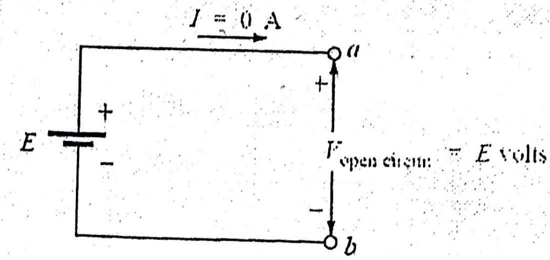
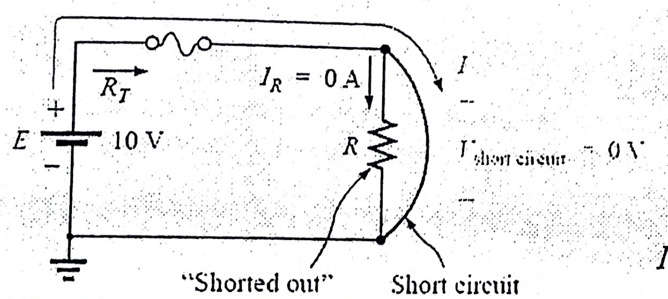
Open and Short Circuits:

An open circuit can have a potential difference (voltage) across its terminals, but the current is always zero amperes.

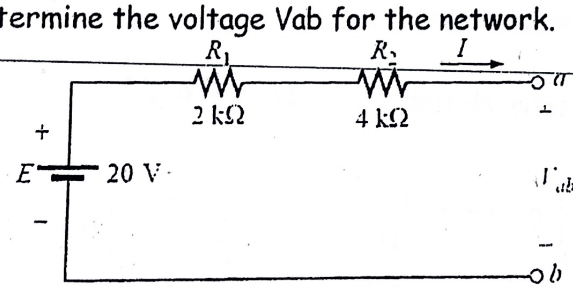


A short circuit can carry a current of a level determined by the external circuit, but the potential difference (voltage) across its terminals is always zero volts.



$$I = \frac{E}{R} = \frac{10\,V}{0\,\Omega} \longrightarrow \infty\,A$$

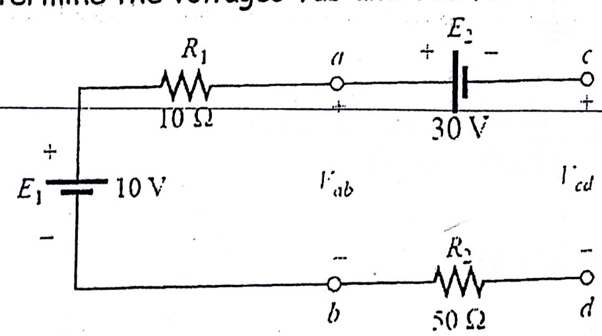
EXAMPLE: Determine the voltage Vab for the network.



Solution:

$$V_{ab} = E = 20\,V$$

EXAMPLE: Determine the voltages Vab and Vcd for the network.



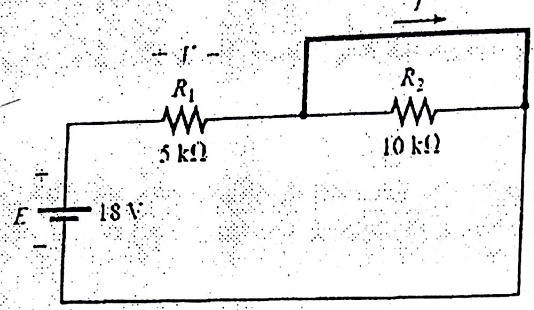
Solution:

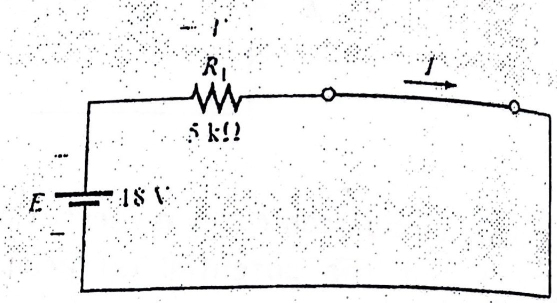
$$V_{ab} = E_1 = 10\ \text{V}$$

$$+E_1 - E_2 - V_{cd} = 0$$

$$V_{cd} = E_1 - E_2 = 10\ \text{V} - 30\ \text{V} = -20\ \text{V}$$

EXAMPLE: Calculate the current I and the voltage V for the network.





