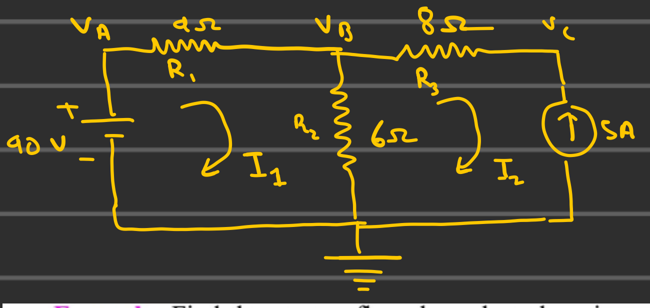
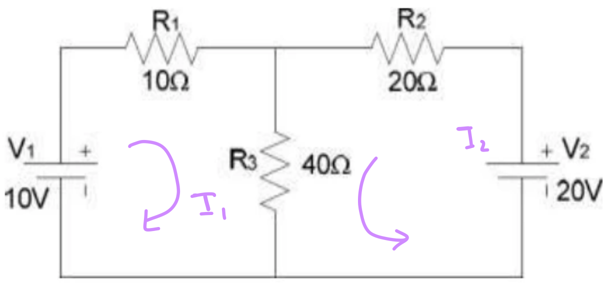
Mesh Current Problems



from −ve to +ve v↑ +v

+ve to −ve v↓ −v

Example: Find the current flow through each resistor using **mesh analysis** for the circuit below.



Solution:

So the equations would be :-   ⊛ So the logic

$I_1R_1 + I_1R_3 + I_2R_3 = V_1$ & $I_2R_2 + I_2R_3 + R_3I_1 = V_2$

$I_1 10 + I_1 40 + I_2 40 = 10$ & $I_2 20 + I_2 40 + I_1 40 = 20$

$50I_1 + 40I_2 = 10$ & $60I_2 + 40I_1 = 20$

upon solving both of the equation simultanously.

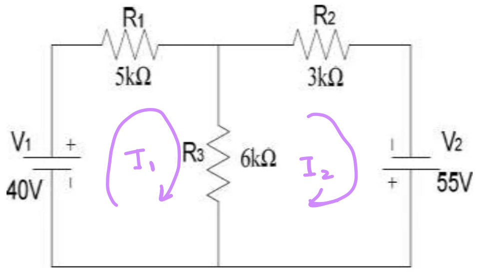
$5\cancel{0}I_1 + 4\cancel{0}I_2 = 1\cancel{0}$ $5I_1 + 4I_2 = 1 \times 4$ $= 2\cancel{0}I_1 + 16I_2 = 4$

$4\cancel{0}I_1 + 6\cancel{0}I_2 = 2\cancel{0}$ $-\ 4I_1 + 6I_2 = 2 \times 5$ $-\cancel{20}I_1 - 30I_2 = 10$

$14I_2 = 6$

$\boxed{I_1 = -0.143A}$ $\boxed{I_2 = 6/14}$

Example: Find the current flow through each resistor using mesh analysis for the circuit.



Take current in clock wise direction preferably

$I_1R_1 + I_1R_3 - I_2R_3 = V_1$ & $I_2R_2 + I_2R_3 - I_1R_3 = V_2$

$I_1 5 + I_1(6) - I_2(6) = 40$ & $I_2(3) + I_2 6 - I_1 6 = 55$

$11I_1 - I_2 6 = 40$ & $9I_2 - I_1 6 = 55$

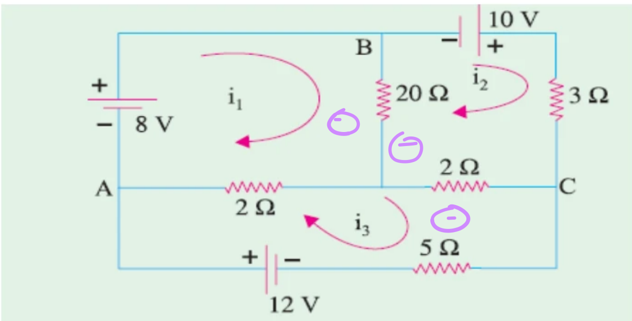
$11I_1 - 6I_2 = 40 \quad \times 6 \Rightarrow \cancel{66I_1} - 36I_2 = 240$

$-6I_1 + 9I_2 = 55 \quad \times 11 \Rightarrow \cancel{-66I_1} + 44I_2 = 605$

$8I_2 = 845$

In this we've to find in mA so you'd need to divide by by 1k upon that you'd get the answer $I_1 = 10.95mA$ & $I_2 = 13.41mA$.

