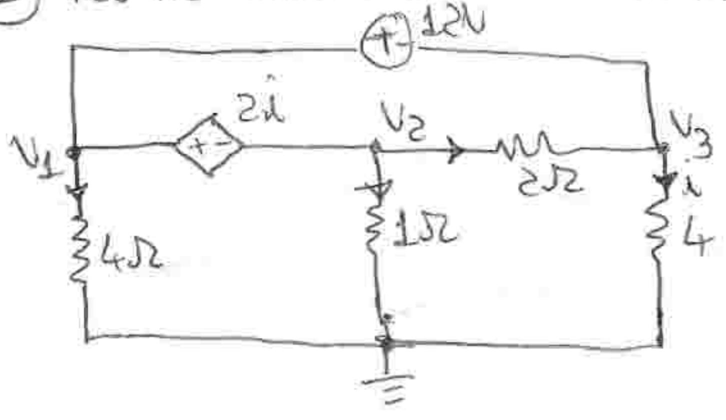
Prepared by PRAHLAD D, Asst. Professor, PESU

(1) For the circuit shown find V_1, V_2, and V_3.



From the ckt.:-

$$\boxed{i = \frac{V_3}{4}} \text{—[1]}$$

we have, $V_1 - V_2 - 2i = 0$

$$\boxed{V_1 - V_2 = 2i} \text{—[2]}$$

From eq-[1]:- $V_1 - V_2 = \frac{V_3}{2}$; $\boxed{2V_1 - 2V_2 - V_3 = 0}$ —[3]

we have, $V_1 - 12 - V_3 = 0$ $\boxed{V_1 - V_3 = 12}$ —[4]

Eq-[3] becomes:- $2(V_3 + 12) - 2V_2 - V_3 = 0$

$$\boxed{V_3 - 2V_2 = -24} \text{—[5]}$$

V_1-V_2-V_3 forms a supernode :- Apply KCL to this 3-nodes at once we get:-

$$\underbrace{\frac{V_1}{4} + \frac{V_2}{1} + \frac{V_3}{4} + \frac{V_2 - V_3}{2}}_{\text{current leaving } (V_1-V_2-V_3 \text{ supernode})} = \underbrace{\frac{V_2 - V_3}{2}}_{\text{(current entering supernode)}}$$

(leaving V_2 part of supernode)

$$\boxed{V_1 + 4V_2 + V_3 = 0} \text{—[6]}$$ From eq-[4]

$V_3 + 12 + 4V_2 + V_3 = 0$ $2V_3 + 4V_2 = -12$ or $\boxed{V_3 + 2V_2 = -6}$ —[7]

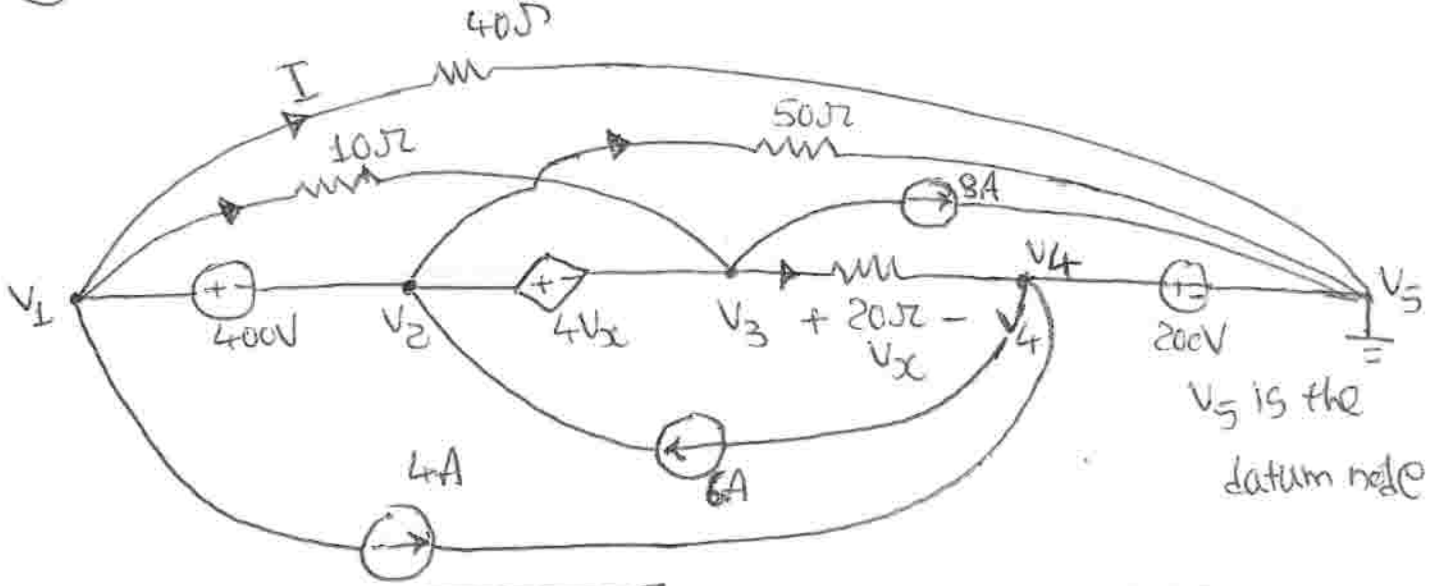
Solving eq-[5] and eq-[7]:- $2V_3 = -30$ $\boxed{V_3 = -15V}$

From eq-[7]:- $V_2 = \frac{-6 + 15}{2} = \frac{9}{2}$ $\boxed{V_2 = 4.5V}$

$$\boxed{V_1 = V_3 + 12 = -3V}$$

— — — — — — — — — — — —

② Use nodal analysis to find current 'I' in the circuit.



From the data:- $\boxed{V_4 = 200V}$ — [1] $V_1 - V_2 - 400 = 0$ $\boxed{V_1 - V_2 = 400}$ — [2]

$\boxed{V_3 - V_4 = V_x}$ — [3]

$\boxed{V_x = V_3 - 200}$ — [3]-a

$\boxed{V_5 = 0V}$ — [5]

$V_2 - 4V_x - V_3 = 0$

$\boxed{V_2 - V_3 = 4V_x}$ — [4]

$V_2 - V_3 = 4(V_3 - 200)$

$\boxed{V_2 - 5V_3 = -800}$ — [4]-a

Now, $V_1 - V_2 - V_3$ (three nodes together) forms a supernode

Applying KCL to these 3-nodes together [~~current~~ sum of the currents leaving the 3-nodes = sum of the currents entering 3-nodes]

$$\frac{V_1 - V_5}{40} + \cancel{\frac{V_1 - V_3}{10}} + 4 + \frac{V_2 - V_5}{50} + 8 + \frac{V_3 - V_4}{20} = 6 + \cancel{\frac{V_1 - V_3}{10}}$$

$$\therefore \frac{V_1}{40} + 4 + \frac{V_2}{50} + 8 + \frac{V_3 - V_4}{20} = 6$$

$$\left[\frac{V_1}{40} + \frac{V_2}{50} + \frac{V_3 - 200}{20} = -6\right] \times 200 \text{ (for simplification)}$$

$$5V_1 + 4V_2 + 10V_3 - 2000 = -1200$$

$\boxed{5V_1 + 4V_2 + 10V_3 = 800}$ — [6]

$\therefore 5(V_2+400) + 4V_2 + 10V_3 = 800$

$$\therefore \boxed{9V_2 + 10V_3 = -1200} \text{ — [7]}$$

$$\boxed{V_2 - 5V_3 = -800} \text{ — [4]-a [× 2]}$$

$$\therefore \boxed{2V_2 - 10V_3 = -1600} \text{ — [8]}$$

solving eq-[7] and eq-[8]:-

$\therefore$ ~~[7]+[8]~~ $11V_2 = -2800$ $\boxed{V_2 = -254.54V}$

$V_1 - V_2 = 400$ $\therefore$ $\boxed{V_1 = 145.45V}$

$\boxed{V_3 = 109.092V}$

$$\therefore I = \frac{V_1}{40} = \frac{145.45}{40}$$

$$\therefore \boxed{I = 3.63A}$$

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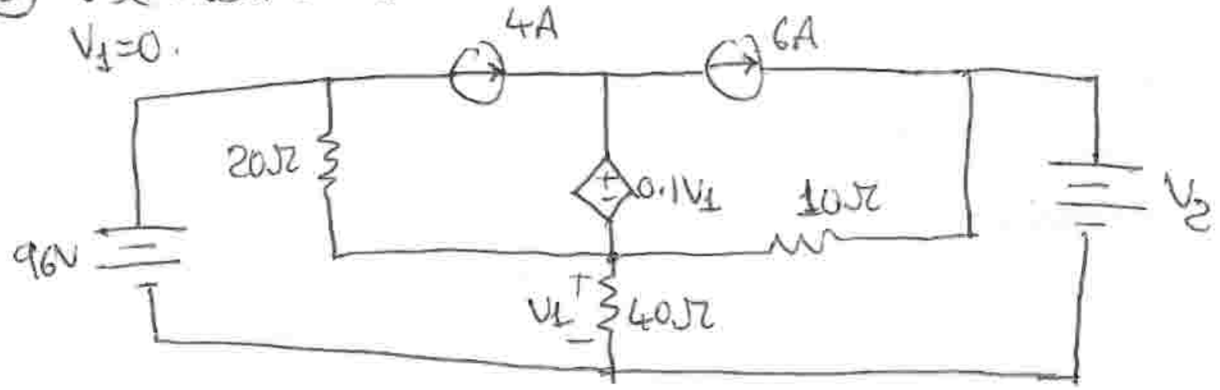
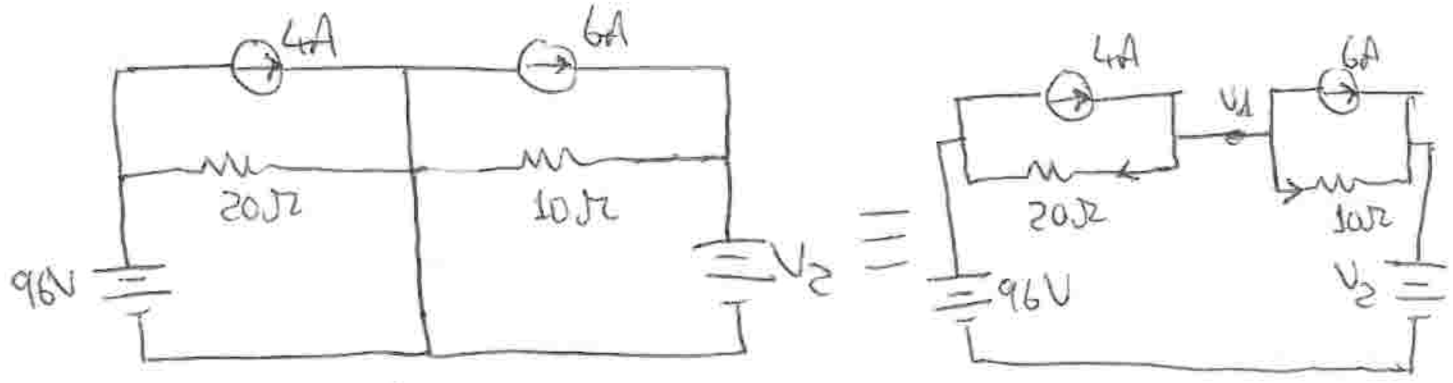
③ Use nodal analysis to determine the value of V_2 which will result $V_1 = 0$.



