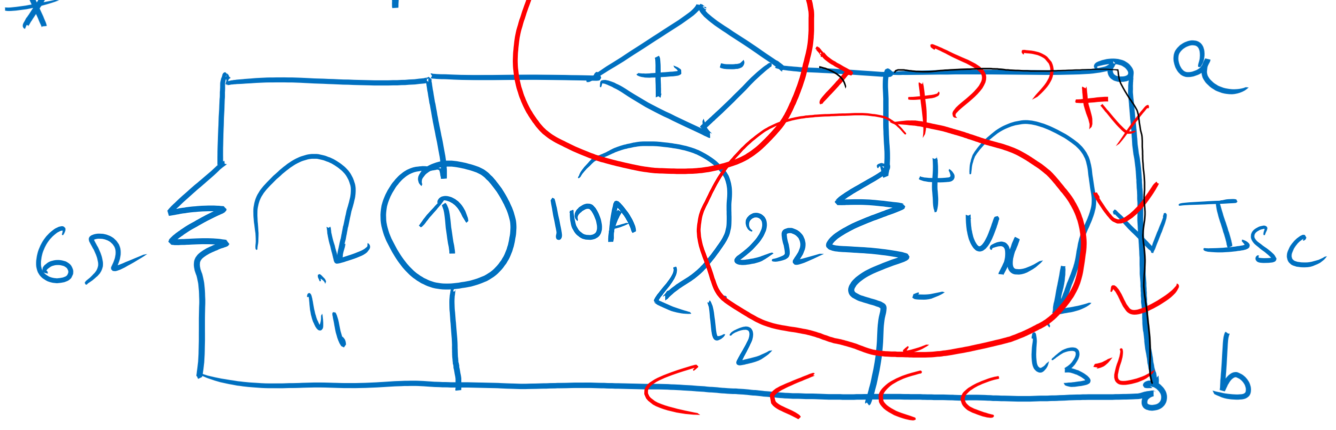


$4(i_2 - i_1) + 8i_2 + 5(i_2 - i_3) + 8i_2 - 12 = 0$ — (1)

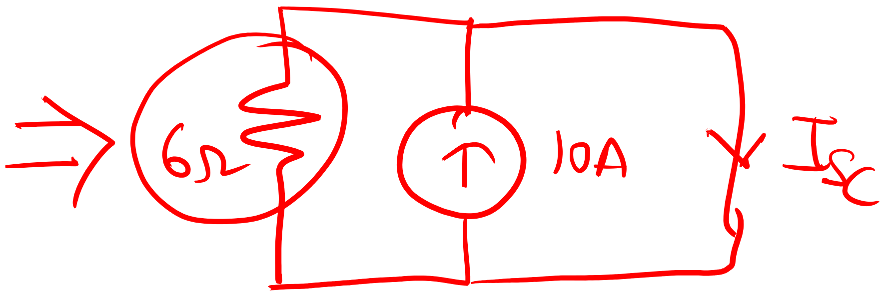
$5(i_3 - i_2) = 0$ — (2)

$i_1 = 2$ — (3)

* Norton eq (a-b)



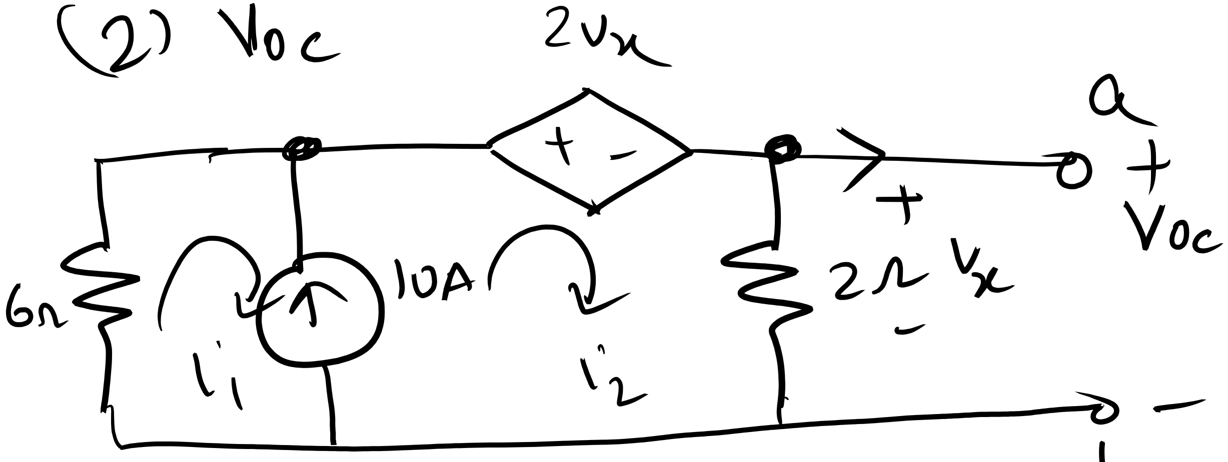
$V_x = 0$



(Redraw)