Example: Determine the current in the 5Ω resistor using Mesh Analysis.



$8 + (i_1 - I_2)20 + (I_1 - I_3)2 = 0$ for mesh 1 $\quad I_1 = x$

$10 + (I_2 - I_1)20 + (I_2 - I_3)2 = 0$ for mesh 2 $\quad I_2 = y$

$12 + (I_3 - I_1)2 + (I_3 - I_2)2 + I_3 5 = 0$ for mesh 3 $\quad I_3 = z$.

$8 + 20I_1 - 20I_2 + 2I_1 - 2I_3 = 0$

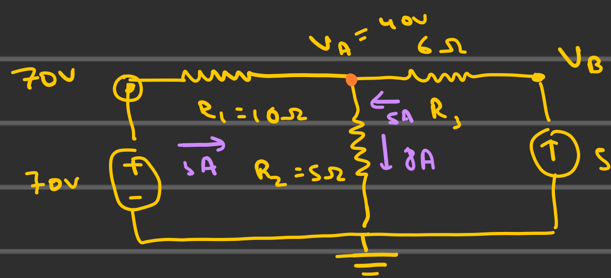
$8 + 22I_1 - 20I_2 = 0$

$10 + 10I_2 - 20I_1 + 2I_2 - 2I_3 = 0 \Rightarrow 10 + 12I_2 - 20I_1 = 0$

$12 + \underbrace{2I_3 - 2I_1 + 2I_3 - 2I_2 + I_3 5}_{} \Rightarrow 12 + 9I_3 - 2I_1 - 2I_2 = 0$

$I_3 = 6.33\ \Omega$

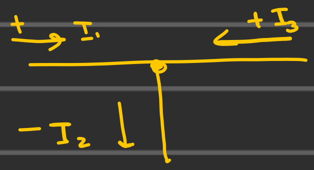
Nodal Analysis :-



• → node

electropotential at GND = 0V

to find VA & VB



towards junction → +ve , away −ve

$V = IR$

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

$I_1 - I_2 + I_3 = 0$

$I = \frac{V_H - V_L}{R} = \frac{70 - V_a}{10} = I_1$ high → low electropotential.

$\frac{70 - V_a}{10} - \frac{V_a}{5} + 5 = 0 \Rightarrow 70 - V_a - 2V_a + 50 = 0$

$70 - 3a + 50 = 0$

$= 120 = 3a$ $\boxed{Va = 40}$

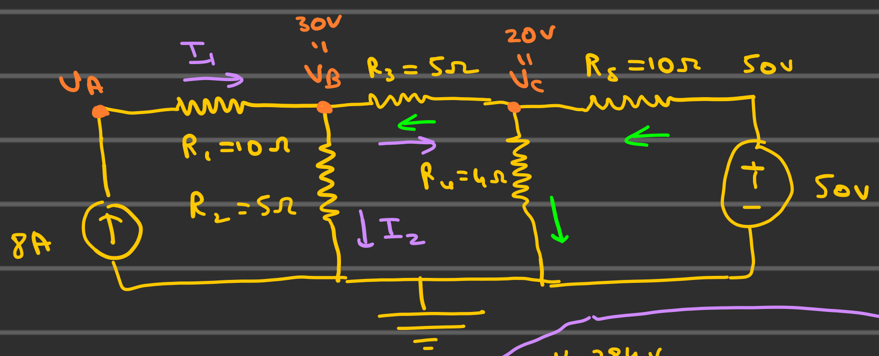
$I_1 = \frac{V_1}{R_1} = \frac{30V}{10\Omega} = 3A$ $I_2 = \frac{V_L}{R_2} = \frac{40}{5\Omega} = 8A$

