[Alexander and Sadiku, 2009, Q4.66]: Max Power Transfer

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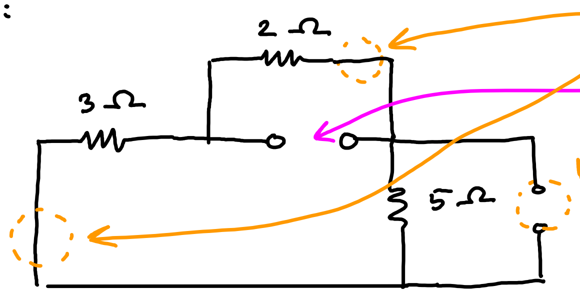
In class, we have seen one important fact :

> To maximize the power transfer to the resistive load, the load's resistance must be the same as R_{TH} from the thevenin equivalent circuit (wrt. the load's two terminals).
> Under such load, the corresponding power delivered to the load is $\frac{V_{TH}^2}{4R_{TH}}$.

So, our first step is to find R_{TH} and V_{TH}

R_{TH} :

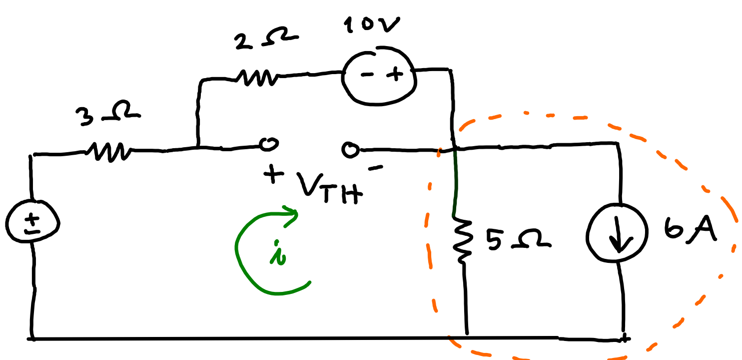


All indp. sources are deactivated when we find R_{TH}.

The load is removed to find the Thevenin eq. circuit for the rest of the circuit.

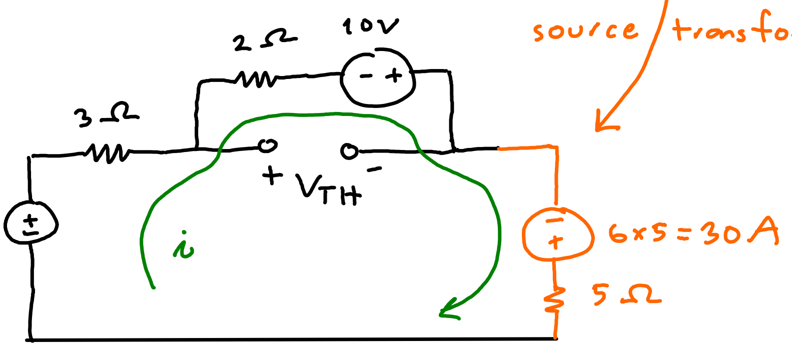
$$R_{TH} = 2 // (3+5) = 2 // 8 = \frac{2 \times 8}{10} = 1.6\ \Omega$$

V_{TH} :



source transformation

V_{TH} :



$$i = \frac{20 + 10 + 30}{3 + 2 + 5} = 6\ A$$

To see this, use KVL around this single loop in the i direction (clockwise) :

$$20 - 3i - 2i + 10 + 30 - 5i = 0$$

$$i = \frac{20+10+30}{3+2+5} = 6\,A$$

in the i direction (clockwise):

$$20 - 3i - 2i + 10 + 30 - 5i = 0$$

$$20+10+30 = (3+2+5)\,i$$

$$V_{TH} = -10 + 2\times 6 = 2\,V$$

To see this, use KVL around the upper (virtual) loop:

$$-i\times 2 + 10 + V_{TH} = 0$$

$$\text{so, max power} = \frac{V_{TH}^2}{4R_{TH}} = \frac{\cancel{2}^2}{\cancel{4}\times 1.6} = \frac{10}{16} = \boxed{\frac{5}{8}\,W} \approx 0.625\,W$$

[Alexander and Sadiku, 2009, Q5.8]