Solution:

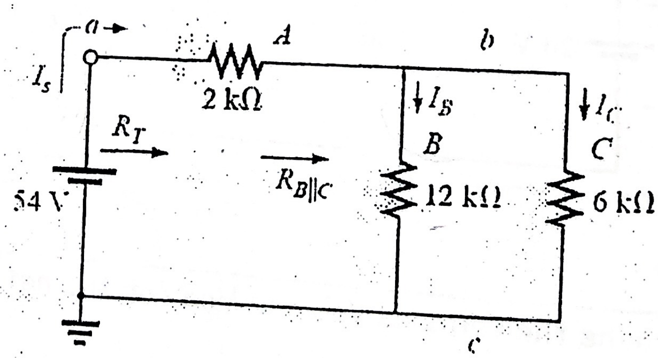
$$I = \frac{E}{R_1} = \frac{18\ \text{V}}{5\ \text{k}\Omega} = 3.6\ \text{mA}$$

$$V = E = 18\ \text{V}$$

Series-Parallel Networks:

Series-parallel networks are networks that contain both series and parallel circuit configurations.

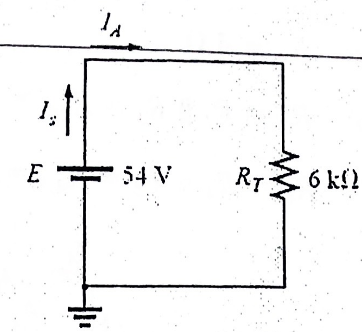
EXAMPLE: for the network find R_T, Is, IA, IB, and IC.



Solution:

$$R_{B\|C} = R_B \parallel R_C = \frac{(12\ \text{k}\Omega)(6\ \text{k}\Omega)}{12\ \text{k}\Omega + 6\ \text{k}\Omega} = 4\ \text{k}\Omega$$

$$R_T = R_A + R_{B\|C}$$
$$= 2\ \text{k}\Omega + 4\ \text{k}\Omega = 6\ \text{k}\Omega$$

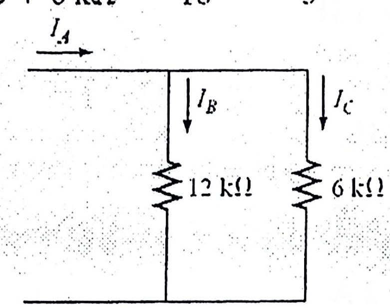


$$I_s = \frac{E}{R_T} = \frac{54\text{ V}}{6\text{ k}\Omega} = 9\text{ mA}$$

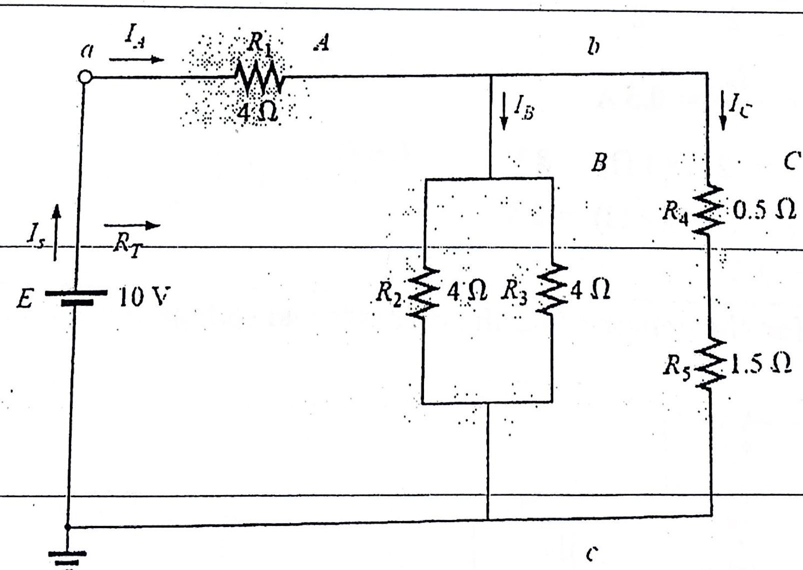
$$I_A = I_s = 9\text{ mA}$$

$$I_B = \frac{6\text{ k}\Omega(I_s)}{6\text{ k}\Omega + 12\text{ k}\Omega} = \frac{6}{18}I_s = \frac{1}{3}(9\text{ mA}) = 3\text{ mA}$$

