HW4, Chapter 4

Monday, December 07, 2009
8:57 PM

4.6

Method 1:

From experiment 1, $V_s^{(1)} = 12 \rightarrow V_o^{(1)} = 4$

For experiment 2, $V_o^{(2)}$ becomes $3 \times V_o^{(1)}$

same factor

So, $V_s^{(2)}$ should be $3 \times V_s^{(1)} = \boxed{48\text{ V}}$

For experiment 3, $V_s^{(3)}$ becomes $\frac{1}{12} V_s^{(1)}$

same factor

So, $V_o^{(3)}$ should be $\frac{1}{12} \times V_o^{(1)} = \frac{1}{12} \times 4$

$= \boxed{\frac{1}{3}\text{ V}}$

For experiment 4, $V_o^{(4)}$ becomes $-\frac{1}{2} V_o^{(1)}$

same factor

So, $V_s^{(4)}$ should be $-\frac{1}{2} V_s^{(1)} = -\frac{1}{2} \times 12$

$= \boxed{-6\text{ V}}$

Method 2:

Consider two experiments on the same linear circuit:

Input | Output

$$V_s^{(1)} \rightarrow \boxed{\text{Linear Circuit}} \rightarrow V_o^{(1)}$$

$$V_s^{(2)} \rightarrow \boxed{\text{Linear Circuit}} \rightarrow V_o^{(2)}$$

If we write $V_s^{(2)} = \dfrac{V_s^{(2)}}{V_s^{(1)}} \times V_s^{(1)}$,

then $V_o^{(2)}$ should be

use same factor

$$\frac{V_s^{(2)}}{V_s^{(1)}} \times V_o^{(1)}$$

By similar reasoning.

Hence, $$\frac{V_o^{(2)}}{V_s^{(2)}} = \frac{V_o^{(1)}}{V_s^{(1)}} = \frac{V_o^{(3)}}{V_s^{(3)}} = \frac{V_o^{(4)}}{V_s^{(4)}}$$

In other words, $\dfrac{V_o}{V_s}$ should be constant for all experiments.

From experiment 1, we have $\dfrac{V_o}{V_s} = \dfrac{4}{12} = \dfrac{1}{3}$.

From experiment 1, we have $\frac{V_o}{V_s} = \frac{4}{12} = \frac{1}{3}$.

For experiment 2, we should have $\frac{V_o}{V_s} = \frac{16}{V_s} = \frac{1}{3}$

$$\Rightarrow V_s = 3 \times 16$$
$$= \boxed{48 \text{ V}}$$

For experiment 3, we should have $\frac{V_o}{V_s} = \frac{V_o}{1} = \frac{1}{3}$

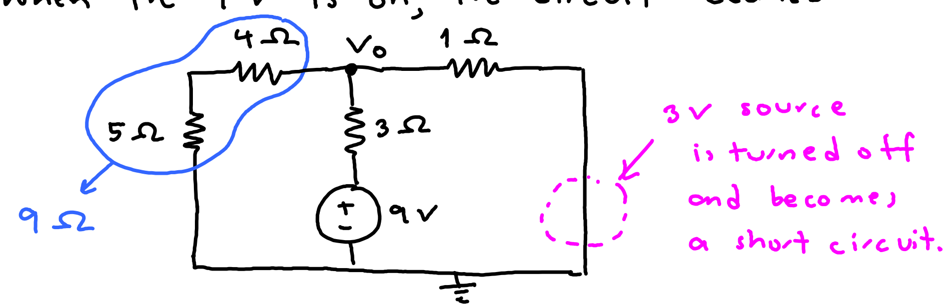
$$\Rightarrow V_o = \boxed{\tfrac{1}{3} \text{ V}}$$

For experiment 4, we should have $\frac{V_o}{V_s} = \frac{-2}{V_s} = \frac{1}{3}$

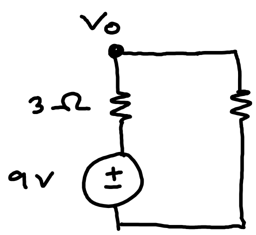
$$\Rightarrow V_s = -2 \times 3$$
$$= \boxed{-6 \text{ V}}$$

