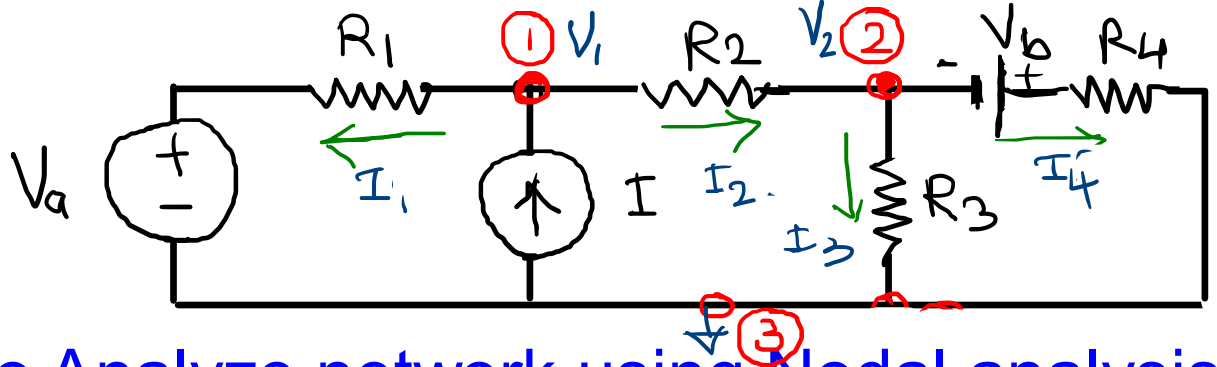
Network Analysis using Node Voltage Method (Nodal Analysis)



Steps to Analyze network using Nodal analysis:

1. Identify non-reference and a reference(datum) node. Mark node voltages.

→ Node ①, ② are Non-reference Nodes & node ③ is reference node

→ Node voltages V_1 & V_2 are assumed to be positive with respect to reference node ③

2. Write KCL at all Non-reference nodes.

→ KCL at node ① $I_1 + I_2 = I$ & KCL at node ② $I_2 = I_3 + I_4$

OR in terms of node voltages

at node ① $\frac{V_1 - V_a}{R_1} + \frac{V_1 - V_2}{R_2} = I$ ... ① & $\frac{V_1 - V_2}{R_2} - \frac{V_2}{R_3} - \left(\frac{V_2 + V_b}{R_4}\right) = 0$

3. Solve the node voltage equations simulteneously to find every node voltage. (V_1 & V_2)

4. Use node voltage to find current/voltage in any branch of the network.

e.g. $V_{R_2} = V_1 - V_2$, $I_{4\Omega} = \frac{V_2 + V_b}{R_4}$ etc.

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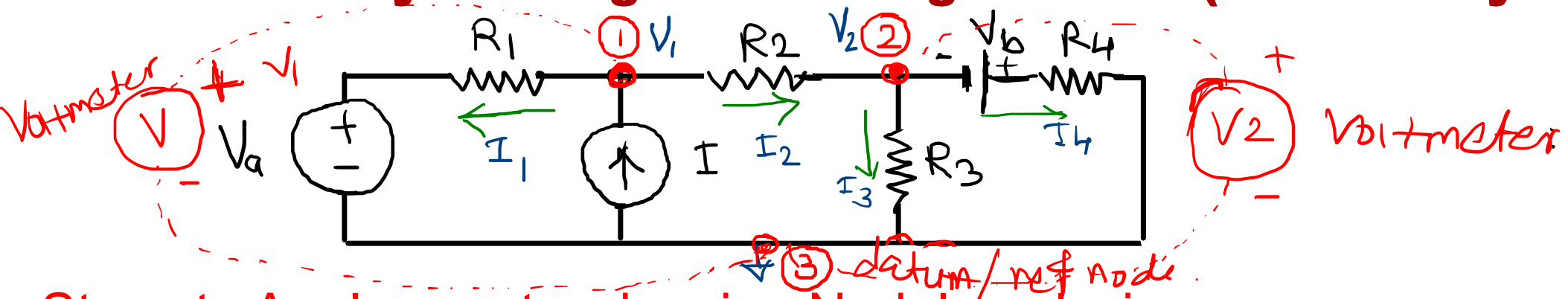
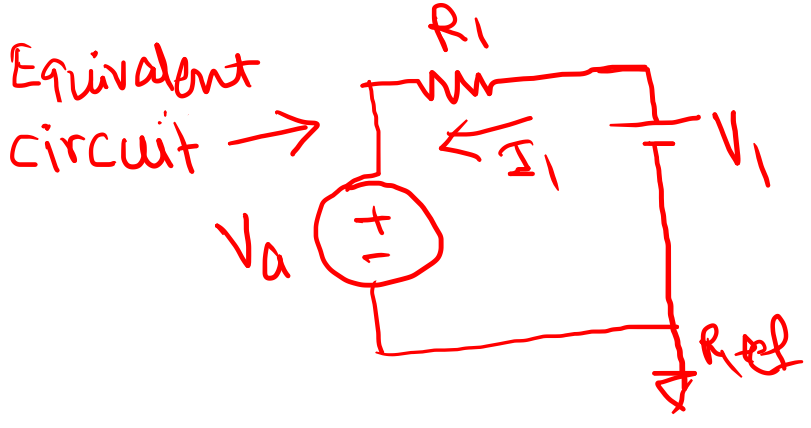