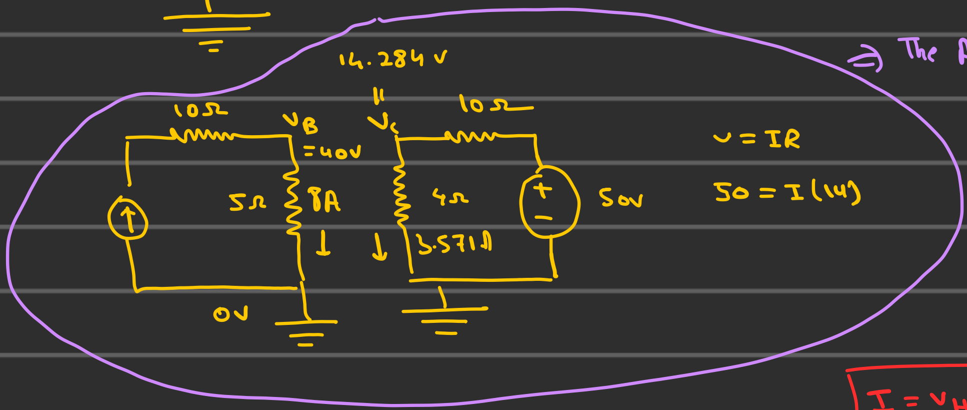
$V = IR$ $V_3 = I_3 R_3$ $V_H - V_L = I_3 R_3$

$V_B - V_A = I_3 R_3$

$V_B - 40 = 30$

$\boxed{V_B = 70V}$



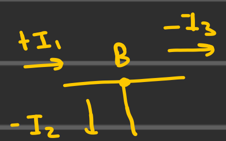


⇒ The Analysis

$V = IR$

$50 = I(14)$

$\boxed{I = \frac{V_H - V_L}{R}}$



$I_1 - I_2 - I_3 = 0$

$\left(8A - \frac{(V_B)}{5} - \frac{(V_B - V_C)}{5} = 0 \right)$

$I_3 = \frac{V_B - V_C}{R_3}$

$40 - V_B - V_B - V_C = 0$

$40 - 2V_B - V_C = 0$

$$\boxed{-2V_B + V_C = -40}$$

$$-4V_B + 2V_C = -80$$
$$+\quad 4V_B - 11V_C = -100$$
$$-9V_C = -180$$
$$\boxed{V_C = 20}\ *$$