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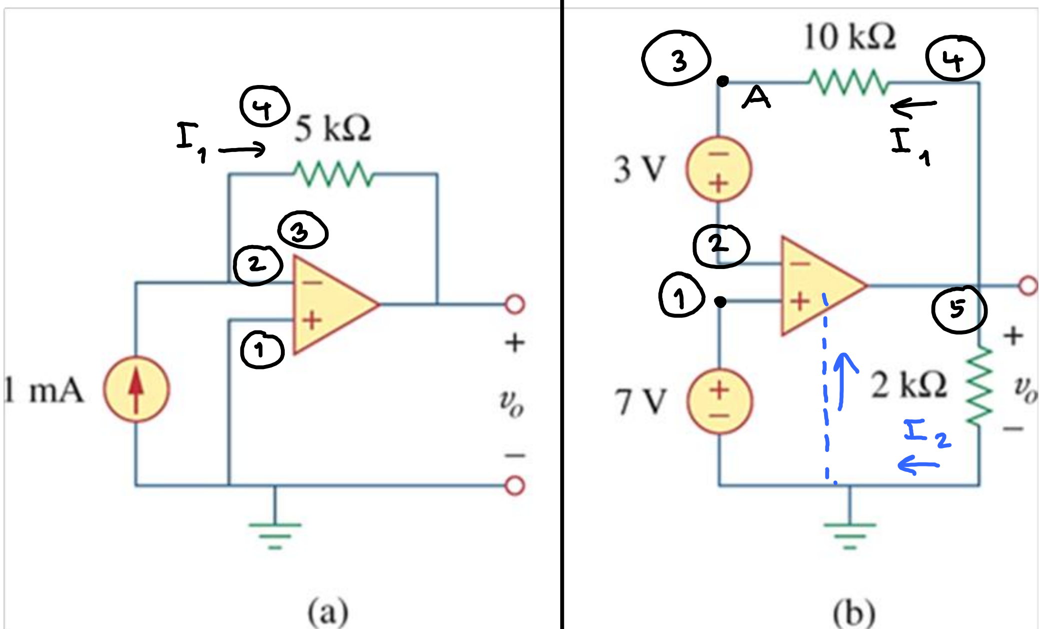

(a)

① $v_+ = 0\ V$ because it is connected to the ground.

② $v_- = v_+ = 0\ V$ by Rule #2

③ $i_- = 0\ A$ by Rule #1

④ $I_1 = 1\ mA$ because $i_- = 0$.

⑤ $v_o = v_- - I_1 \times 5k$

$= 0 - 1mA \times 5k\Omega$

$= \boxed{-5\ V}$

(b)

① $v_+ = 7V$.

② $v_- = v_+ = 7V$ by Rule #2.

③ $v_- - v_A = 3V$

$v_A = v_- - 3V = 7V - 3V = 4V$

④ $I_1 = i_- = 0$ by Rule #1

⑤ $v_o = v_A + I_1 \times 10k = v_A + 0 = v_A$

$= \boxed{4\ V}$

Note: It is tempting to say

$I_2 = i_+ = 0$ by Rule #1 and hence

$v_o = 0 + I_2 \times 2k\Omega = 0 + 0 = 0$

This is not true because I_2 can still flows via the hidden connection into the op-amp.

[Alexander and Sadiku, 2009, Q5.10]

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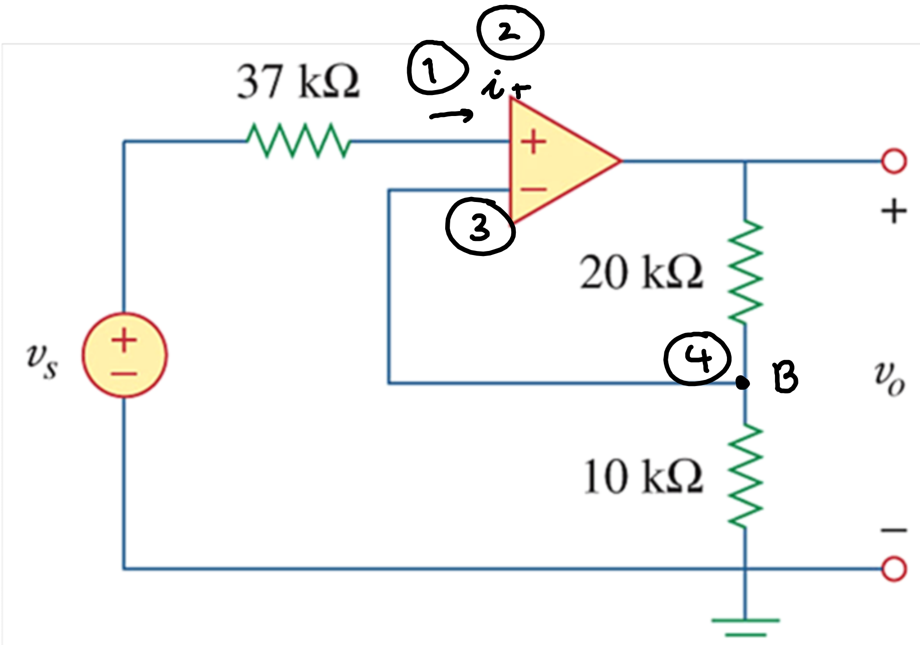