(1) $I_N = I_{sc} = 10A$

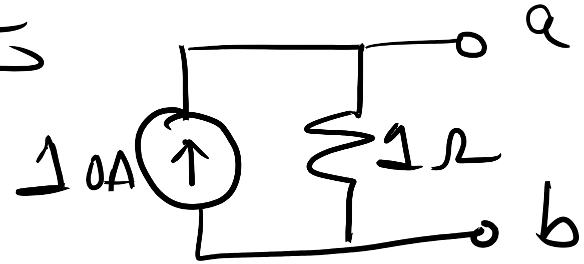
(2) V_{oc}



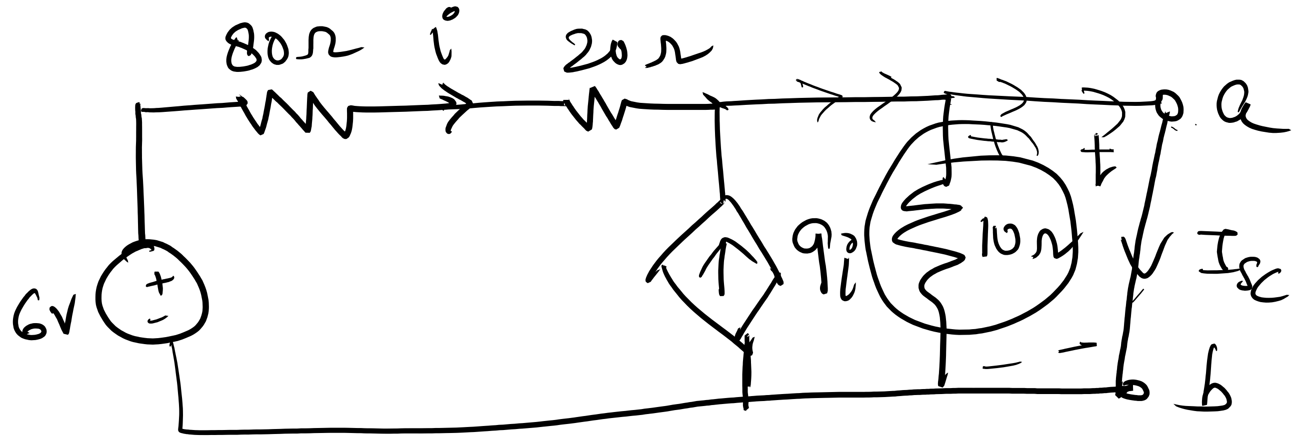
$V_{oc} = V_x$

$V_{oc} = 10V$

$R_N = 1\Omega$



*



~~$I_{sc} = 0.48\,A$~~

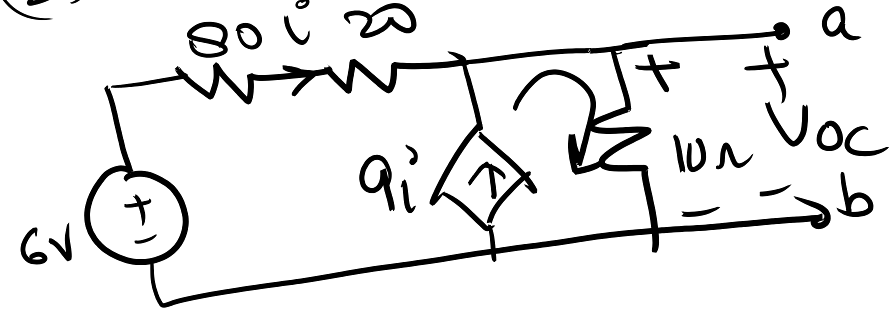
~~$V_{oc} = 4.86\,V$~~

$R_N =$

(1) I_{sc}

$I_{sc} = \underline{0.6A}$

(2) $V_{oc} = \cancel{60V}\ \underline{3V}$



$$-6 + 80i_1 + 20i_1 = 0$$

$$i_2 - i_1 = 9i$$

$$i = i_1$$

$$R_N = \frac{V_{oc}}{I_{sc}} = \frac{3}{0.6} = 5\Omega$$