4.8 We will turn on one source at a time

a) When the 9 V is on, the circuit becomes



Note that the 9 Ω and 1 Ω are in parallel.
Hence, we have

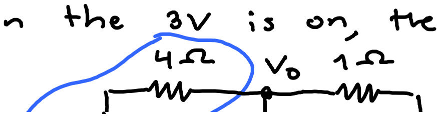


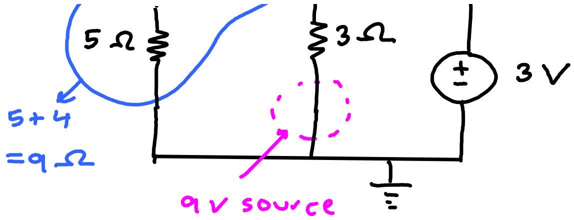
$$9 // 1 = \frac{9 \times 1}{9+1} = \frac{9}{10} = 0.9$$

By the voltage divider formula,

$$V_o = \frac{0.9}{3+0.9} \times 9 = \frac{\cancel{0.9}^{\,3}}{\cancel{3.9}_{\,13}} \times 9 = \frac{27}{13} \text{ V}$$

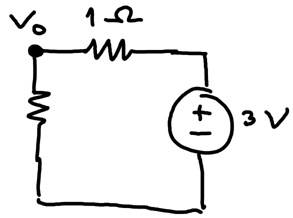
b) When the 3V is on, the circuit becomes





is turned off and becomes a short circuit.

Note that the 9 Ω and 3 Ω are in parallel.
Hence, we have



$$\frac{9}{4} = \frac{9 \times \cancel{3}^{\,1}}{\cancel{9}_{3} + \cancel{3}_{1}} = 9/\!/3$$

By the voltage divider formula,

$$V_o = \frac{\frac{9}{4}}{\frac{9}{4}+1} \times 3 = \frac{9}{9+4} \times 3 = \frac{27}{13}$$

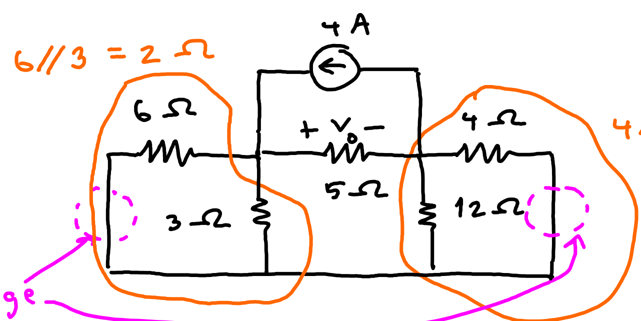
c) By superposition theorem,

$$V_o = V_o^{(a)} + V_o^{(b)} = \frac{27}{13} + \frac{27}{13} = \boxed{\frac{54}{13}\ V}$$

≈ 4.154 V

4.12

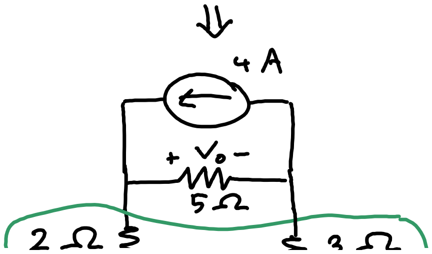
a) When only 4 A ($\leftarrow$) is on:

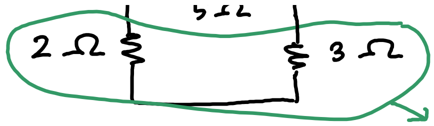


$$4/\!/12 = \frac{12 \times 4}{12+4} = \frac{\cancel{12}^{\,3} \times \cancel{4}}{\cancel{16}_{\cancel{4}}} = 3\ \Omega$$

Voltage sources are turned off and replace by short circuits

$\Downarrow$



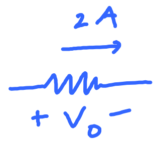


$2+3=5\,\Omega$

So, 4 A is split between the two $5\,\Omega$ resistors
Hence 2 A passes through each $5\,\Omega$ and

$$V_o = 5 \times 2 = 10\,V$$

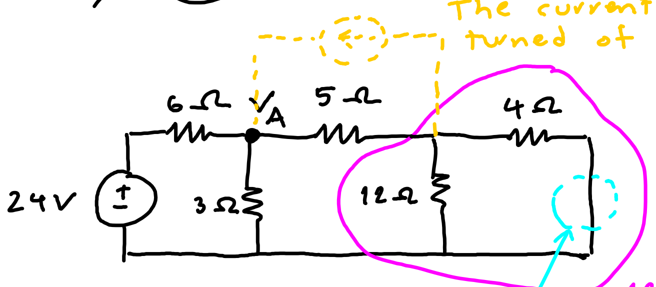
(By ohm's law,



$V_o = I \times R$)

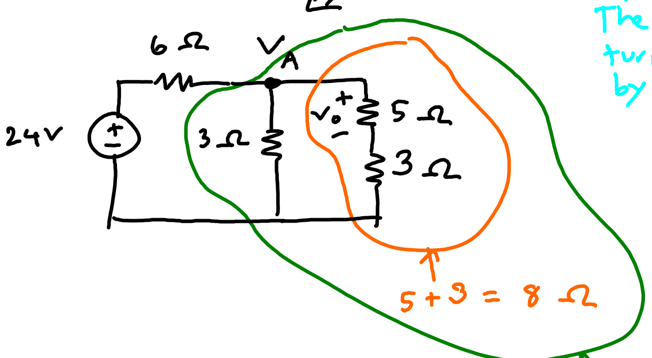
b) When only 24V (±) is on,

The current source is turned off and replaced by open circuit.