Steps to Analyze network using Nodal analysis:

1. Identify non-reference and a reference(datum) node. Mark node voltages.
2. Write KCL at all Non-reference nodes.

KCL at node ① $I_1 + I_2 = I$ & KCL at node ② $I_2 = I_3 + I_4$

To I_1, I_2, I_3 & I_4 in terms of V_1 & V_2



KVL to loop

$$-I_1 R_1 - V_a + V_1 = 0$$

$$I_1 = \frac{V_1 - V_a}{R_1}$$

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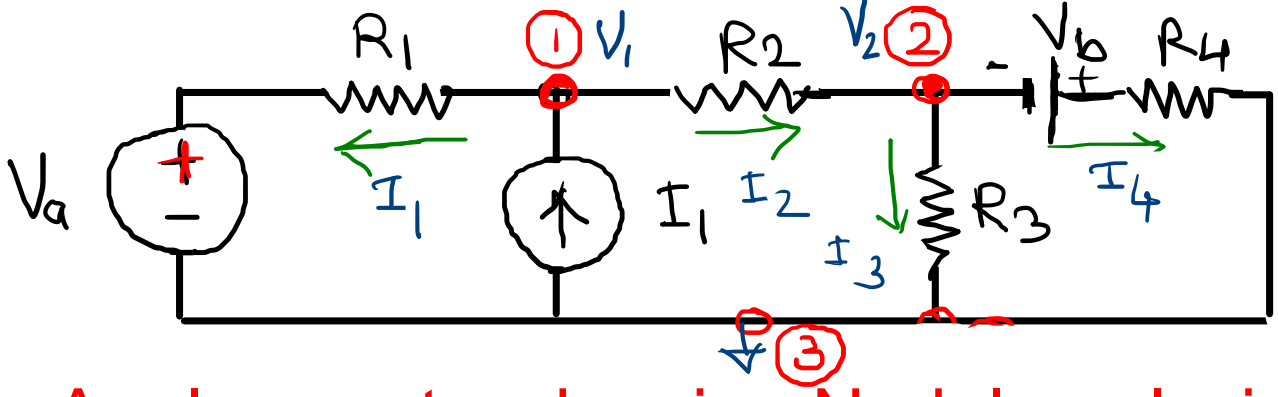
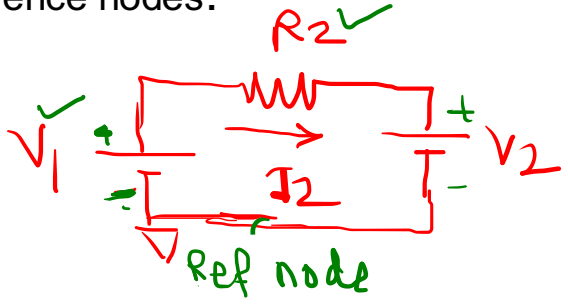


Steps to Analyze network using Nodal analysis:

1. Identify non-reference and a reference(datum) node. Mark node voltages.
2. Write KCL at all Non-reference nodes.

$$I_1 = \frac{V_1 - V_a}{R_1}$$

Let I_2

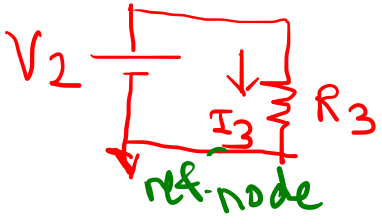


By KVL

$$V_1 - I_2 R_2 - V_2 = 0$$

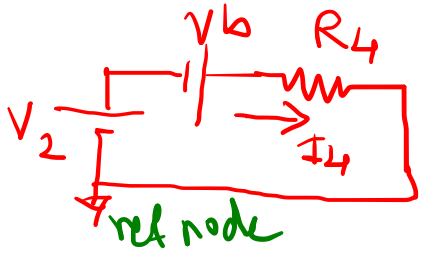
$$I_2 = \frac{V_1 - V_2}{R_2}$$

Let I_3



$$I_3 = \frac{V_2}{R_3}$$

Let I_4

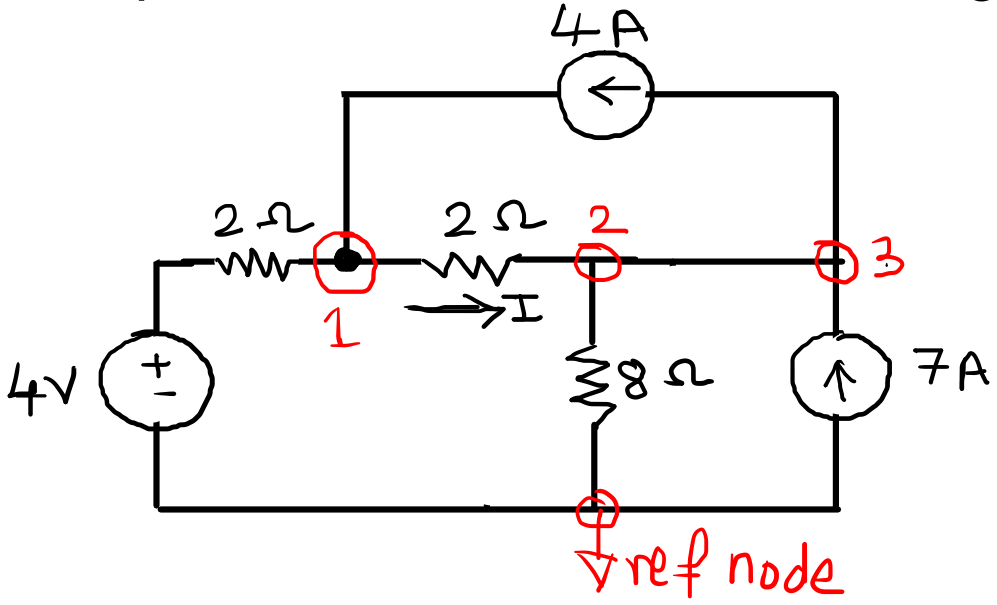


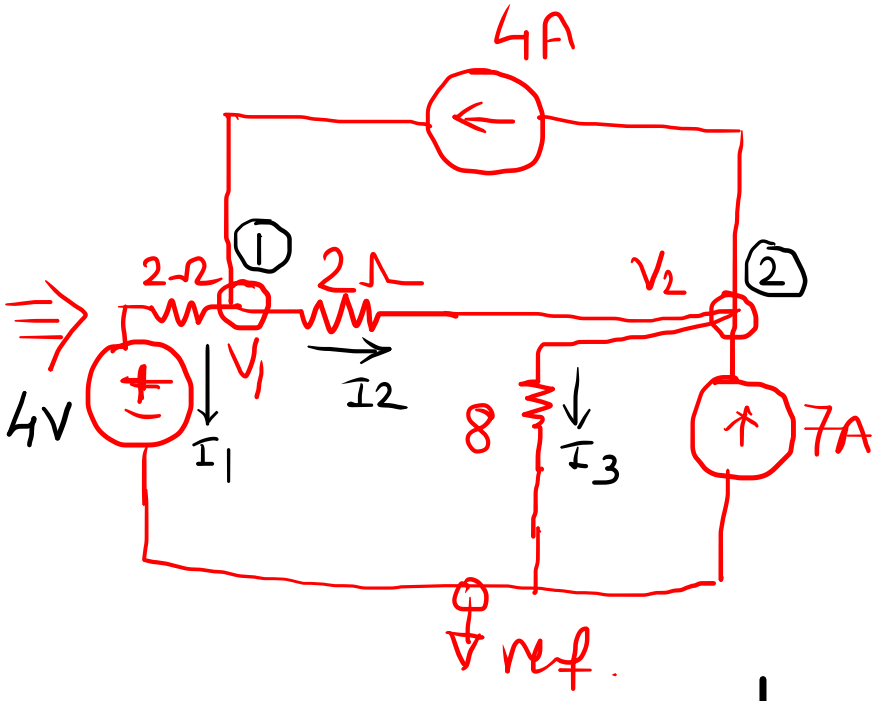
KVL $V_2 + V_b - I_4 R_4 = 0$ so

$$I_4 = \frac{V_2 + V_b}{R_4}$$

Network Analysis using nodal analysis

Example:- 1. Find current I in following network.





Apply KCL at node (1)

$$I_1 + I_2 = 4$$

$$\frac{V_1 - 4}{2} + \frac{V_1 - V_2}{2} = 4$$

$$2V_1 - V_2 = 12 \quad \text{---(i)}$$

KCL at node (2)