With $V_1 = 0$; the circuit can be redrawn as:- $(0.1V_1)$ voltage source, ~~short~~ gets shorted, so also 40Ω.



With V_1 as node applying KCL:-

$$\frac{V_1 - 96}{20} + \frac{V_1 - V_2}{10} + 6 = 4 \quad \boxed{\text{As } V_1 = 0}$$

$$\frac{-96}{20} - \frac{V_2}{10} = -2 \qquad \frac{V_2}{10} = -\frac{96}{20} + 2 \qquad \therefore \boxed{V_2 = -28V}$$

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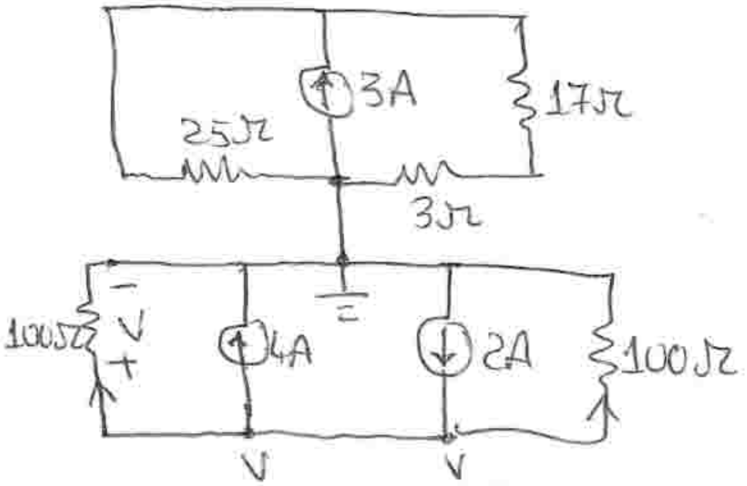
(4) Determine the voltage labeled 'v' using nodal analysis.



In this ckt., 3A current source supplies current to the top part of the circuit and returns to ground. So, to find 'v' we need to consider, bottom part of the circuit only. Considering node 'v' at the bottom of the circuit, and applying KCL at this node we get:-

$$\frac{v}{100} + \frac{v}{100} + 4 = 2$$

$$\frac{2v}{100} = -2 \qquad \therefore \boxed{v = -100V}$$

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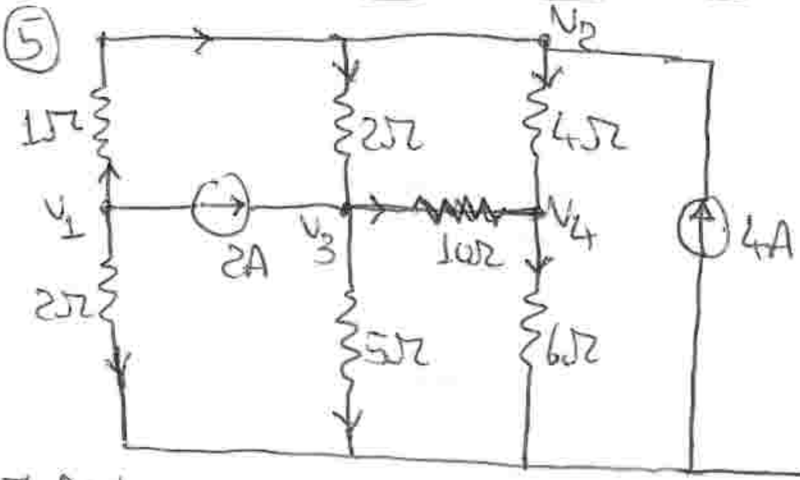
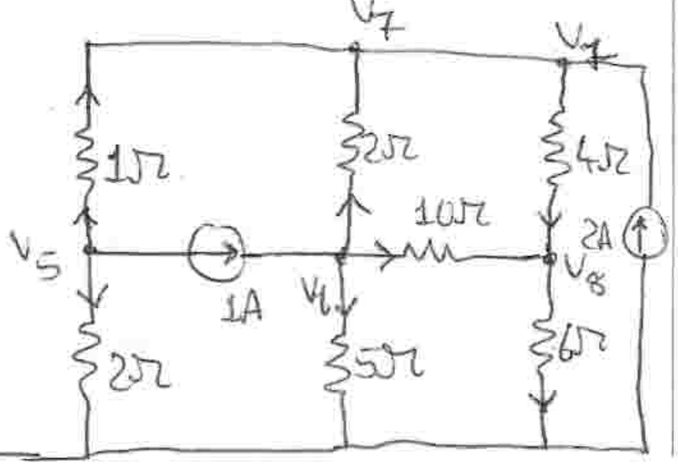
(5)





a] Applying KCL at node V_1:-

$$\boxed{\frac{V_1 - V_2}{1} + \frac{V_1}{2} + 2 = 0} \quad \text{— [1]}$$

b] At node V_2:-

$$\boxed{\frac{V_1 - V_2}{1} + 4 = \frac{V_2 - V_3}{2} + \frac{V_2 - V_4}{4}} \quad \text{— [2]}$$

c] At node V_3:-

$$\boxed{\frac{V_2 - V_3}{2} + 2 = \frac{V_3 - V_4}{10} + \frac{V_3}{5}} \quad \text{— [3]}$$

d] At node V_4:-

$$\boxed{\frac{V_3 - V_4}{10} + \frac{V_2 - V_4}{4} \cancel{+2} = \frac{V_4}{6}} \quad \text{— [4]}$$

Note:- The 2 parts of the circuit can be considered, separate and nodal eqns. can be solved to get V_1 to V_4 from the 1st part of the ckt. and similarly, V_5 to V_8 can be solved by nodal eqns. from 2nd part of ckt e] At node V_5:- $\boxed{\frac{V_5}{2} + \frac{V_5 - V_7}{1} + 1 = 0}$ — [5]

f] At node V_6:- $\boxed{\frac{V_6}{5} + \frac{V_6 - V_7}{2} + \frac{V_6 - V_8}{10} = 1}$ — [6]

g] At node V_7:- $\boxed{\frac{V_7 - V_8}{4} = \frac{V_5 - V_7}{1} + 2 + \frac{V_6 - V_7}{2}}$ — [7]

h] At node V_8:- $\boxed{\frac{V_6 - V_8}{10} + \frac{V_7 - V_8}{4} = \frac{V_8}{6}}$ — [8]

Solving eq-[1] to [4] we get:- $\boxed{V_1 = 3.37V}$ $\boxed{V_2 = 7.055V}$ $\boxed{V_3 = 7.518V}$ $\boxed{V_4 = 4.869V}$

Solving eq-[5] to [8] we get:- $\boxed{V_5 = 1.685V}$ $\boxed{V_6 = 3.759V}$ $\boxed{V_7 = 3.527V}$ $\boxed{V_8 = 2.434V}$

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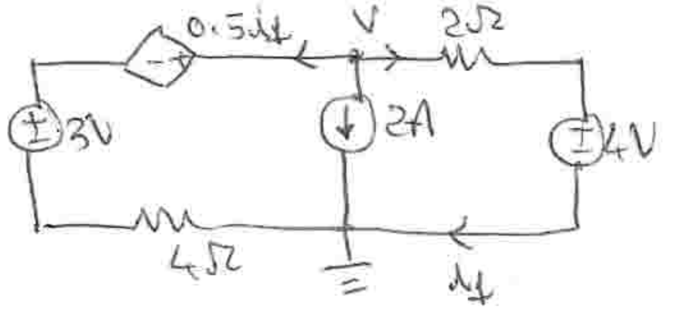
6) For the Ckt. shown find the current 'i_1'.



Applying KCL at V,

$$\boxed{\frac{V - 0.5i_1 - 3}{4} + 2 + \frac{V-4}{2} = 0} \quad -[1]$$

also, $\boxed{i_1 = \frac{V-4}{2}}$ -(2)

$$\frac{V}{4} - \frac{0.5}{4}\left(\frac{V-4}{2}\right) - \frac{3}{4} + 2 + \frac{V}{2} - 2 = 0$$

$2V - 0.5V + 2 - 6 + 4V = 0$ $\quad$ $6V - 0.5V = 4$ $\quad$ $5.5V = 4$

$\boxed{V = 0.727V}$

$\therefore i_1 = \frac{V-4}{2} = \frac{0.727-4}{2}$

$\therefore \boxed{i_1 = -1.636A}$

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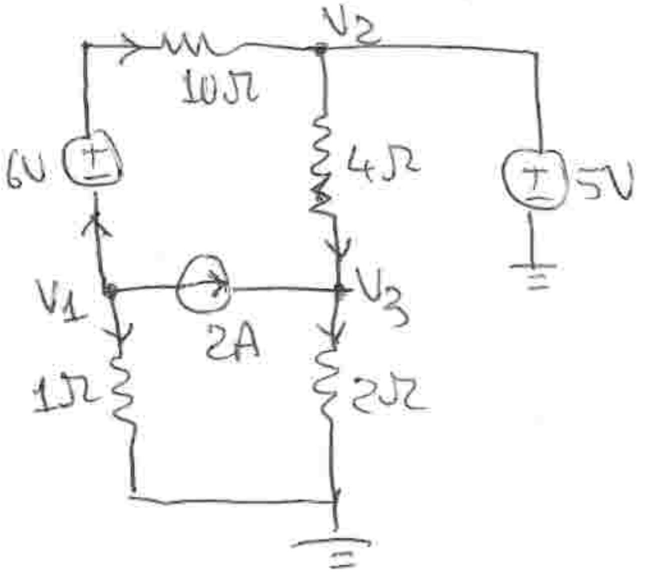
(7) Determine all the nodal voltages in the circuit shown.