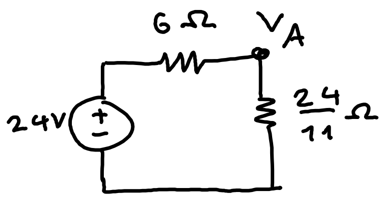
$12 // 4 = 3\,\Omega$

The voltage source is turned off and replaced by short circuit.



$5+3 = 8\,\Omega$

$$8 // 3 = \frac{8 \times 3}{8+3} = \frac{24}{11}\,\Omega$$



By voltage divider formula,

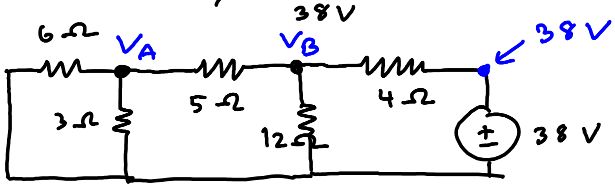
$$V_A = \frac{\frac{24}{11}}{\frac{24}{11}+6} \times 24 = \frac{24}{24+66} \times 24$$

$$= \frac{24^2}{90} = \frac{8^2}{10}$$

Aagin, by voltage divider formula

$$V_o = \frac{5}{5+3} \times V_A = \frac{5}{\cancel{8}} \times \frac{8}{10} = 4\,V$$

c) When only (±) 38V is on,



Here, let's try nodal analysis :

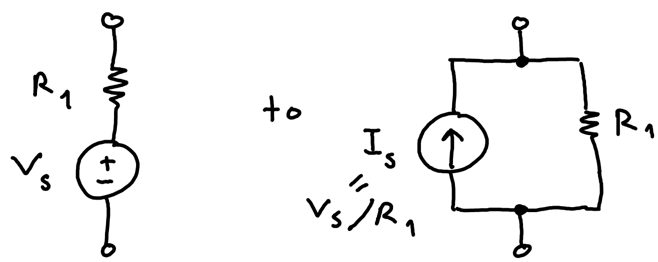
$$\left.\begin{aligned} &\frac{V_A}{6} + \frac{V_A}{3} + \frac{V_A - V_B}{5} = 0 \\ &\frac{V_B - V_A}{5} + \frac{V_B}{12} + \frac{V_B - 38}{4} = 0 \end{aligned}\right\} \Rightarrow \begin{aligned} V_A &= \frac{57}{10} \\ V_B &= \frac{399}{20} \end{aligned}$$

$$\Rightarrow V_o = V_A - V_B = \frac{57}{10} - \frac{399}{20} = -\frac{57}{4}\,V \approx -14.25\,V$$

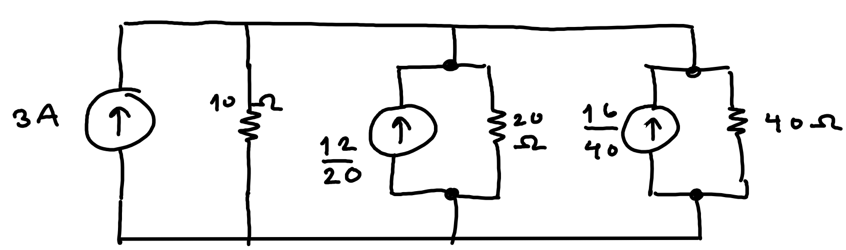
d) By superposition theorem,

$$V_o = 10 + 4 + (-14.25) = -0.25\,V = \boxed{-250\,mV}$$

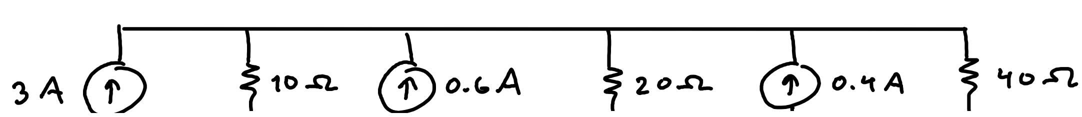
(4.20) By source transformation, we will convert