$$I_C = \frac{12\text{ k}\Omega(I_s)}{12\text{ k}\Omega + 6\text{ k}\Omega} = \frac{12}{18}I_s = \frac{2}{3}(9\text{ mA}) = 6\text{ mA}$$



EXAMPLE: for the network find the currents and voltage for each element.

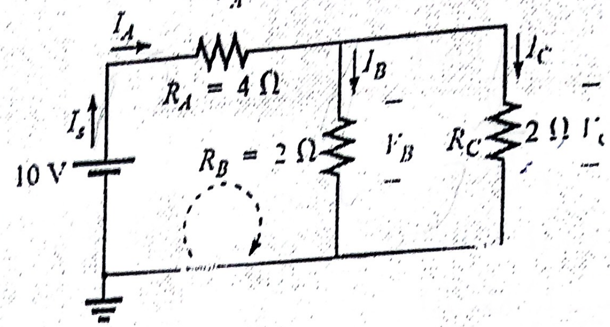


Solution:

A: $R_A = 4\,\Omega$

B: $R_B = R_2 \parallel R_3 = R_{2\parallel 3} = \dfrac{R}{N} = \dfrac{4\,\Omega}{2} = 2\,\Omega$

C: $R_C = R_4 + R_5 = R_{4,5} = 0.5\,\Omega + 1.5\,\Omega = 2\,\Omega$



$$R_{B\parallel C} = \frac{R}{N} = \frac{2\,\Omega}{2} = 1\,\Omega$$

$$R_T = R_A + R_{B\parallel C}$$
$$= 4\,\Omega + 1\,\Omega = 5\,\Omega$$

$$I_s = \frac{E}{R_T} = \frac{10\text{ V}}{5\,\Omega} = 2\text{ A}$$

$$I_A = I_s = 2\text{ A}$$

$$I_B = I_C = \frac{I_A}{2} = \frac{I_s}{2} = \frac{2\text{ A}}{2} = 1\text{ A}$$

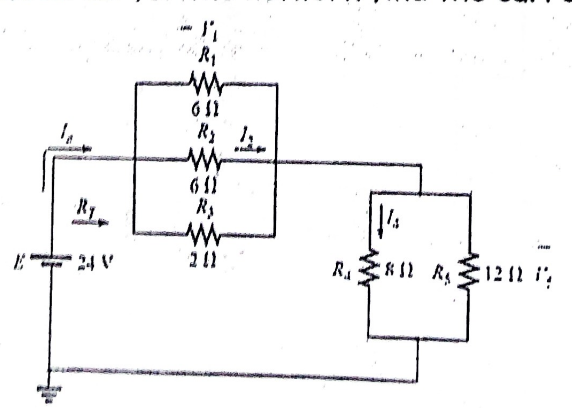
$$I_{R_2} = I_{R_3} = \frac{I_B}{2} = 0.5\text{ A}$$

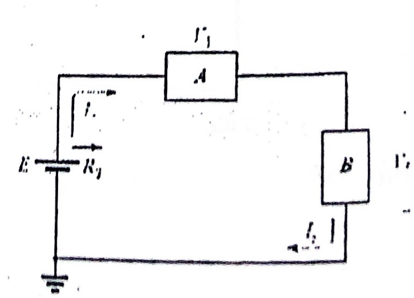
$$V_A = I_A R_A = (2\text{ A})(4\,\Omega) = 8\text{ V}$$

$$V_B = I_B R_B = (1\text{ A})(2\,\Omega) = 2\text{ V}$$

$$V_C = V_B = 2\text{ V}$$

EXAMPLE: for the network find the currents and voltage for each element.