$$-2V_B + 20 = -40$$
$$-2V_B = -60$$
$$\boxed{V_B = 30}\ *$$

For node C:-

$$I_3 - I_4 + I_5 = 0$$

$$\frac{V_B - V_C}{5} - \left(\frac{V_C}{4}\right) + \frac{50 - V_C}{10} = 0$$

$$4V_B - V_C \underbrace{- 5V_C + 100 - 2V_C}_{} = 0$$

$$4V_B - 11V_C + 100 = 0$$

$$V = IR$$
$$V_A - 30 = I_1 R_1$$
$$V_A - 30 = 8(10)$$
$$\boxed{V_A = 110V}$$

$$I_2 = \frac{V_H - V_L}{R} = \frac{30 - 0}{5} = 6A.$$

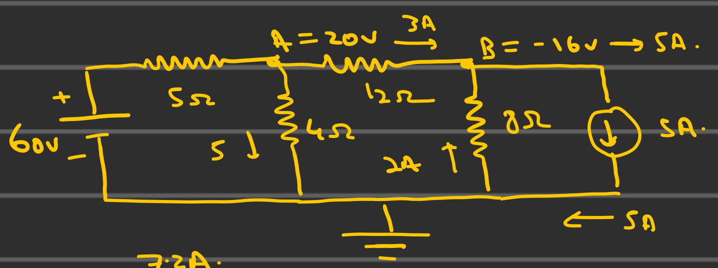
$$I_4 = \frac{20 - 0}{4} = 5A$$

$$I_3 = \frac{V_H - V_L}{R_3} = \frac{30 - 20}{5} = 2A.$$

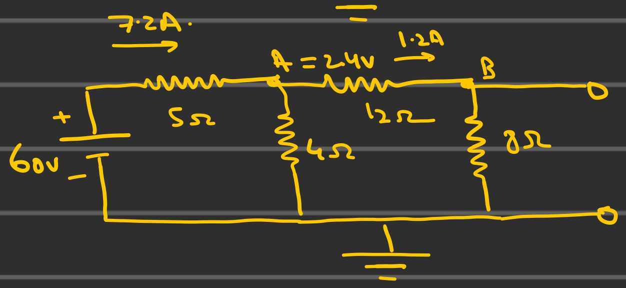
$$I_5 = \frac{50 - 20}{10} = 3A.$$

watch ~~nodal~~, ~~Superposition~~, $\underbrace{\text{Thevenin}}_{9\,min}$, $\underbrace{\text{norton}}_{11\,min}$, $\underbrace{\text{maximum power transfer}}_{15\,min}$.

Superposition Theorem



$$V_A = -IR.$$



$$20 \| 4 = \left(\frac{1}{20} + \frac{1}{4}\right)^{-1} = \left(\frac{1}{20} + \frac{5}{20}\right)^{-1}$$

$$= \left(\frac{6}{20}\right)^{-1} = \frac{20}{6} = \frac{10}{3}$$

$$\boxed{R_T = 8.3\Omega}$$

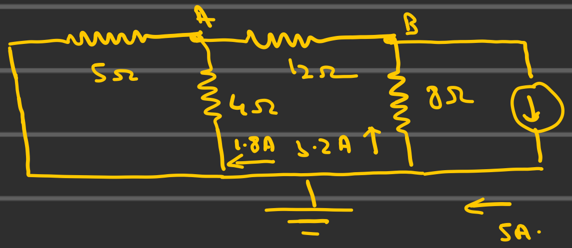
$$I = \frac{V}{R_T} = \frac{60}{8.333} =$$

$$I_{4\Omega} = \frac{V}{R} = \frac{24}{4} = 6A.$$

$$V_a = 60V - 7.2(5) = 24V$$

$$V_B - V_A = -IR$$

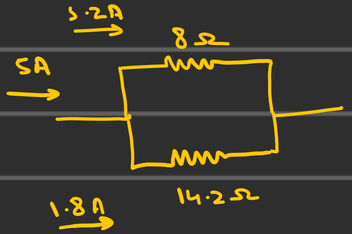
$V_0 = 24 - 1.2(11)$ $\quad V_A = 14V$; $V_B = 9.6V$; $I_4 = 6A$.



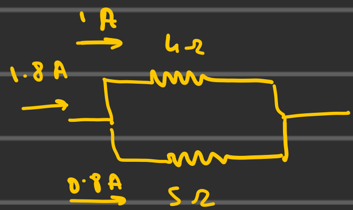
$[5 \| 4 + 12] \| 8$

$= \left(\frac{1}{5} + \frac{1}{4}\right)^{-1} + 12 = 2.22 + 12 = 14.\overline{2}$

$14.2 \| 8$



$5A \cdot \frac{14.\overline{2}}{22.\overline{2}} = 3.2A.$

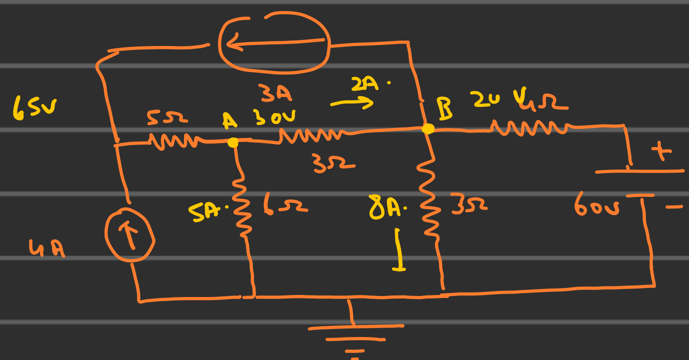


$1.8\left(\frac{5}{9}\right) = 1A.$

$V_B = -8(3.2) = -25.6v$; $V_A = -4v$, $V_0 = -25.6v$ $\quad I_4 = 1A$

now upon applying Superposition. $I = \frac{V}{k} = \frac{40V}{5} = 20 - 3(12) = -16$