$$I_2 + 7 = I_3 + 4$$

$$I_2 - I_3 = -3$$

$$\frac{V_1 - V_2}{2} - \left(\frac{V_2}{8}\right) = -3$$

$$4V_1 - 5V_2 = -24 \quad \text{---(ii)}$$

Solving (i) & (ii) $V_1 = 14V$ & $V_2 = 16V$

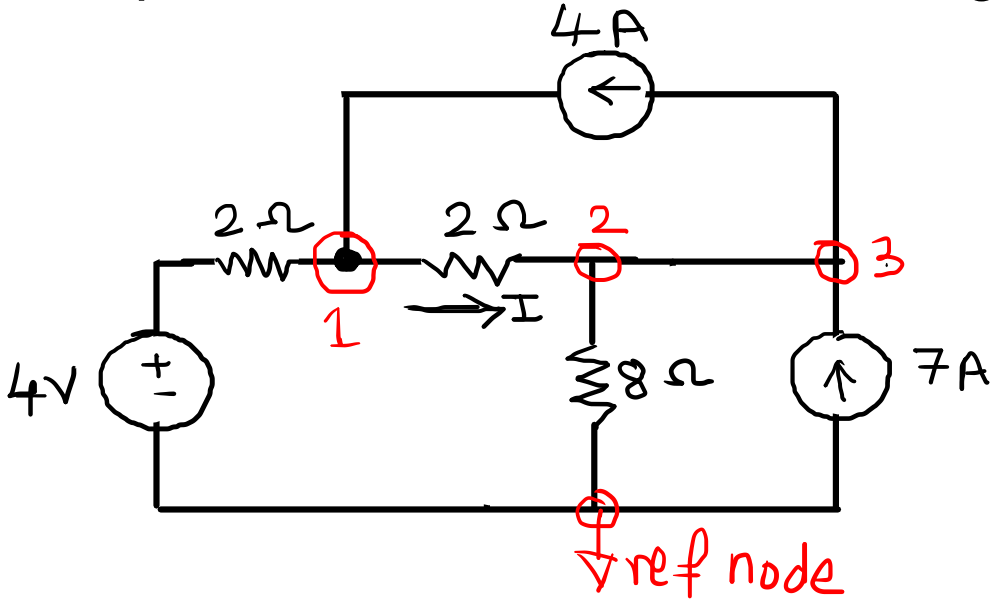
$$I = \frac{V_1 - V_2}{2}$$

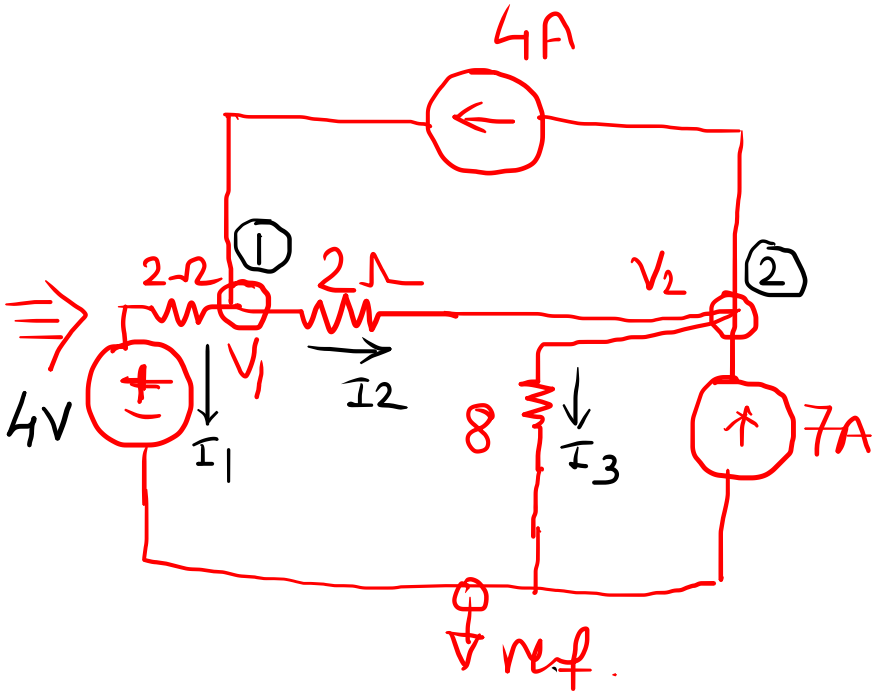
$$I = \frac{14 - 16}{2}$$

$$\boxed{I = -1A}$$

Network Analysis using nodal analysis

Example:- 1. Find current I in following network.





→ Apply KCL at node (1)

$$I_1 + I_2 = 4$$

$$\frac{V_1 - 4}{2} + \frac{V_1 - V_2}{2} = 4$$

$$2V_1 - V_2 = 12 \quad \text{— (1)}$$

→ KCL at node (2)

$$I_2 + 7 = I_3 + 4$$

$$I_2 - I_3 = -3$$

$$\frac{V_1 - V_2}{2} - \left(\frac{V_2}{8}\right) = -3$$

$$4V_1 - 5V_2 = -24 \quad \text{— (2)}$$

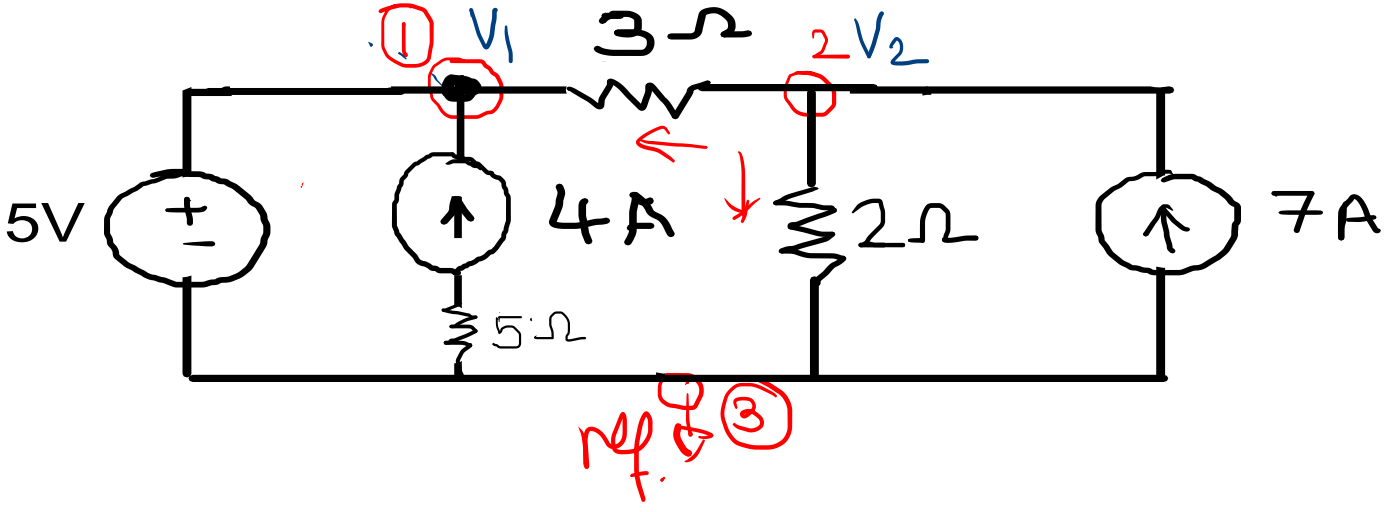
$$I = \frac{V_1 - V_2}{2}$$

$$I = \frac{14 - 16}{2}$$

$$\boxed{I = -1A}$$

Solving (1) & (2) $V_1 = 14V$ & $V_2 = 16V$

Example:- 2. Find voltage across 2 Ohm resistor in the following network.