we have, $\boxed{V_2 = 5V}$

Applying KCL at node V_1:-

$$\boxed{\frac{V_1 + 6 - V_2}{10} + \frac{V_1}{1} + 2 = 0} \quad -[1]$$

× by 10

$$V_1 + 6 - \overset{=5V}{V_2} + 10V_1 + 20 = 0$$

$$V_1 + 1 + 10V_1 + 20 = 0$$

$$11V_1 = -21 \qquad \boxed{V_1 = \frac{-21}{11} = -1.909V}$$

Applying KCL at node V_3:-

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

$$V_2 - V_3 + 8 = 2V_3 \qquad 3V_3 = V_2 + 8 \qquad \therefore\ 3V_3 = 8 + 5 = 13$$

$$\therefore \boxed{V_3 = 4.333V}$$

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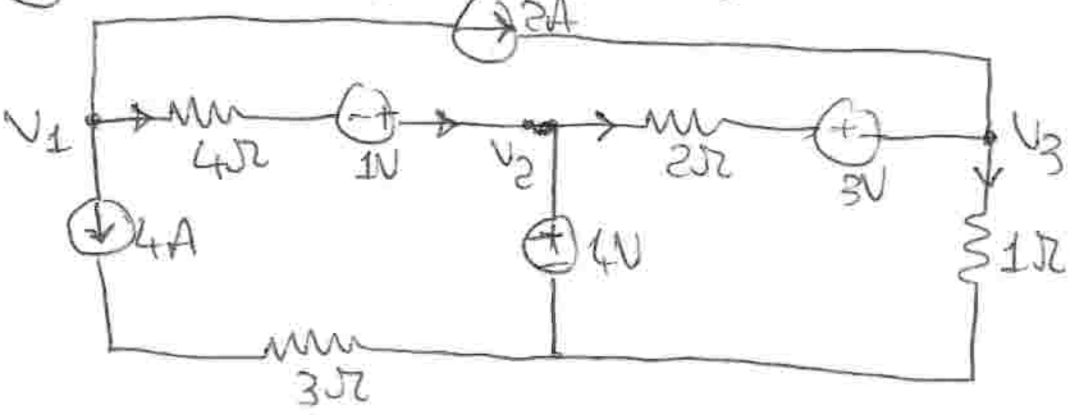
(8) Determine the power supplied by 2A current source (use nodal analysis).



we have,

$\boxed{V_2 = 4V}$

3Ω in series with 4A current source can be neglected.

Applying KCL at node V_1:-

$$\boxed{\frac{V_1 + 1 - V_2}{4} + 4 + 2 = 0} \quad -[1]$$

$$\therefore \frac{V_1 + 1 - 4}{4} + 6 = 0$$

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

$$V_1 - 3 + 24 = 0$$

$$\boxed{V_1 = -21V}$$

Applying KCL at node V_3:- $\boxed{\frac{V_2-3-V_3}{2}+2=\frac{V_3}{1}}$ —[1]

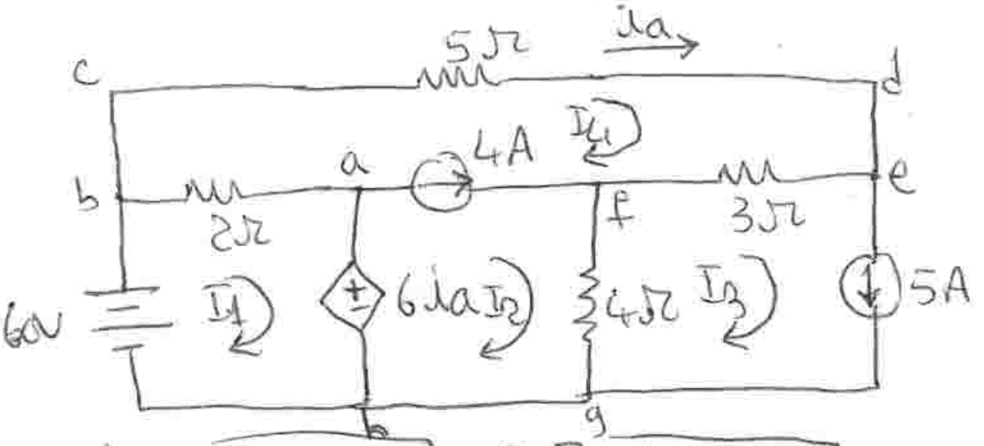
$\frac{4-3-V_3}{2}+2=\frac{V_3}{1}$ $\therefore$ $\frac{1-V_3}{2}+2=V_3$

$\therefore$ $1-V_3+4=2V_3$ $\therefore$ $3V_3=5$ $\boxed{V_3=1.667V}$

$\therefore$ Potential difference across 2A current source $=(V_1-V_3)$
$=-22.667V$

$\therefore$ Power supplied by 2A current source $=(-22.667)(2)=-45.33W$
or $\boxed{\text{Power supplied}=45.33W}$

(9) Calculate the power being dissipated by 2Ω resistor for the circuit shown (employ mesh analysis).



The four mesh currents are assumed as shown.

we have, $\boxed{I_4=i_a}$ —[1] $\boxed{I_3=5A}$ —[2]

Applying KVL to mesh I_1:- $60-2(I_1-i_a)-6i_a=0$

$60-2I_1-4i_a=0$ $2I_1+4i_a=60$ $\therefore$ $\boxed{I_1+2i_a=30}$ —[3]

Applying KVL to supermesh I_2-I_4 (h-a-b-c-d-e-f-g-h):-

$\boxed{+6i_a-2(i_a-I_1)-5i_a-3(i_a-5)-4(I_2-I_3)=0}$ —[4] but, I_2

From eq-[2] and [5]

$I_2-i_a=4$

$\therefore$ $\boxed{I_2=i_a+4}$ —[5]

$4i_a + 2I_1 - 5i_a - 3i_a + 15 - 4(i_a + 4 - 5) = 0$

$2I_1 - 4i_a + 15 - 4(i_a - 1) = 0$

$\therefore \boxed{2I_1 - 8i_a = -19}$ — [6] solving eq-[4] and eq-[6]:-

$\boxed{I_1 = 16.833A}$ $\boxed{i_a = 6.583A}$

$\therefore$ Power dissipated by 2Ω resistor $= (I_1 - i_a)^2 [2\Omega]$

$\therefore P_{2\Omega} = (16.833 - 6.583)^2 (2) = (10.25)^2 (2)$

$\therefore \boxed{P_{2\Omega} = 210.125W}$

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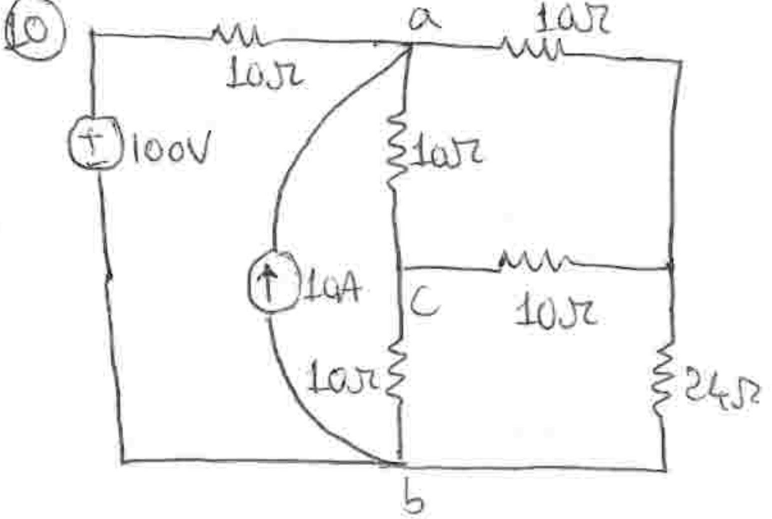
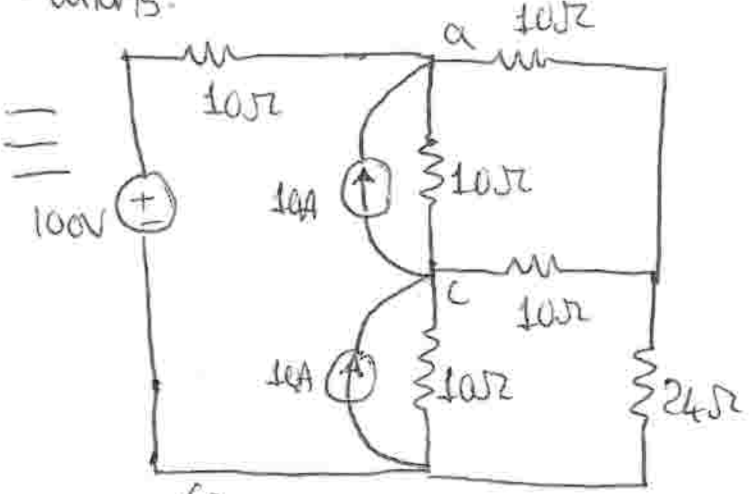
9 In the circuit shown, find the current through 24Ω, using mesh analysis, source-shifting, and source transformations.