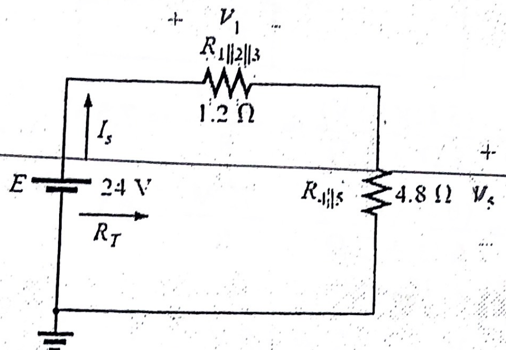


Solution:

$$R_{1\|2} = \frac{R}{N} = \frac{6\ \Omega}{2} = 3\ \Omega$$

$$R_A = R_{1\|2\|3} = \frac{(3\ \Omega)(2\ \Omega)}{3\ \Omega + 2\ \Omega} = \frac{6\ \Omega}{5} = 1.2\ \Omega$$

$$R_B = R_{4\|5} = \frac{(8\ \Omega)(12\ \Omega)}{8\ \Omega + 12\ \Omega} = \frac{96\ \Omega}{20} = 4.8\ \Omega$$



$$R_T = R_{1\|2\|3} + R_{4\|5} = 1.2\ \Omega + 4.8\ \Omega = 6\ \Omega$$

$$I_s = \frac{E}{R_T} = \frac{24\text{ V}}{6\ \Omega} = 4\text{ A}$$

$$V_1 = I_s R_{1\|2\|3} = (4\text{ A})(1.2\ \Omega) = 4.8\text{ V}$$

$$V_5 = I_s R_{4\|5} = (4\text{ A})(4.8\ \Omega) = 19.2\text{ V}$$

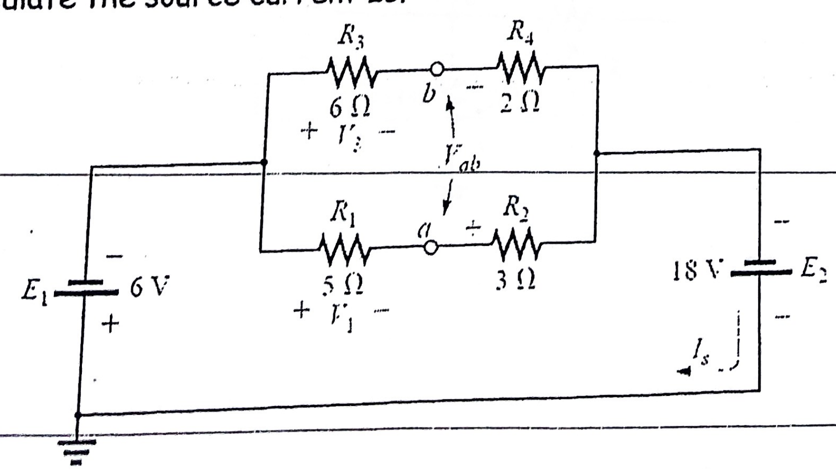
$$I_4 = \frac{V_5}{R_4} = \frac{19.2\text{ V}}{8\ \Omega} = 2.4\text{ A}$$

$$I_2 = \frac{V_2}{R_2} = \frac{V_1}{R_2} = \frac{4.8\text{ V}}{6\ \Omega} = 0.8\text{ A}$$

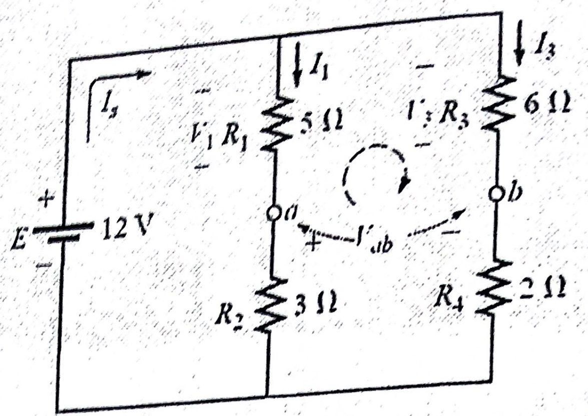
EXAMPLE:

a. Find the voltages $V1$, $V3$, and Vab for the network.

b. Calculate the source current Is.