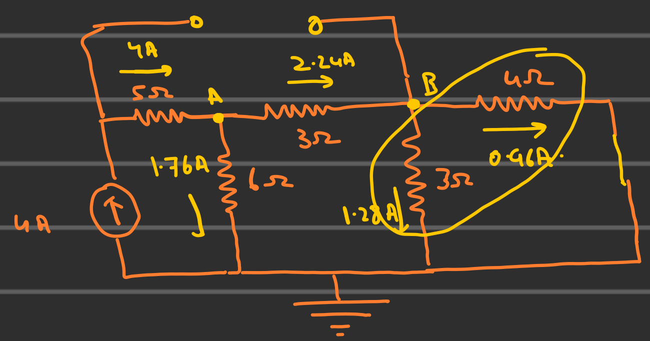
Solve circuit with one power at an time & then add.



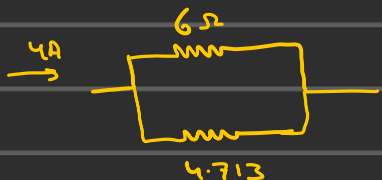
$V_B = 3.84v.$

$V_A = 10.56V$

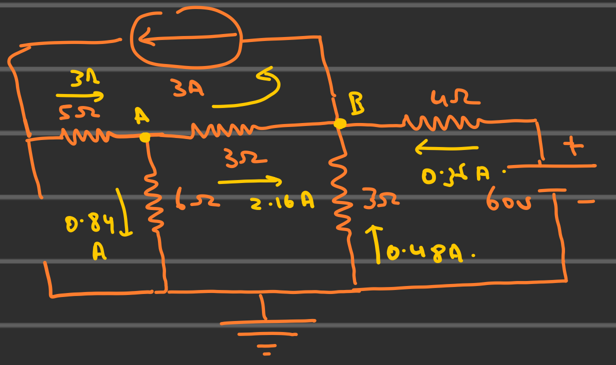
$R_T = 4.71435Ω$



$3 \| 4 = \left(\frac{1}{3} + \frac{1}{4}\right)^{-1} + 3 = 4.7143Ω$

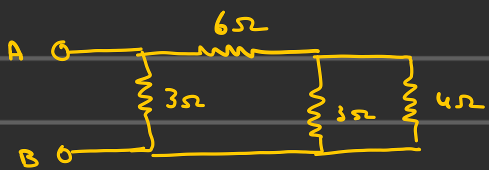


$4A \cdot \frac{4.7143}{10.7143}$; $2.24A \cdot \frac{4}{7} = 1.28A.$



$V_a = 0.84(6) = 5.14\,v$

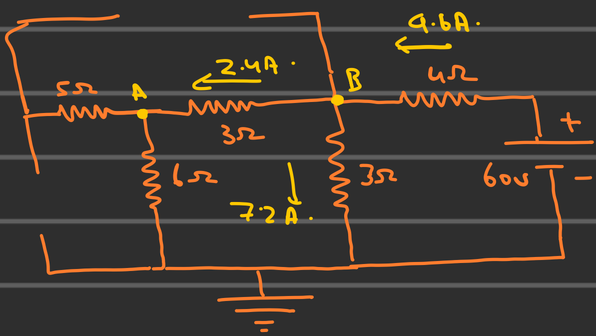
$V_B = 5.04 - 2.16A(3\Omega) = -1.44v.$



$3\|4 + 6 = \left(\frac{1}{3} + \frac{1}{4}\right)^{-1} + 6 = 7.7143\,\Omega$

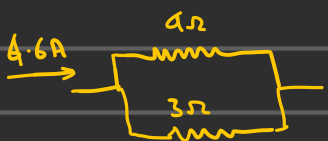
Current divider Circuit

$3A \cdot \frac{7.7143}{10.7143} = 2.16A.$



$9\|3+4 = \left(\frac{1}{9} + \frac{1}{3}\right)^{-1} + 4 = 6.25\Omega$

$I = \frac{V}{R_T} = \frac{60v}{6.25\Omega}$



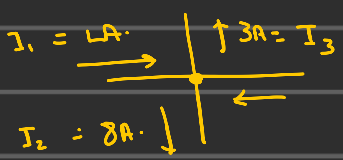
$9.6\,A \cdot \frac{9\Omega}{12\Omega}$

$V_B = 60 - 4(9.6) = 21.6v$

$V_A = V_B - IR = 21.6 - 2.4A(3)$

$V_A = 14.4, \quad V_B = 21.6$

$\therefore$ the final $V_A = 30v$ & $V_B = 24v$



$I_1 + I_2 + I_3 + I_4 = 0$