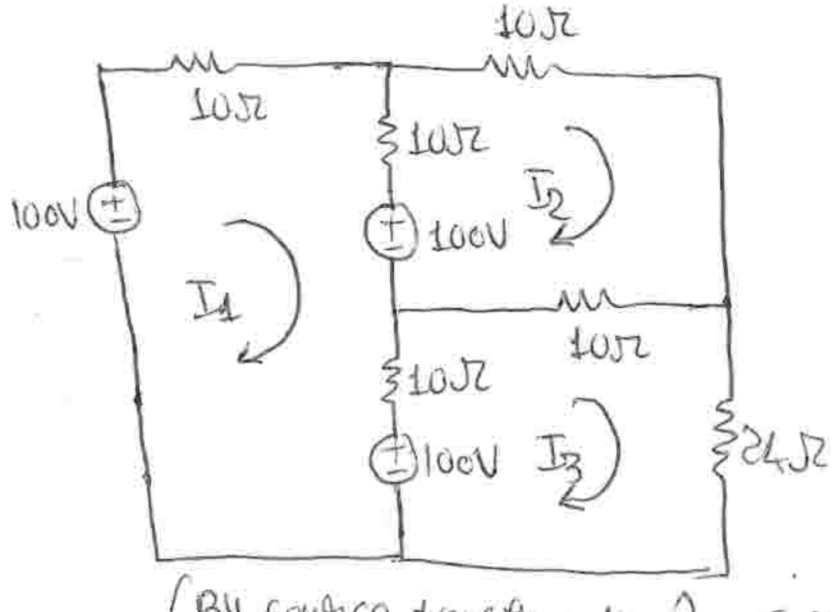
10



$\equiv$



(By source-shifting)



(By source-transformations)

Applying KVL to mesh-I_1:-

$+100 - 10I_1 - 200 - 10(I_1 - I_2) - 10(I_1 - I_3) = 0$

$-100 = 10I_1 + 10(I_1 - I_2) + 10(I_1 - I_3)$

$\therefore 30I_1 - 10I_2 - 10I_3 = -100$

$\boxed{3I_1 - I_2 - I_3 = -10}$ — [1]

Applying KVL to mesh-I_2:- $-10I_2-10(I_2-I_3)-10(I_2-I_1)+100=0$

$$10I_2+10(I_2-I_3)+10(I_2-I_1)=100$$

$$-10I_1+30I_2-10I_3=100 \quad \therefore \boxed{-I_1+3I_2-I_3=10} \text{ — [2]}$$

Applying KVL to mesh-I_3:-

$$-24I_3+100-10(I_3-I_1)-10(I_3-I_2)=0$$

$$24I_3+10(I_3-I_1)+10(I_3-I_2)=100$$

$$-10I_1-10I_2+44I_3=100 \quad \therefore \boxed{-5I_1-5I_2+22I_3=50} \text{ — [3]}$$

Solving equns. -[1], [2], and [3] for I_3 we get

$\boxed{I_3 = \text{Current through } 24\Omega = 2.94A}$

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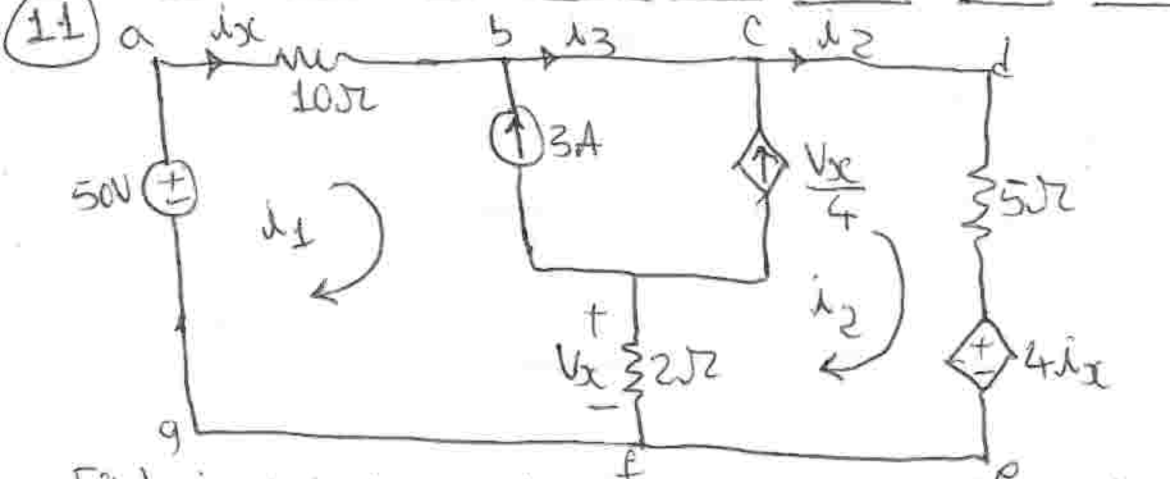
(11)



mesh currents are assumed as shown.

Note:- $\boxed{i_1 = i_x}$

Find i_x and V_x in the circuit using mesh analysis.

$\therefore \boxed{V_x = 2(i_x - i_2)}$ — [1] $\quad \boxed{i_3 = i_x + 3}$ — [2] $\quad \boxed{i_2 = i_3 + \frac{V_x}{4}}$ — [3]

$$\therefore \boxed{i_2 = i_x + 3 + \frac{2(i_x-i_2)}{4}} \text{ — [4]}$$

$$i_2 = i_x + 3 + \frac{(i_x-i_2)}{2}$$

$$2i_2 = 2i_x + 6 + i_x - i_2$$

$$\therefore -3i_x + 3i_2 = 6 \quad \therefore \boxed{-i_x + i_2 = 2} \text{ — [5]}$$

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Applying KVL to mesh a-b-c-d-e-f-g-a :-

$50 - 10i_x - 5i_2 - 4i_x = 0$; $\boxed{14i_x + 5i_2 = 50}$ — [6]

Solving eqⁿ-[5] and [6] :-

$\boxed{i_x = 2.105A}$ $\boxed{i_2 = 4.105A}$

$\therefore V_x = 2(i_x - i_2) = 2(2.105 - 4.105)$

$\therefore \boxed{V_x = -4V}$

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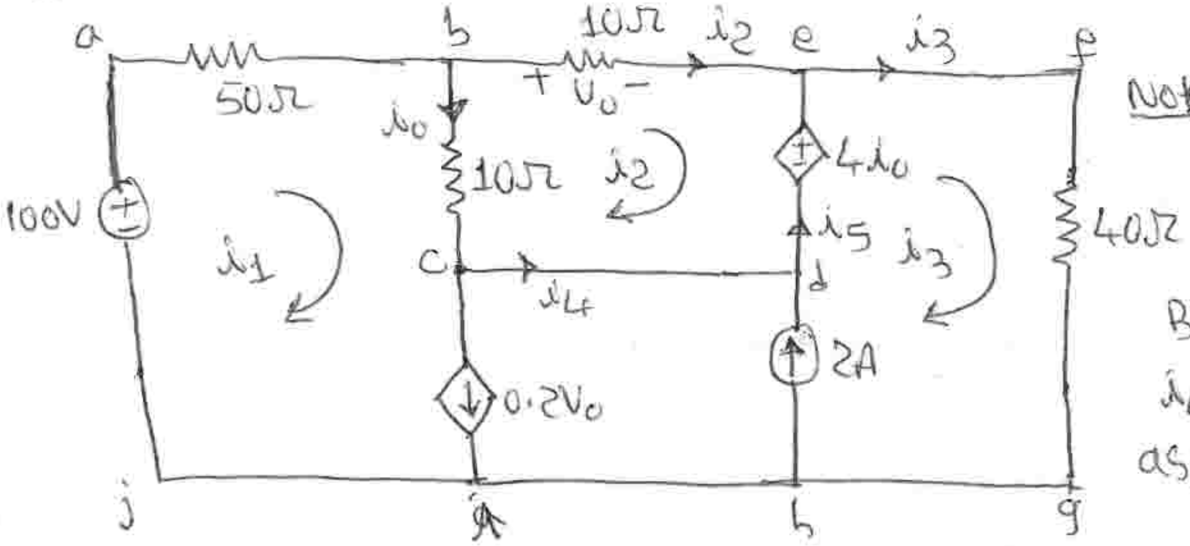
(12) Find V_0 and i_0 in the circuit shown using mesh analysis.



Note:- mesh currents i_1, i_2 and i_3 are assumed. Branch currents i_4 and i_5 are also assumed.

We have:- $\boxed{i_0 = (i_1 - i_2)}$ — [1] $\boxed{V_0 = 10i_2}$ — [2]

Applying KCL at node-C :- $i_0 = 0.2V_0 + i_4$

$\therefore i_4 = i_0 - 0.2V_0 = i_0 - 0.2(10i_2) = i_1 - i_2 - 2i_2$

$\therefore \boxed{i_4 = (i_1 - 3i_2)}$ — [3]

Applying KCL at node d :- $\boxed{i_5 = i_4 + 2}$ — [4]

$\boxed{i_5 = i_1 - 3i_2 + 2}$ — [5]

Applying KCL at node e :- $\boxed{i_3 = i_2 + i_5}$ — [6]

$i_3 = i_2 + i_1 - 3i_2 + 2$

$\boxed{i_3 = i_1 - 2i_2 + 2}$ — [7]

Applying KVL to mesh-I_2:- $-10i_2 - 4i_0 - 10(i_2 - i_1) = 0$

$$-10i_2 - 4(i_1 - i_2) - 10i_2 + 10i_1 = 0$$

$$\boxed{6i_1 - 16i_2 = 0} \text{ — [8]}$$

Applying KVL to supermesh → a-b-c-d-e-f-g-h-i-j-a:-

$$100 - 50i_1 - 10i_0 + 4i_0 - 40i_3 = 0$$

$$100 - 50i_1 - 6(i_1 - i_2) - 40i_3 = 0$$

$$100 - 56i_1 + 6i_2 - 40i_3 = 0 \qquad \boxed{56i_1 - 6i_2 + 40i_3 = 100} \text{ — [9]}$$

From eq-[7]:- $56i_1 - 6i_2 + 40(i_1 - 2i_2 + 2) = 100$

$$\boxed{96i_1 - 86i_2 = 20} \text{ — [10]}$$

Solving eq-[8] and [10]:- $\therefore \boxed{i_1 = 0.3137A}$ $\boxed{i_2 = 0.11764A}$

$\therefore \boxed{i_0 = (i_1 - i_2) = 0.196A}$ $V_0 = 10i_2$

$\therefore \boxed{V_0 = 1.1764V}$

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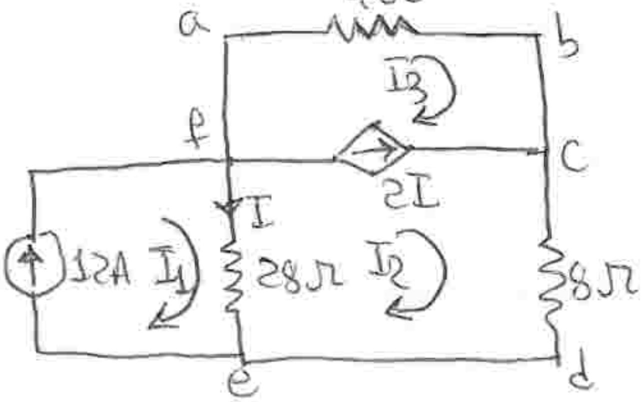
(13) Find the current 'I' using mesh analysis for the circuit shown.