Solution:



$$V_1 = \frac{R_1E}{R_1 + R_2} = \frac{(5\ \Omega)(12\ \text{V})}{5\ \Omega + 3\ \Omega} = \frac{60\ \text{V}}{8} = 7.5\ \text{V}$$

$$V_3 = \frac{R_3E}{R_3 + R_4} = \frac{(6\ \Omega)(12\ \text{V})}{6\ \Omega + 2\ \Omega} = \frac{72\ \text{V}}{8} = 9\ \text{V}$$

$$+V_1 - V_3 + V_{ab} = 0$$

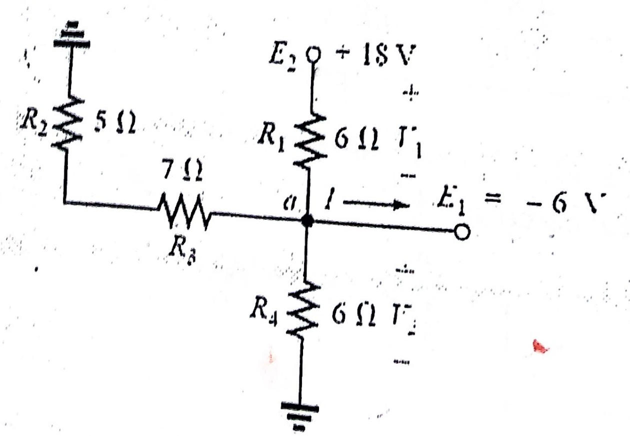
$$V_{ab} = V_3 - V_1 = 9\ \text{V} - 7.5\ \text{V} = 1.5\ \text{V}$$

$$I_1 = \frac{V_1}{R_1} = \frac{7.5\ \text{V}}{5\ \Omega} = 1.5\ \text{A}$$

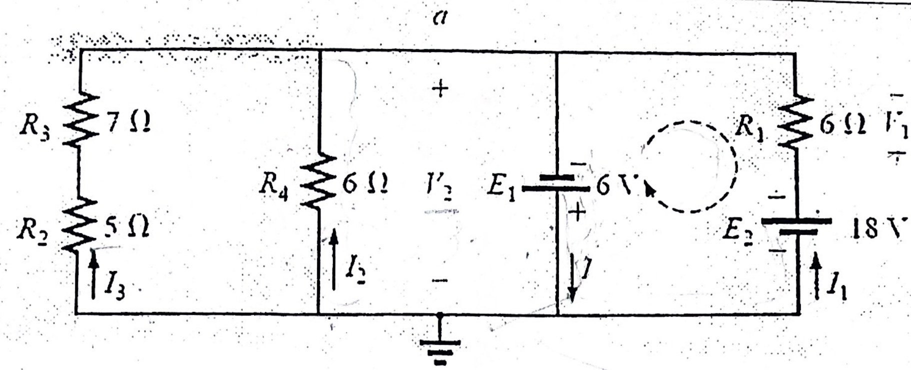
$$I_3 = \frac{V_3}{R_3} = \frac{9\ \text{V}}{6\ \Omega} = 1.5\ \text{A}$$

$$I_s = I_1 + I_3 = 1.5\ \text{A} + 1.5\ \text{A} = 3\ \text{A}$$

EXAMPLE: For the network, determine the voltages $V1$ and $V2$ and the current I.



Solution:



$$V_2 = -E_1 = -6\text{ V}$$

$$-E_1 + V_1 - E_2 = 0$$

$$V_1 = E_2 + E_1 = 18\text{ V} + 6\text{ V} = 24\text{ V}$$

$$I = I_1 + I_2 + I_3$$

$$= \frac{V_1}{R_1} + \frac{E_1}{R_4} + \frac{E_1}{R_2 + R_3}$$

$$= \frac{24\text{ V}}{6\ \Omega} + \frac{6\text{ V}}{6\ \Omega} + \frac{6\text{ V}}{12\ \Omega}$$

$$= 4\text{ A} + 1\text{ A} + 0.5\text{ A}$$

$$I = 5.5\text{ A}$$