If there is a voltage source without series resistance appearing between Non-reference node and reference node then, the non-reference node voltage will be equal to value of the voltage source.

5V Source without a series resistance appeared between V_1 and Reference Node

$$V_1 = 5V$$

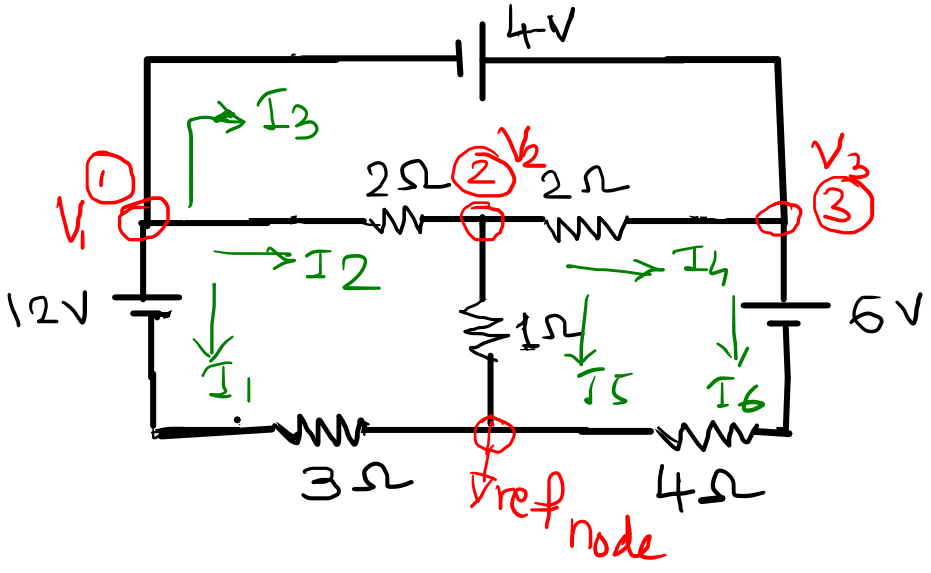
KCL at node (2)

$$\frac{V_2 - V_1}{3} + \frac{V_2}{2} = 7 \rightarrow \text{Substitute } V_1 = 5V$$

$$V_2 = 10.4V = V_{2\Omega}$$

Network Analysis using Mesh Current Method

Example:- 3. Find current flowing in 1 ohm resistor.



KCL at node (1)

$$I_1 + I_2 + I_3 = 0$$

$$\frac{V_1 - 12}{3} + \frac{V_1 - V_2}{2} + \frac{V_1 + 4 - V_3}{2} = 0$$

KCL at node (3)

$$I_3 + I_4 = I_6$$

$$\frac{V_1 + 4 - V_3}{2} + \frac{V_2 - V_3}{2} = \frac{V_3 - 6}{4}$$

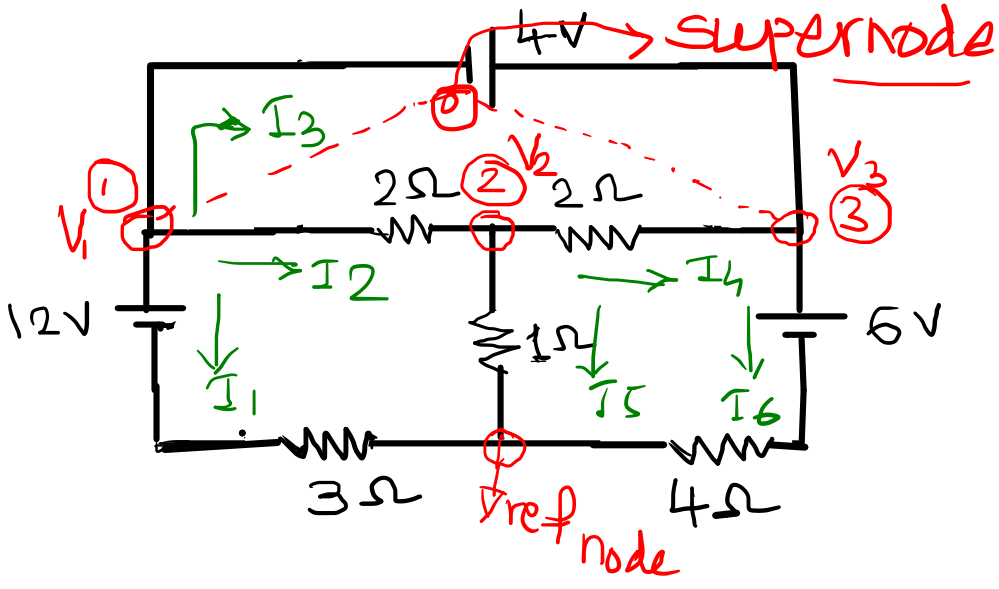
KCL at node (2)

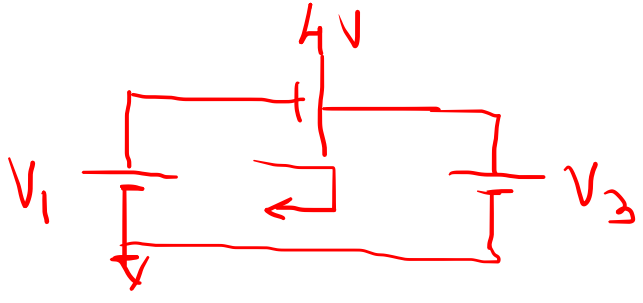
$$I_2 = I_4 + I_5$$

$$\frac{V_1 - V_2}{2} = \frac{V_2 - V_3}{2} + \frac{V_2}{1}$$

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

If a voltage source without a series resistance appears between two non-reference noddes then write that source interms of two non-reference node voltages (Equation-1) and form a node called supernode. Write KCL at supernode keeping non-ref node voltages intact (equation-2). We get two equations in terms of non-ref. node voltages.