we have:- $\boxed{(I_1 - I_2) = I}$ — [1]

$\boxed{I_2 - I_3 = 2I}$ — [2]

$\boxed{I_2 - I_3 = 2(I_1 - I_2)}$ — [3]

$\boxed{2I_1 - 3I_2 + I_3 = 0}$ — [4]

$\boxed{I_1 = 12A}$ — [5] by inspection

Putting eq-[5] in [4]:-

$\therefore 24 - 3I_2 + I_3 = 0$

$\boxed{3I_2 - I_3 = 24}$ — [6]

Applying KVL to supermesh → a-b-c-d-e-f-a :-

$-8I_2 - 28(I_2 - I_1) - 4I_3 = 0$

$-36I_2 + 28I_1 - 4I_3 = 0$

$36I_2 + 4I_3 = 28I_1 \quad [\because I_1 = 12A]$

$\therefore 36I_2 + 4I_3 = 28(12)$

$\therefore 36I_2 + 4I_3 = 336 \quad \therefore \boxed{9I_2 + I_3 = 84}$ — [7]

Solving eq-[6] and [7] :- $\boxed{I_2 = 9A}$ $\boxed{I_3 = 3A}$

$\therefore I = (I_1 - I_2) = (12 - 9)$

$\therefore \boxed{I = 3A}$

---

(14) The voltage of a node in a network is given by:-

$$V_2 = \frac{\begin{vmatrix} 2 & 1 & -1 \\ -1 & 0 & -1 \\ -1 & 1 & 2 \end{vmatrix}}{\begin{vmatrix} 2 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 2 \end{vmatrix}}$$

Construct the network.

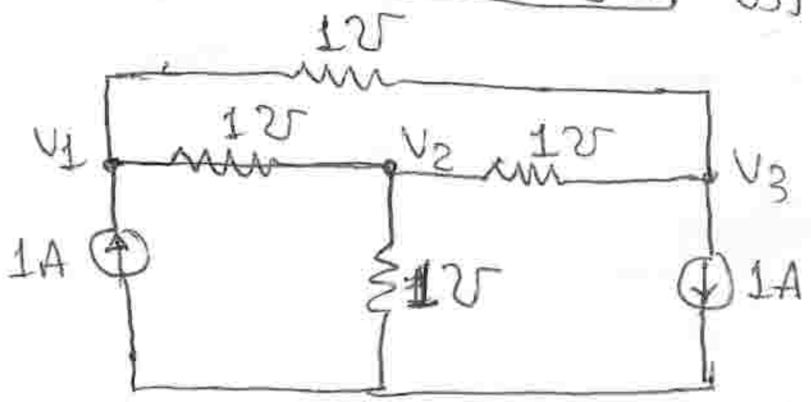
$\therefore \boxed{V_2 = \frac{\Delta_2}{\Delta}}$

In the numerator, Δ_2 is obtained, by replacing the 2nd column by the current sources present. Thus, the nodal equns. are given by:-

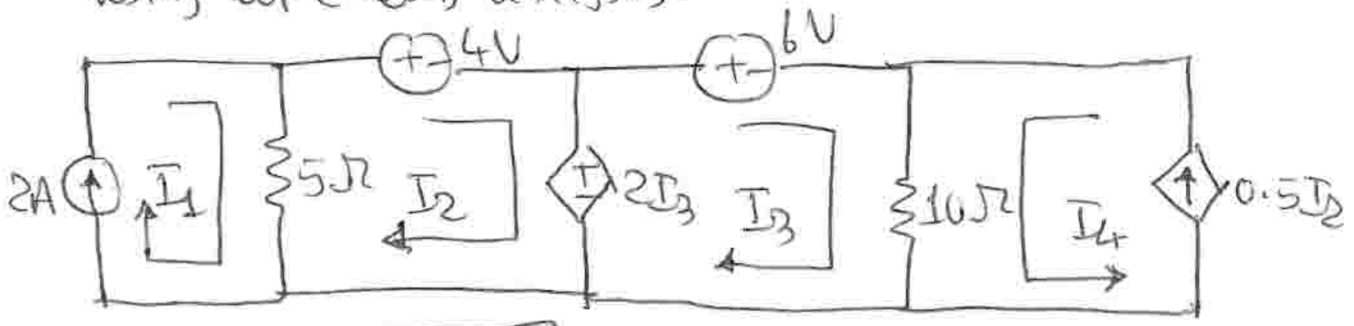
$\boxed{2V_1 - V_2 - V_3 = 1}$ — [1]

$\boxed{-V_1 + 3V_2 - V_3 = 0}$ — [2]

$\boxed{-V_1 - V_2 + 2V_3 = 1}$ — [3]



(15) Find the power delivered by the 6V source in the circuit shown using loop (mesh) analysis.



We have:- $\boxed{I_1 = 2A}$ — [1] $\boxed{I_4 = 0.5 I_2}$ — [2]

Applying KVL to mesh-I_2:- $-4 - 2I_3 - 5(I_2 - I_1) = 0$

$-4 - 2I_3 - 5I_2 + 10 = 0$ $\therefore \boxed{5I_2 + 2I_3 = 6}$ — [3]

Applying KVL to mesh-I_3:- $-10(I_3 + I_4) - 6 + 2I_3 = 0$

$-10I_3 - 10(0.5I_2) - 6 + 2I_3 = 0$

$-10I_3 - 5I_2 - 6 + 2I_3 = 0$ $\therefore \boxed{-5I_2 - 8I_3 = +6}$ — [4]

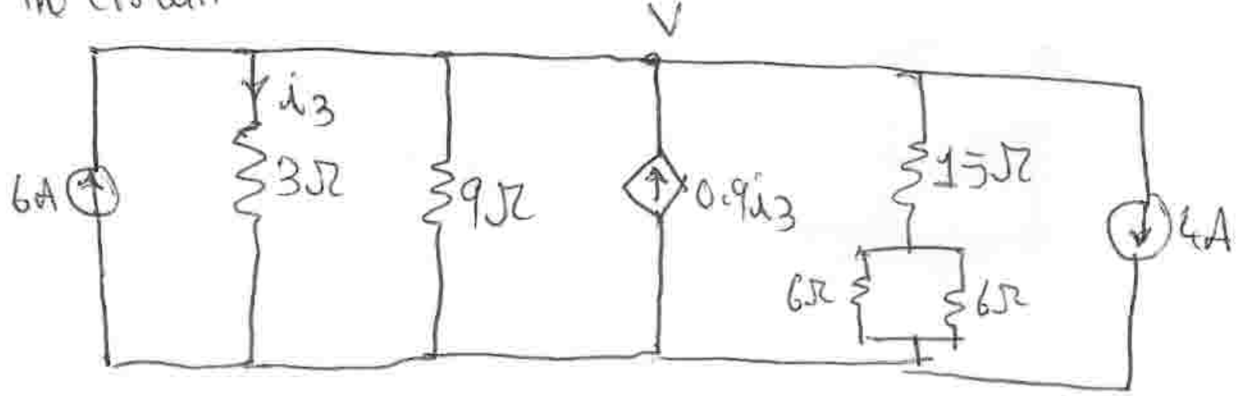
Solving eq-[3] and [4]:- $-6I_3 = 12$ $\boxed{I_3 = -2A}$

$\boxed{I_2 = 2A}$

$\therefore$ $\boxed{\text{Power delivered} = (-6V)(-2A) = 12W}$ → supplied power

(current I_3 enters the negative terminal of the battery 6V)

(16) Calculate the voltage and power output of the dependent source shown in the circuit.



Applying KCL at node-V:

$$\boxed{6 + 0.9 i_3 = \frac{V}{3} + \frac{V}{9} + \frac{V}{18} + 4} \quad \text{--- [1]}$$

$$\boxed{i_3 = \frac{V}{3}} \quad \text{--- [2]}$$

$$\boxed{6 + 0.3V = \frac{V}{3} + \frac{V}{9} + \frac{V}{18} + 4} \quad \text{--- [3]} \times 18$$