So, the circuit becomes



$\Downarrow$



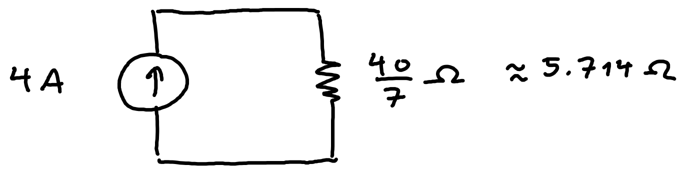
The three parallel current sources can be combined into

$$3 + 0.6 + 0.4 = 4\ A \quad \text{current source}$$

The three parallel resistors can be combined into

$$\frac{1}{\frac{1}{10}+\frac{1}{20}+\frac{1}{40}} = \frac{40}{4+2+1} = \frac{40}{7}\ \Omega \ \text{resistor.}$$

Hence, we have



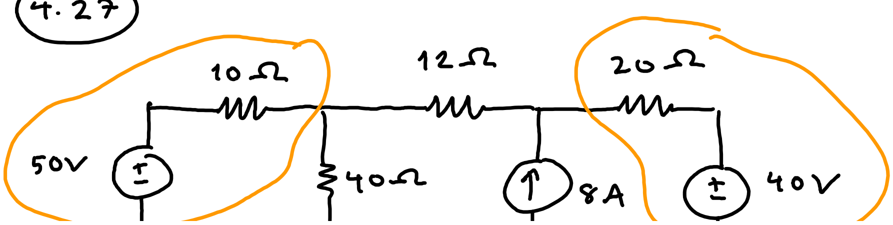
Remark: This is merely an exercise in applying source transformation.

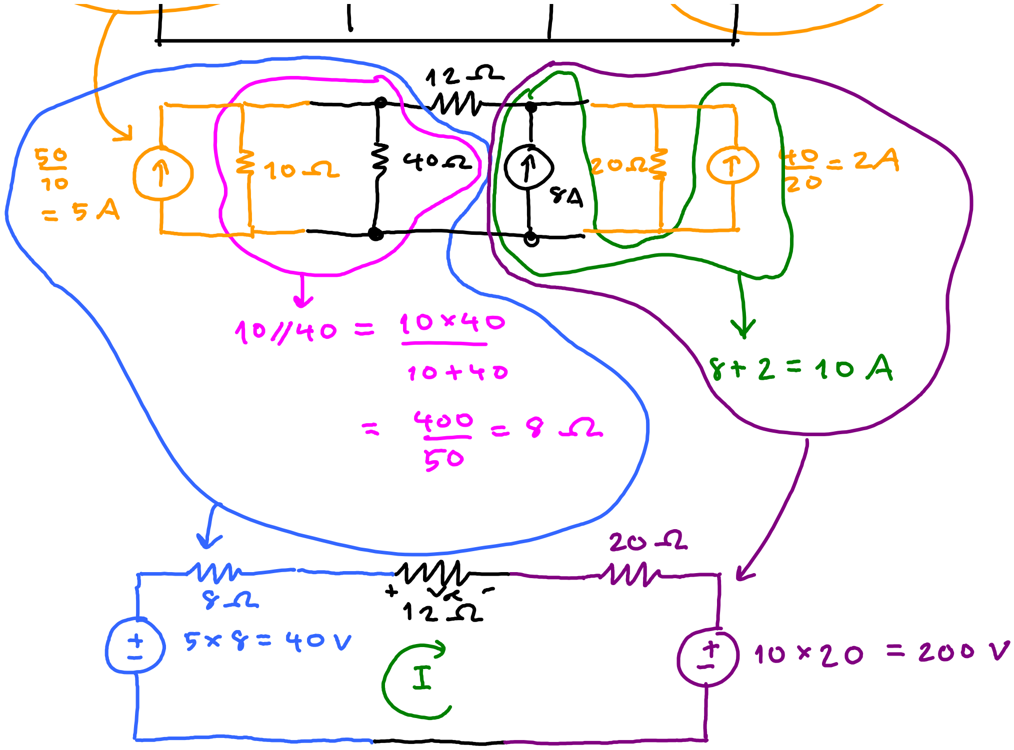
The final answer we have has no real purpose.

In a practical situation, we will need some kind of reference (terminals). This is shown in the next question.

* You may get different answers, depending on the choice of your transformation.