Apply KVL

$V_1 + 4 - V_3 = 0$

$V_1 - V_3 = -4$ — (1)

KCL at supernode

keep V_1 & V_3 intact to write KCL.

$$I_1 + I_2 - I_4 + I_6 = 0$$

$$\frac{V_1 - 12}{3} + \frac{V_1 - V_2}{2} - \left(\frac{V_2 - V_3}{2}\right) + \frac{V_3 - 6}{4} = 0$$

$$\frac{4V_1 - 48 + 6V_1 - 6V_2 - 6V_2 + 6V_3 + 3V_3 - 18}{12} = 0$$

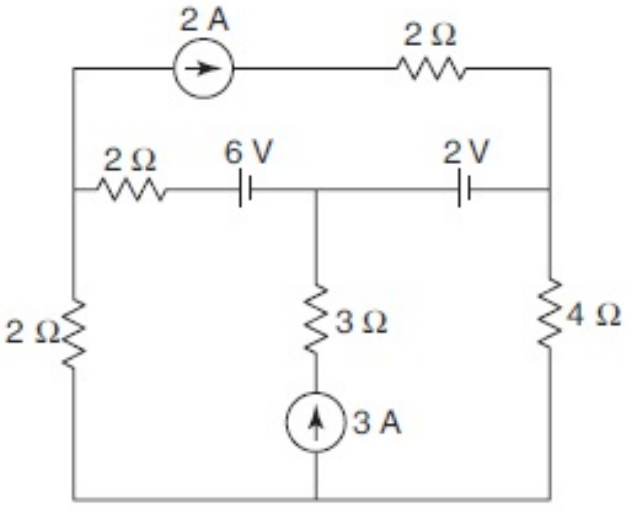
$$10V_1 - 12V_2 + 9V_3 = 66 \quad \text{— (111)}$$

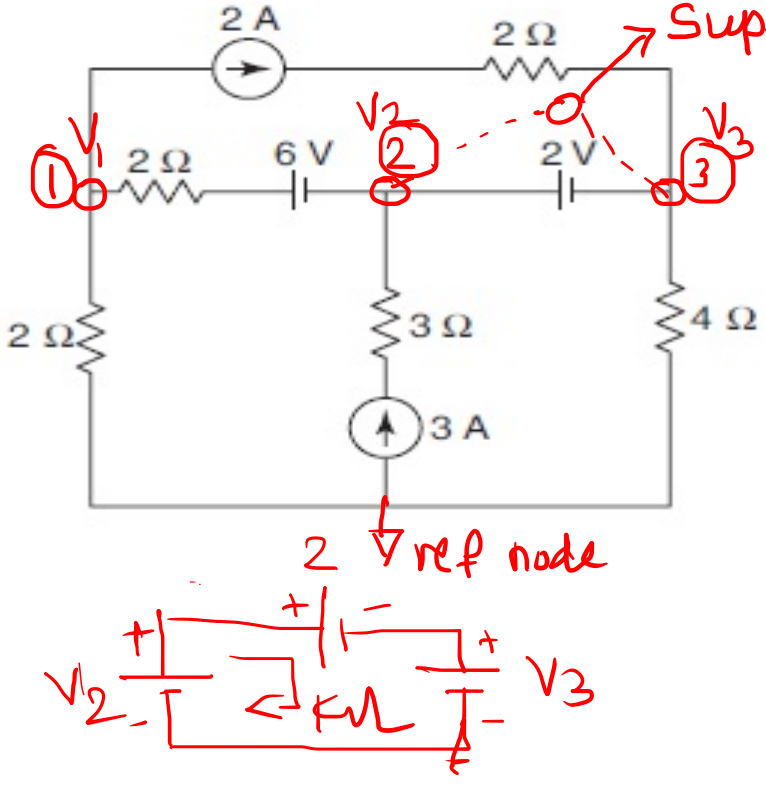
Solving (1) (11) & (111)

$V_1 = 3.2V \quad V_2 = 2.6V \quad V_3 = 7.23V$

$I_{1\Omega} = \frac{V_2}{1} = 2.6A$

Example:- 4. Find current flowing in 4 ohm resistor.





Since 2V source without series resistance betn node ② & ③, so its a case of supernode.