$$108 + 5.4V = 6V + 2V + V + 72$$

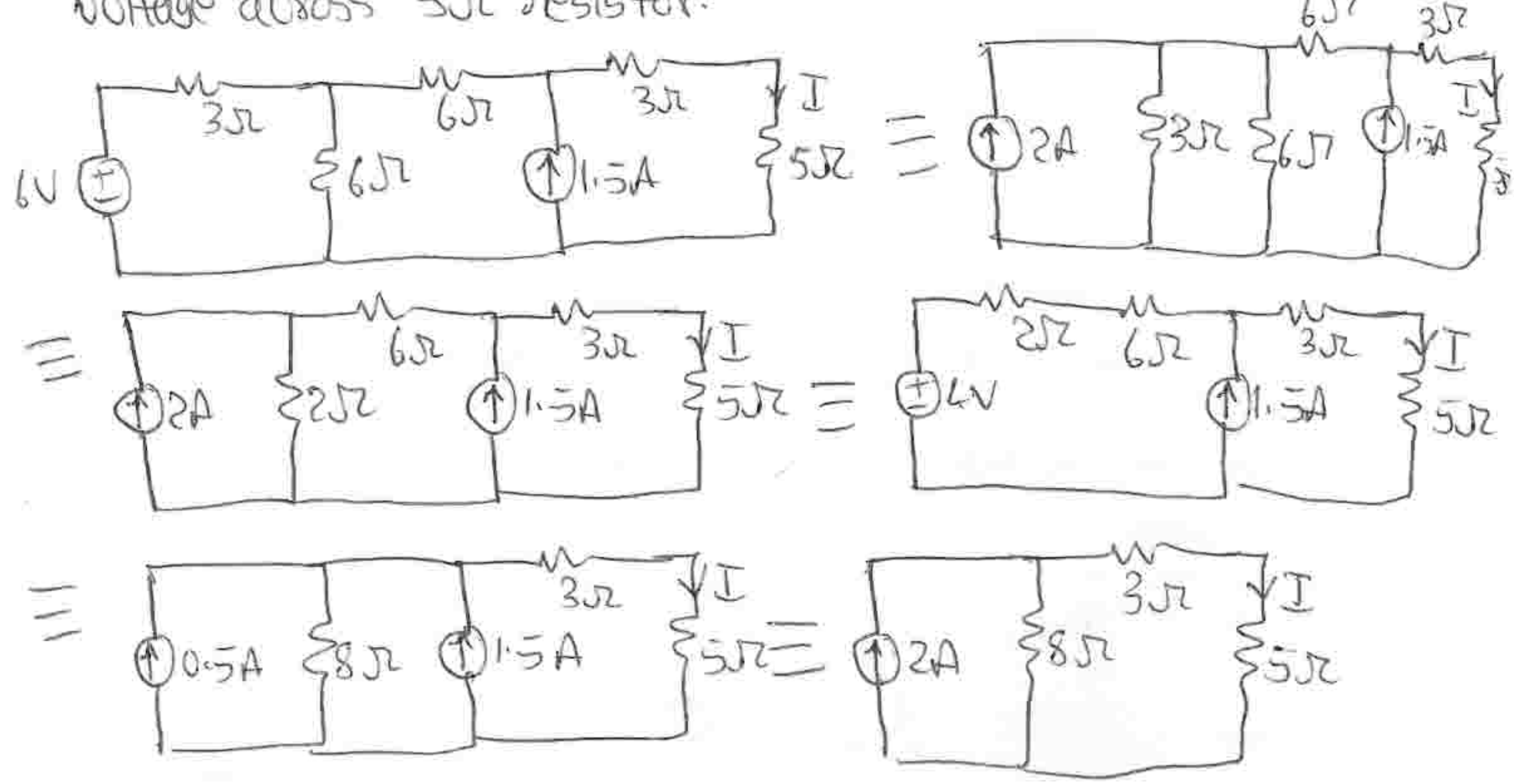
$$\therefore 9V - 5.4V = 108 - 72 \quad \therefore 3.6V = 36$$

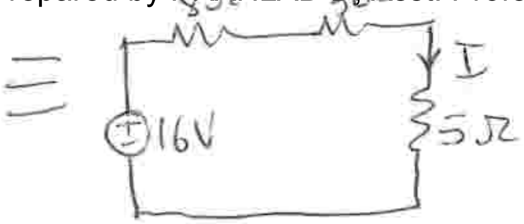
$$\therefore \boxed{V = 10V}$$

$\boxed{\text{Voltage o/p of dependent source} = 10V = V}$

Power o/p $= (0.9 i_3) V = \frac{(0.9)(V)}{3} \times 10 = \frac{100 \times 0.9}{3} = \boxed{30W}$

(17) Using repeated source transformation, find the current through and voltage across 5Ω resistor.

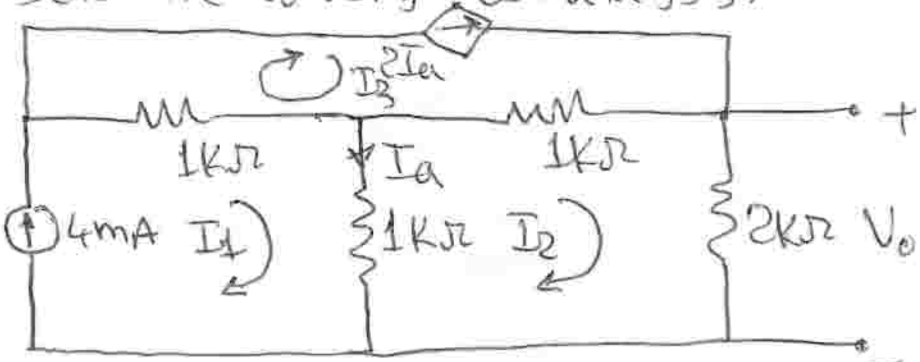




$I_{5\Omega} = \frac{16}{8+3+5} = \frac{16}{16}$

$\boxed{I_{5\Omega} = 1A}$ $\boxed{V_{5\Omega} = I_{5\Omega}(5\Omega) = 5V}$

(18) Determine V_o using mesh analysis.



we have:-

$\boxed{I_a = (I_1 - I_2)}$ —[1]

$\boxed{I_3 = 2I_a}$ —[2]

$\boxed{I_1 = 4mA}$ —[3]

Applying KVL to mesh-I_2:-

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

$2I_2 + 1(I_2 - 4) + 1(I_2 - 2I_a) = 0$

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

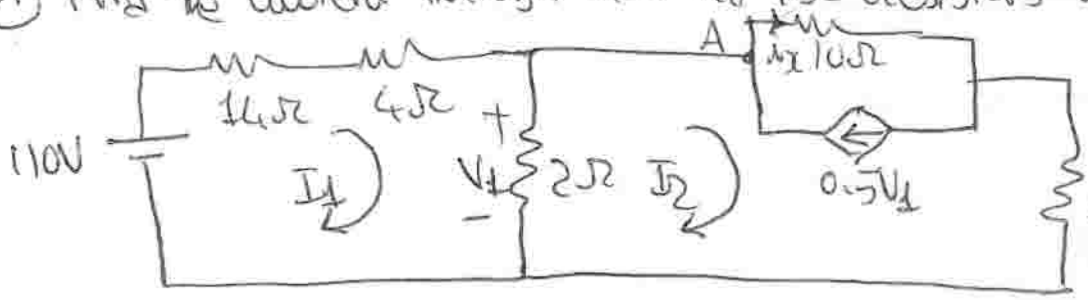
$3I_2 - 4 + I_2 - 2I_1 + 2I_2 = 0$

$\boxed{6I_2 - 2I_1 = 4}$ —[4] $\therefore 6I_2 = 4 + 2I_1$

$\therefore 6I_2 = 4 + 2(4) = 12$ $\therefore \boxed{I_2 = 2mA}$

$\therefore V_o = (I_2)(2K\Omega) = (2mA)(2K\Omega)$ $\therefore \boxed{V_o = 4V}$

(19) Find the current through 4Ω and 6Ω resistors using mesh analysis.



we have

$\boxed{V_1 = 2(I_1 - I_2)}$ —[2]

Applying KCL at node-A:-

$\boxed{I_2 + 0.5V_1 = i_x}$ —[1]

$i_x = I_2 + 0.5[2(I_1 - I_2)] = I_2 + 0.5[2I_1 - 2I_2]$

$\therefore i_x = I_2 + I_1 - I_2 \quad \therefore \boxed{i_x = I_1}$ — [3]

Applying KVL to mesh I_1:— $110 - 18I_1 - 2(I_1 - I_2) = 0$

$18I_1 + 2(I_1 - I_2) = 110$

$\therefore 20I_1 - 2I_2 = 110 \quad \therefore \boxed{10I_1 - I_2 = 55}$ — [4]

Applying KVL to mesh I_2 (supermesh bypassing current source $0.5V_0$):— ~~$10i_x - 6I_2$~~

$-10i_x - 6I_2 - 2(I_2 - I_1) = 0$

$-10I_1 - 6I_2 - 2I_2 + 2I_1 = 0$

$\therefore 8I_1 + 8I_2 = 0$

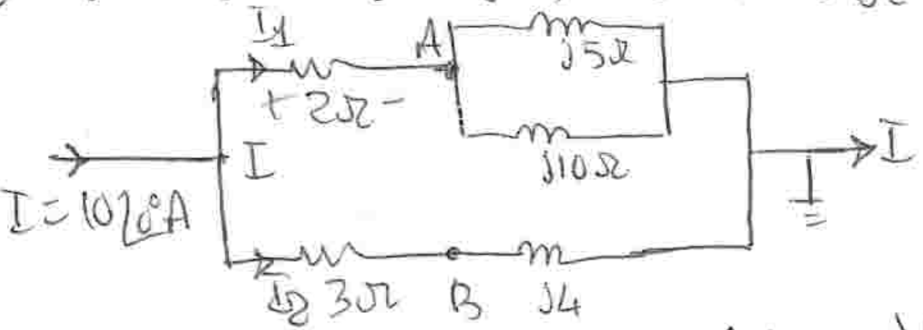
$\boxed{I_1 + I_2 = 0}$ — [5] $\therefore \boxed{I_2 = -I_1}$

Solving eq [4] and [5]:— $10I_1 - (-I_1) = 55$

$\therefore 11I_1 = 55 \quad \therefore \boxed{I_1 = 5A}$ is the current through 4Ω.

$\boxed{I_2 = -5A}$ is the current through 6Ω.

(20) By using nodal analysis, find the voltage V_{AB} for the network shown.



Applying KCL at node I:— $10 = \frac{V_I}{2 + (j5 \| j10)} + \frac{V_I}{3 + j4}$

$$10 = \frac{V_I}{2 + \frac{(-50)}{j15}} + \frac{V_I}{3 + j4} = \frac{V_I}{2 + j3.333} + \frac{V_I}{3 + j4}$$

$$10 = V_I\left[\frac{1}{2 + j3.333} + \frac{1}{3 + j4}\right]$$

$$10 = V_I\left[\frac{2-j3.333}{15.1} + \frac{3-j4}{25}\right]$$

$$10 = V_I\left[0.1324 - j0.22 + 0.12 - j0.16\right]$$

$$10 = V_I\left[0.2524 - j0.38\right] \quad \therefore 10 = V_I\left[0.4562\angle{-56.4^\circ}\right]$$

$$\therefore \boxed{V_I = 21.92\angle 56.4^\circ}$$

$$\therefore I_1 = \frac{V_I}{2+j3.333} = \frac{21.92\angle 56.4^\circ}{3.887\angle 59.03^\circ} = \boxed{5.64\angle{-2.63^\circ}}$$

$$\therefore \boxed{I_1 = (5.634 - j0.2588)A}$$

$$\therefore I_2 = \frac{V_I}{3+j4} = \frac{21.92\angle 56.4^\circ}{5\angle 53.13^\circ} = \boxed{4.384\angle 3.27^\circ}$$