4.27





By KVL

$$+40 - 8I - 12I - 20I - 200 = 0$$

$$-40I = 160$$

$$I = -4 \text{ A}$$

$$V_\alpha = I \times 12\,\Omega$$

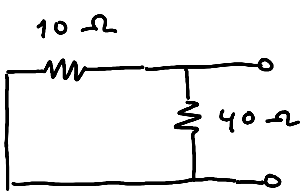
$$= -4 \times 12$$

$$= \boxed{-48 \text{ V}}$$

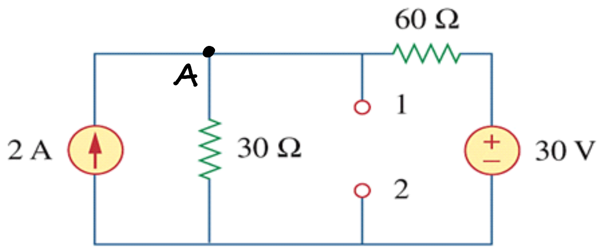
4.33

(a) $V_{TH} = \dfrac{4\cancel{0}}{1\cancel{0}+4\cancel{0}} \times 20 = \dfrac{4}{5} \times 20 = \boxed{16\text{ V}}$

$R_{TH} = 10//40 = \dfrac{10 \times 40}{10+40} = \boxed{8\,\Omega}$



(b)



(b)

At node A

$$-2 + \frac{v_A}{30} + \frac{v_A - 30}{60} = 0$$

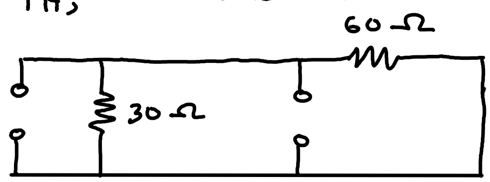
$$-120 + 2v_A + v_A - 30 = 0$$

$$3v_A = 150\,V$$

$$v_A = 50\,V$$

$$V_{TH} = v_A = \boxed{50\,V}$$

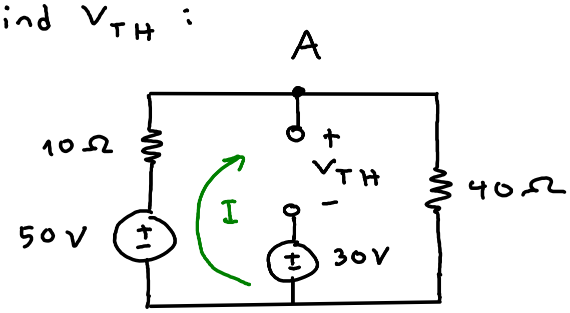
For R_{TH}, we deactivate all the sources:



$$R_{TH} = 30 // 60 = \frac{30\times 60}{30+60} = \frac{\cancel{30}^{10}\times\cancel{60}^{2}}{\cancel{90}_{\cancel{3}}} = \boxed{20\,\Omega}$$

4.36

Find V_{TH}:



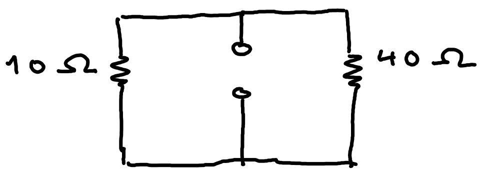
$$I = \frac{50}{10+40} = 1\,A$$

(There is no current through the 30 V source.)

$$v_A = 50 - 10\times I = 40\,V$$

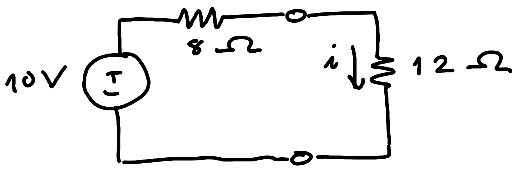
$v_{TH} = v_A - 30 = 10\text{ V}$

Find R_{TH}:



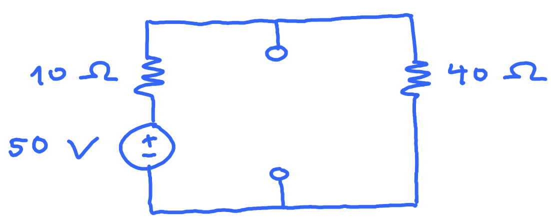
$$R_{TH} = 10 // 40 = \frac{10 \times 40}{10 + 40} = 8\ \Omega$$

So, an equivalent circuit is



So, $i = \dfrac{10}{8+12} = \dfrac{10}{20} = \dfrac{1}{2} = \boxed{0.5\text{ A}}$

Note: it is posible to find the Thevenin equivalent of



However, I modify the question so that you can not do this!!

I ask specifically for the Thevenin equivalent as seen by the 12 Ω resistor!