$\therefore \quad V_2 - 2 - V_3 = 0$

$V_2 - V_3 = 2 \quad \cdots (1)$

KCL at supernode

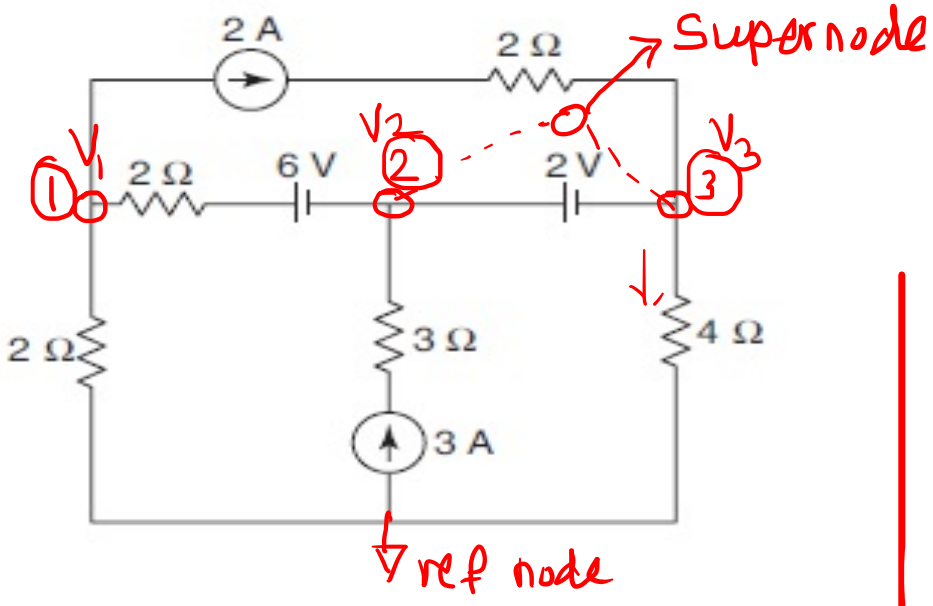
$$\frac{V_2 + 6 - V_1}{2} - 3 + \frac{V_3}{4} - 2 = 0$$

$$\frac{V_2 + 6 - V_1}{2} + \frac{V_3}{4} = 5$$

$$2V_2 + 12 - 2V_1 + V_3 = 20$$

$$-2V_1 + 2V_2 + V_3 = 8 \quad \text{—} \quad (11)$$

Example:- 4...



KCL at node (1)

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

$$V_1 + V_1 - 6 - V_2 = -4$$

$$2V_1 - V_2 = 2 \quad \text{— (III)}$$

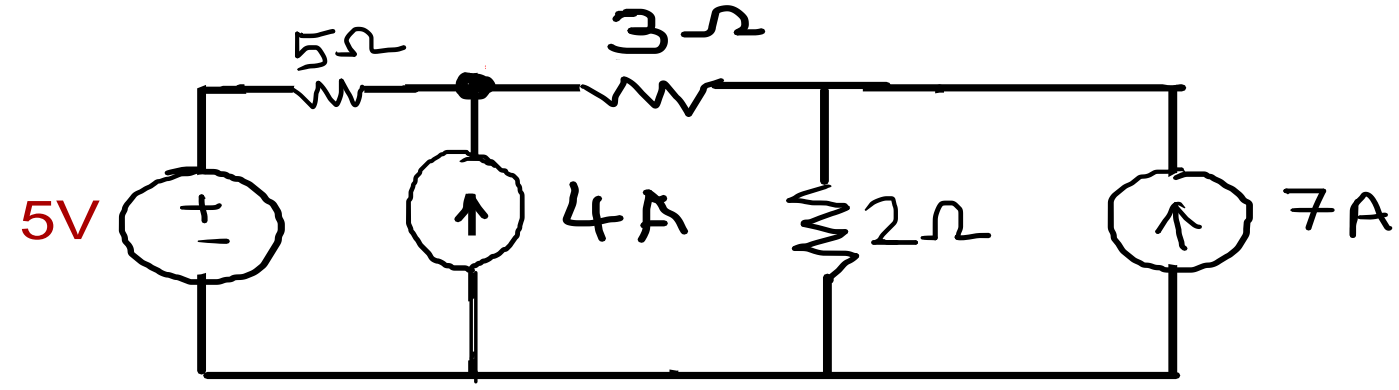
Solving (I) (II) & (III)