$$\therefore \boxed{I_2 = (4.377 + j0.25)A}$$

$\underline{V_{AB} = ?}$:- $+V_A + 2I_1 - 3I_2 - V_B = 0$

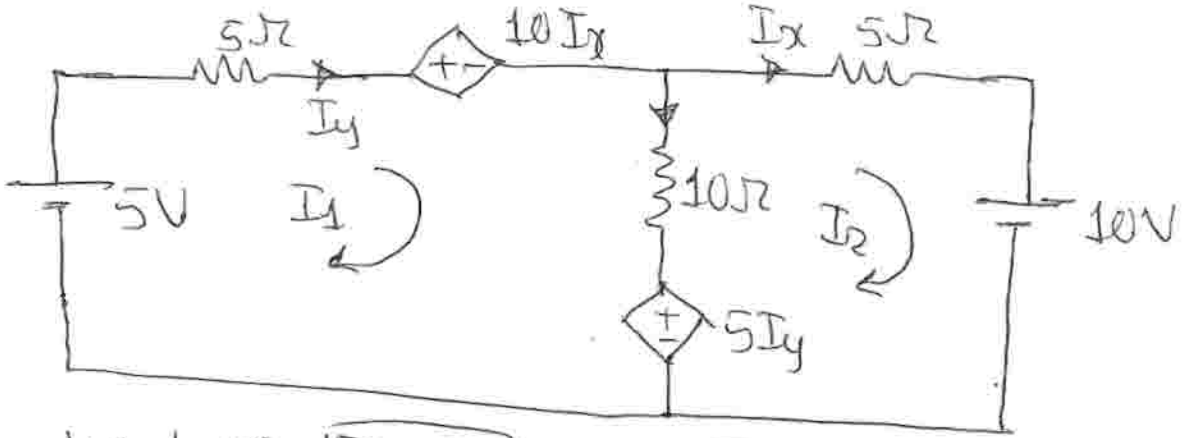
$$\therefore V_{AB} = 3I_2 - 2I_1$$

$$\therefore V_{AB} = 3\left[4.337 + j0.25\right] - 2\left[5.634 - j0.2588\right]$$

$$\therefore V_{AB} = 13.011 + j0.75 - 11.268 + j0.5176$$

$$\therefore \boxed{V_{AB} = (1.743 + j1.2676)V = 2.1552\angle 36^\circ}$$

(21) Using mesh analysis, find the current through 10Ω resistor in the network shown.



We have, $\boxed{I_1 = I_y}$ —[1] $\boxed{I_2 = I_x}$ —[2]

Applying KVL to mesh-I_1:-

$$+5 - 5I_1 - 10I_2 - 10(I_1 - I_2) - 5I_1 = 0$$

$$5 - 5I_1 - 10I_2 - 10I_1 + 10I_2 - 5I_1 = 0$$

$$5 - 10I_1 - 10I_1 = 0 \quad \therefore 20I_1 = 5 \quad \therefore \boxed{I_1 = 0.25A = I_y}$$

Applying KVL to mesh-I_2:-

$$-5I_2 - 10 + 5I_1 - 10(I_2 - I_1) = 0$$

$$-5I_2 - 10 + 5(0.25) - 10I_2 + 10(0.25) = 0$$

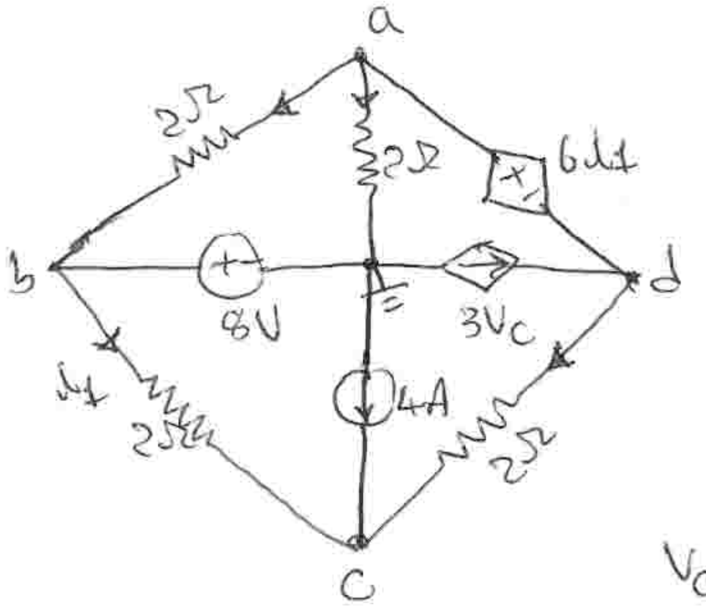
$$-5I_2 - 10 + 1.25 - 10I_2 + 2.5 = 0$$

$$15I_2 = -6.25 \quad \therefore \boxed{I_2 = -0.4167A = I_x}$$

$\therefore$ current through $10\Omega = I_{10\Omega} = (I_1 - I_2) = 0.25 - (-0.4167)$

$$\therefore \boxed{I_{10\Omega} = 0.667A}$$

(22) Find the node voltages V_d and V_c, and current i_1 in the circuit shown.



We have by inspection:-

$$\boxed{V_b = 8V} \quad -[1]$$

$$\boxed{i_1 = \frac{V_b - V_c}{2}} \quad -[2]$$

$$\boxed{V_a - V_d = 6i_1} \quad -[3]$$

From eq [2]:-

$$V_a - V_d = 6\frac{(V_b - V_c)}{2}$$

$$\therefore \boxed{V_a - V_d = 3(V_b - V_c)} \quad -[4]-a$$

$$\therefore V_a - V_d = 3V_b - 3V_c$$

$$\therefore \boxed{3V_c = 3V_b - V_a + V_d} \quad -[4]-b$$

Applying KCL at node -c:-

$$\boxed{i_1 + 4 + \frac{V_d - V_c}{2} = 0} \quad -[5]$$

From eq-[2] and [4]

$$\therefore \frac{V_b - V_c}{2} + 4 + \frac{V_a - 3V_b + 3V_c - V_c}{2} = 0$$

$$\therefore \frac{V_b - V_c}{2} + 4 + \frac{V_a - 3V_b + 2V_c}{2} = 0$$

$$\therefore V_b - V_c + 8 + V_a - 3V_b + 2V_c = 0$$

$$\therefore \boxed{V_a - 2V_b + V_c = -8} \quad -[6] \text{ From eq-[1]}$$

$$\therefore \boxed{V_a + V_c = 8} \quad -[7]$$

Applying KCL to supernode → a-d :-

$$\boxed{\frac{V_a-V_b}{2}+\frac{V_a}{2}+\frac{V_d-V_c}{2}=3V_c} \text{ —[8]}$$

$$\frac{V_a-V_b}{2}+\frac{V_a}{2}+\frac{V_d-V_c}{2}=3V_b-V_a+V_d$$

$$V_a-V_b+V_a+V_d-V_c=6V_b-2V_a+2V_d$$

$$V_a+V_a+2V_a-V_b-6V_b-V_c+V_d-2V_d=0$$

$$\boxed{4V_a-7V_b-V_c-V_d=0} \text{ —[9]}$$

$$4V_a-V_c-(V_a-3V_b+3V_c)=56$$

$$4V_a-V_a+3V_b-V_c-3V_c=56$$

$$3V_a-4V_c=56-3V_b$$

$$\therefore 3V_a-4V_c=56-24 \qquad \therefore \boxed{3V_a-4V_c=32} \text{ —[10]}$$

$$\boxed{V_a+V_c=8} \text{ —[7]} \times 4 \qquad \boxed{4V_a+4V_c=32} \text{ —[11]}$$

$$7V_a=64$$

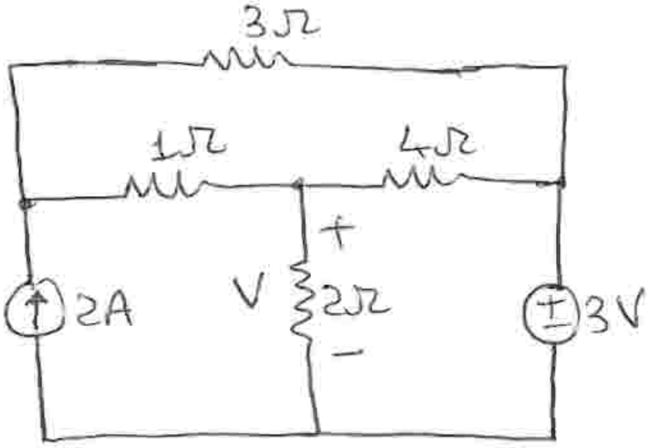
$$\boxed{V_a=9.142V}$$

$$i_1=\frac{V_b-V_c}{2} \qquad \boxed{V_c=-1.1428V} \qquad V_d=V_a-3V_b+3V_c$$

$$\therefore \boxed{i_1=4.57A} \qquad V_d=9.142-24+(-3.428)$$

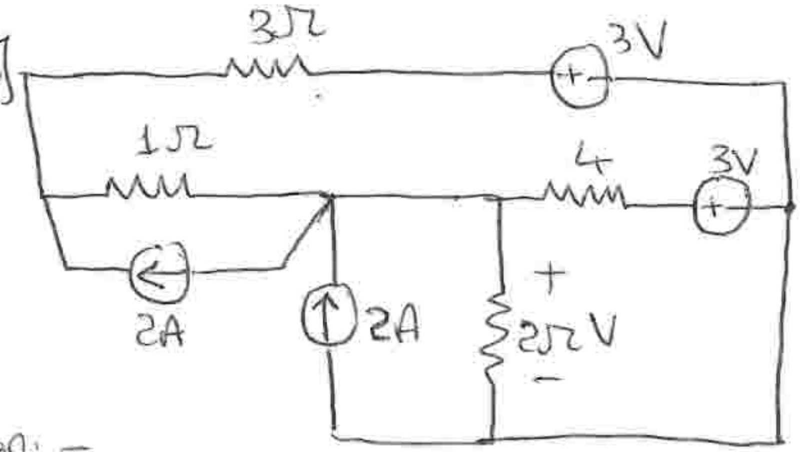
$$\therefore \boxed{V_d=-18.28V}$$

(23) In the circuit shown find the value of voltage 'v' using source transformation and/or source-shifting techniques only.