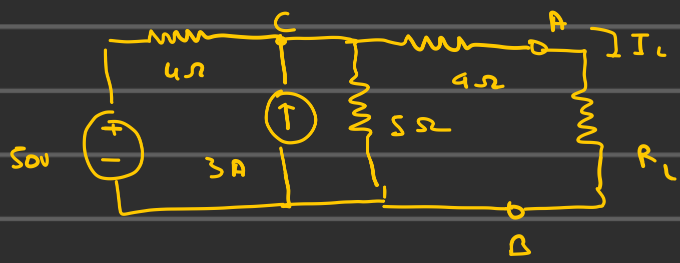
$2 + (-8) + (-3) + I_4 = 0$

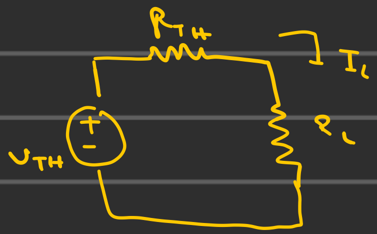
$-6 - 3 + I_4 = 0$

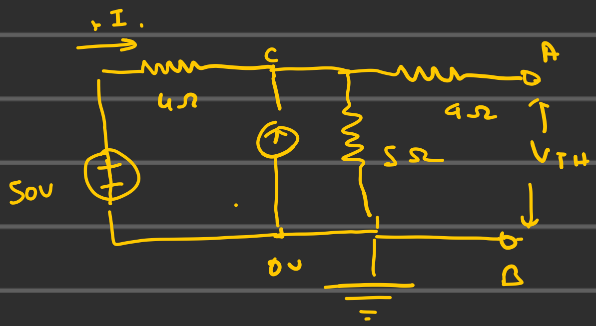
$\therefore \boxed{I_4 = 9A.}$

$I = V/R = \frac{60 - 24}{4} = \frac{36}{4} = 9A.$

Thevenin's Theorem







$$\left(\frac{1}{4}+\frac{1}{5}\right)^{-1} + 9 = 11.\bar{2}\ \Omega$$

To calculate thevenin voltage

$$V_c = V_A = V_{TH}.$$

$$I_1 + I_2 - I_3 = 0 \qquad I = V/R$$

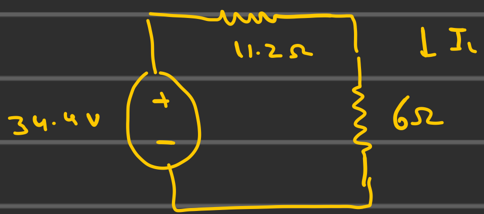
$$\left(\frac{50-V_c}{4} + 3 - \frac{V_c - 0}{5} = 0\right) 20$$

$$250 - 5V_c + 60 - 4V_c = 0$$

$$5(50-V_c) + 60 - 4V_c = 0$$

$$\frac{310}{9} = \frac{9V_c}{9}$$

$$V_c = 34.\bar{4}\ \Omega$$



$$I_L = \frac{V}{R_T}$$

$$= \frac{34.\bar{4}}{11.\bar{2}+6} = \frac{34.\bar{4}}{17.\bar{2}} = \boxed{2A}$$

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

C \ AB	00	01	11	10
0	0	1	1	1
1	0	0	0	1

This is an K map.

Can circle 1, 2, 4, 8 1's

$$F = B\bar{C} + A\bar{B}$$

$$= 1(\bar{1}) + 0(\bar{1})$$

$$= 1(0) + 0(0)$$

$$= 0 + 0 = 0$$

→ to find what variables don't change.