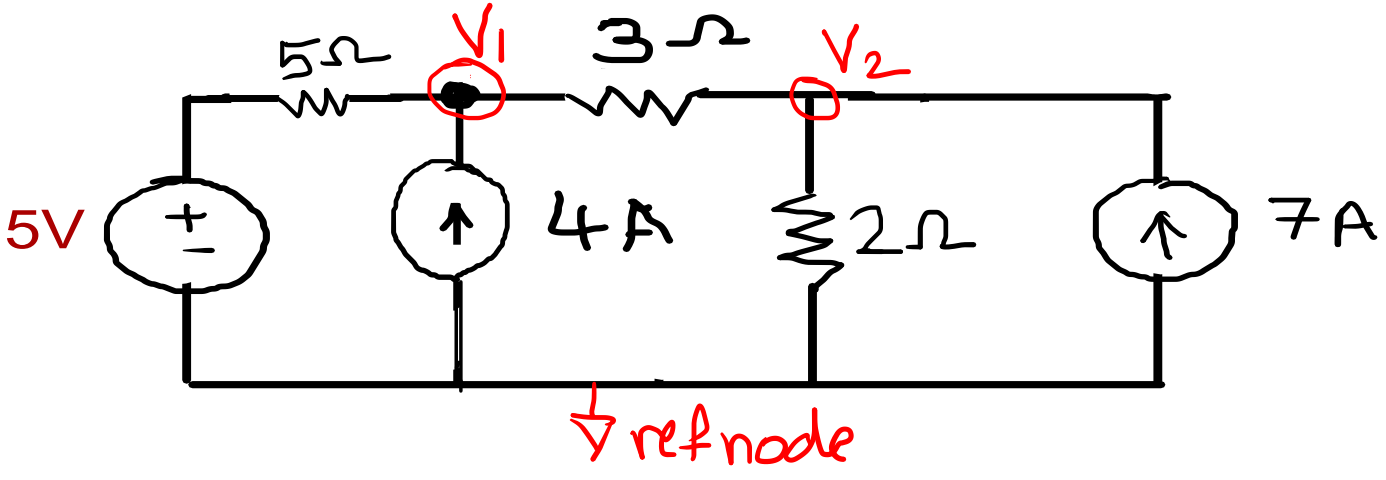
$V_1 = 4V$, $V_2 = 6V$, $V_3 = 4V$

$$I_{4\Omega} = \frac{V_3}{4} = \frac{4}{4} = 1A$$

Network Analysis using Mesh Current Method

Example:- 5. Find voltage across 2 Ohm resistor in the flowing network.





KCL at node ①

$$\frac{V_1-5}{5}+\frac{V_1-V_2}{3}=4$$

$$\frac{3V_1-15+5V_1-5V_2}{15}=4$$

$$8V_1-5V_2=75 \quad -(1)$$

KCL node ②

$$\frac{V_2-V_1}{3}+\frac{V_2}{2}=7$$

$$2V_2-2V_1+3V_2=42$$

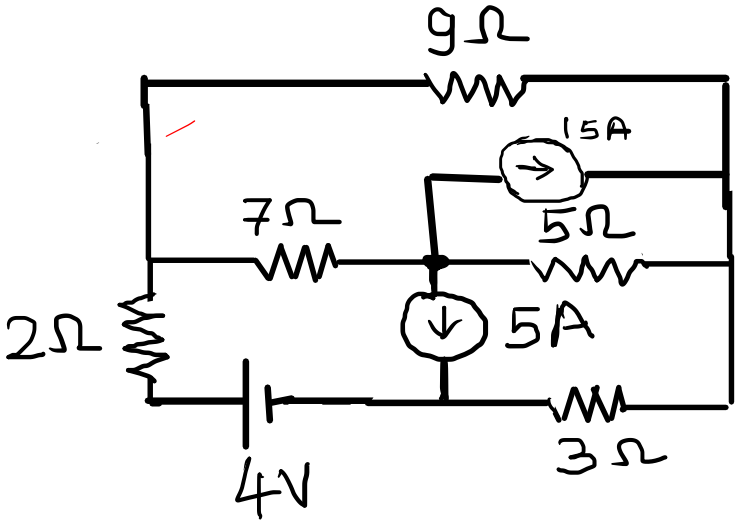
$$-2V_1+5V_2=42 \quad -(2)$$

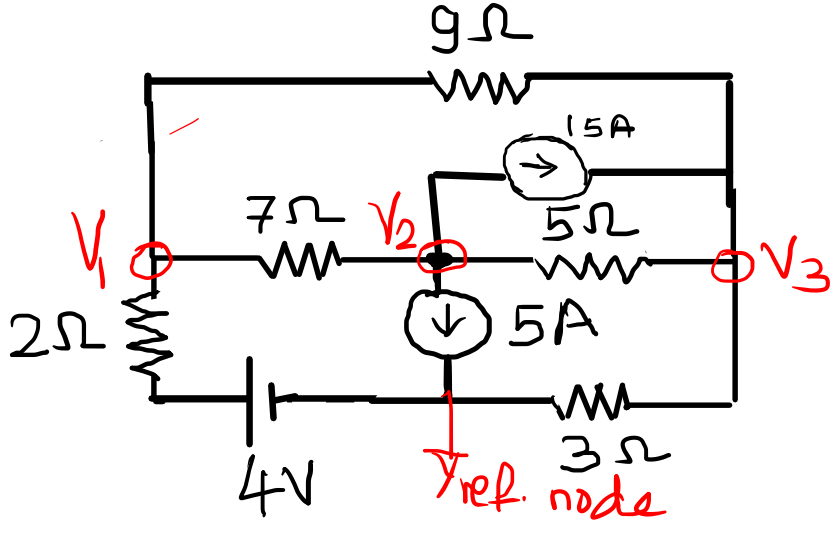
Solving ① & ②

$V_1 = 19.5V$, $V_2 = 16.2V$

$$V_{2\Omega} = V_2 = 16.2V$$

Example:- 6. Find current through 3 Ohm resistor in the following network.





→ KCL at node (1)

$$\frac{V_1-4}{2}+\frac{V_1-V_2}{7}+\frac{V_1-V_3}{9}=0$$

$$95V_1-18V_2-14V_3=252 \quad \text{----(1)}$$

→ KCL at node (2)

$$\frac{V_2-V_1}{7}+\frac{V_2-V_3}{5}=-20$$

$$-5V_1+12V_2-7V_3=-700 \quad \text{----(2)}$$

→ KCL at node (3)

$$\frac{V_3-V_1}{9}+\frac{V_3-V_2}{5}+\frac{V_3}{3}=15$$

$$-5V_1-9V_2+29V_3=675 \quad \text{----(3)}$$

Solving (1), (2) & (3)

$V_1=-8.19V$, $V_2=-59.82V$, $V_3=3.29V$, $I_{3\Omega}=\frac{V_3}{3}=1.09A$