(1) $i_+ = 0$ by Rule #1

(2) $v_+ = v_s - i_+ \times 37\,k\Omega = v_s - 0 = v_s$

(3) $v_- = v_+ = v_s$ by Rule #2

(4) KCL at B gives

$$\frac{v_B - v_o}{20k} + \underbrace{i_-}_{0} + \frac{v_B}{10k} = 0$$

by Rule #1

$v_B = v_- = v_s$ by (3)

$$\frac{v_B}{2\cancel{0k}} + \frac{v_B}{1\cancel{0k}} = \frac{v_o}{2\cancel{0k}}$$

$$v_B + 2v_B = v_o$$

$$v_B = \frac{1}{3} v_o$$

$$\therefore \quad v_s = \frac{1}{3} v_o$$

Alternatively, because $i_- = 0$, the relationship between v_B and v_o is given by voltage divider formula

$$v_B = \frac{10k}{20k + 10k} v_o$$

$$v_B = \frac{1}{3} v_o$$

$$\therefore \quad v_s = \frac{1}{3} v_o$$

$$\frac{v_o}{v_s} = 3$$

$$v_B = \frac{10k}{20k + 10k} v_o$$

[Alexander and Sadiku, 2009, Q5.20]

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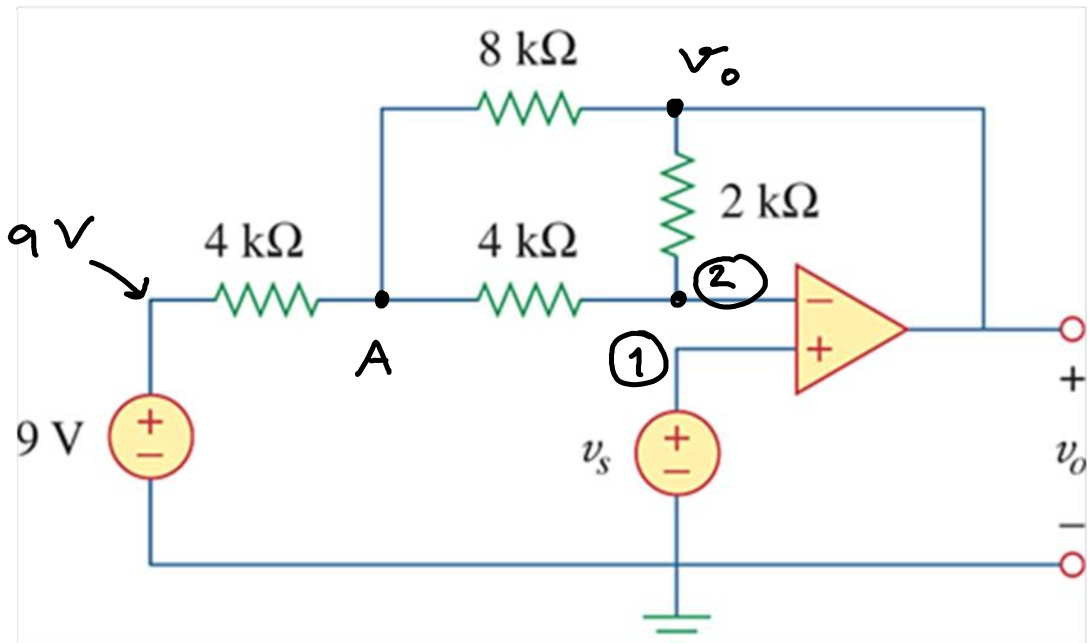

① $v_+ = v_s$

② $v_- = v_+ = v_s$ by Rule # 2.

③ At A $\quad \dfrac{v_A - 9}{4} + \dfrac{v_A - v_o}{8} + \dfrac{v_A - v_s}{4} = 0$

At (−) $\quad \dfrac{v_s - v_A}{4} + \dfrac{v_s - v_o}{2} = 0$

$$\Rightarrow v_A = \frac{7}{11} v_s$$

$$v_o = \frac{13}{11} v_s - \frac{18}{11}$$

If $v_s = 0$, we have $\boxed{v_o = -\frac{18}{11} \text{ V}}$

[Alexander and Sadiku, 2009, Q5.37]

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$$v_o = -\left(\frac{30}{10} \times 1 + \frac{30}{20} \times 2 + \frac{30}{30} \times (-3) \right) = \boxed{-3V}$$

(This is a summing amplifier.)