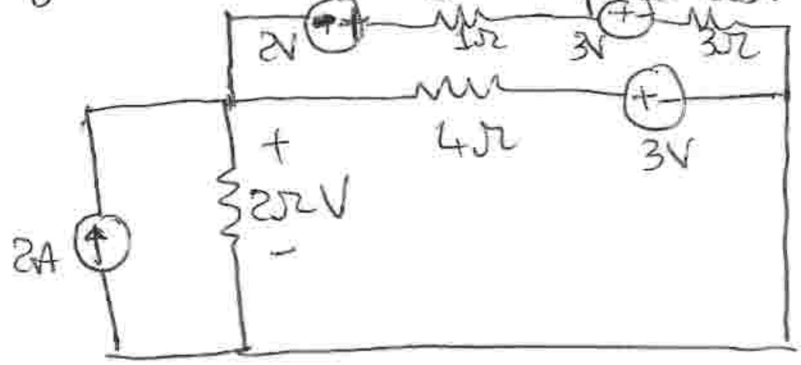


The circuit can be re-drawn, by shifting 2A current source and 3V voltage source as shown.

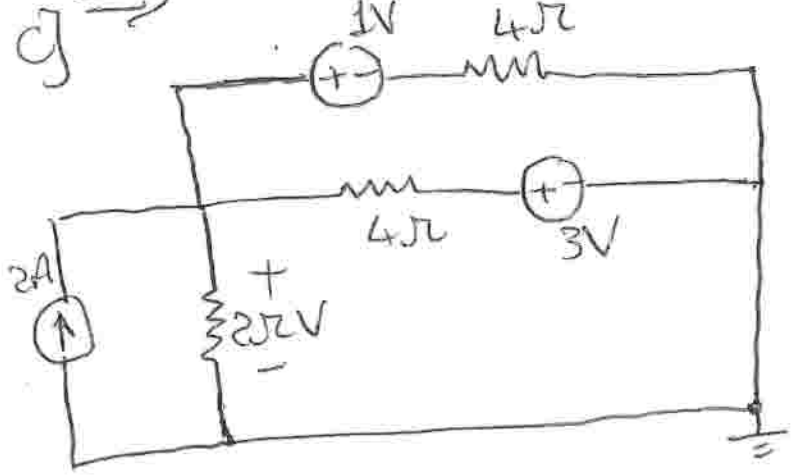
a]



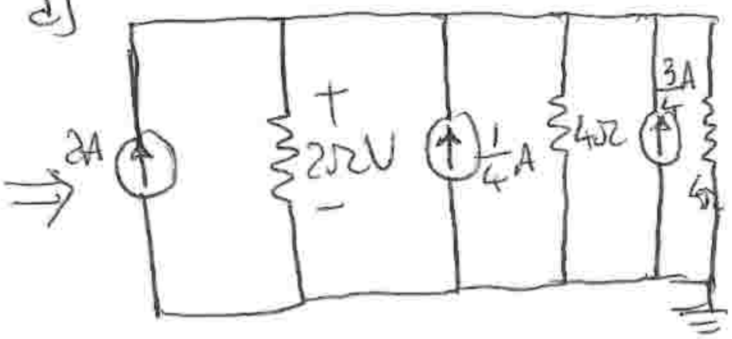
b] The circuit can be simplified as:-



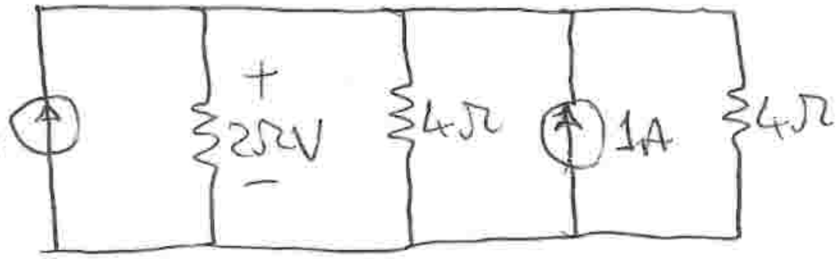
c] ⇒



d]

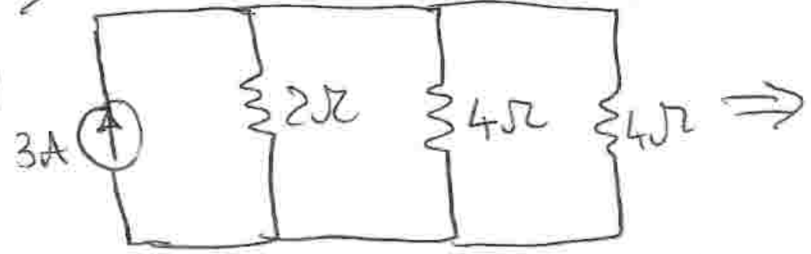


e]



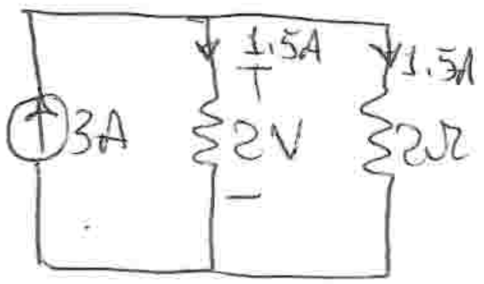
⇒

f]



⇒

g]



$\therefore \boxed{V = (1.5)(2) = 3V}$

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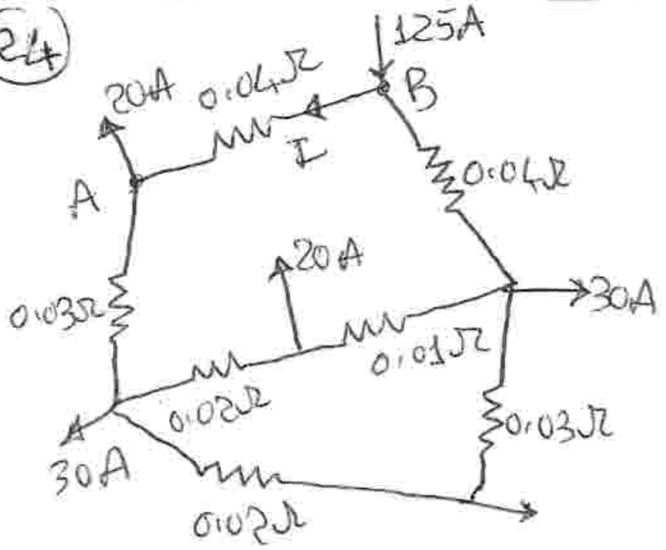
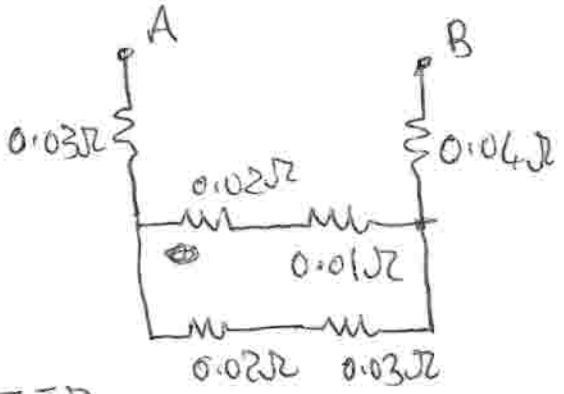
(24)



Use Thevinin's theorem to calculate current 'I' in the circuit shown.

To find R_{Th}, resis. 0.04Ω b/n A and B is open-circuited and all current sources reduced to zero.



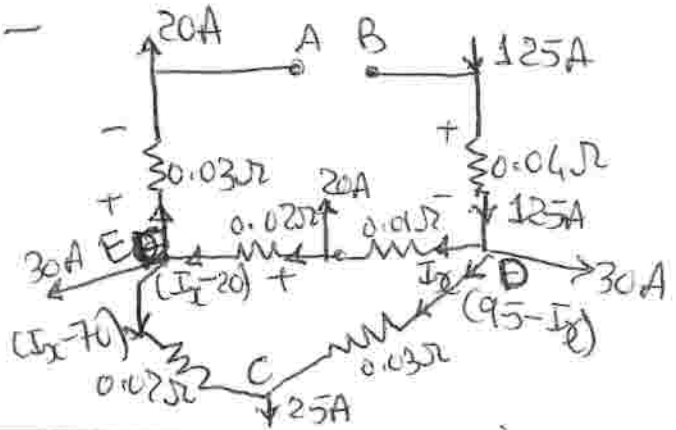
$R_{Th} = [(0.03) \| (0.05)]$

$+ 0.03 + 0.04$

$R_{Th} = 0.01875 + 0.07 = 0.08875\,\Omega$

or $\boxed{R_{Th} = 88.75\,m\Omega}$

To find V_{Th} :-



Applying KVL to loop CDE:-

$$-0.02(I_x-20) - I_x(0.01) + (0.03)(95-I_x) - 0.02(I_x-70) = 0$$

solving for $I_x = \frac{-4.65}{-0.08}$ ∴ $\boxed{I_x = 58.125A}$

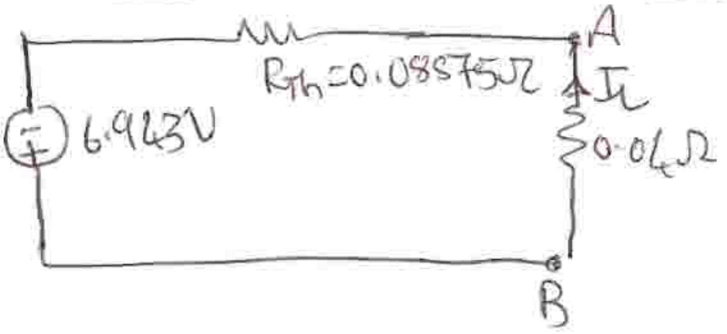
∴ ~~VAB~~ $V_{AB} = V_{Th} = ?$ Taking potential along the path A-E-D-B:-

$$+V_A + 20(0.03) + (58.125-20)(0.02) + (0.01)(58.125) + (0.04)(125) - V_B = 0$$

$$\therefore V_A - V_B = V_{AB} = -20(0.03) - (0.02)(58.125-20) - (0.01)(58.125) - (0.04)(125)$$

∴ $\boxed{V_{AB} = -6.943V} = V_{Th}$

Thevinin's eq. Ckt. with resis. 0.04 Ω b/n A and B:-



∴ $I_L = \frac{V_{Th}}{R_{Th}+0.04}$

∴ $I_L = I = \frac{6.493}{0.08875+0.04}$

∴ $\boxed{I = 53.93A \text{ from B to A}}$