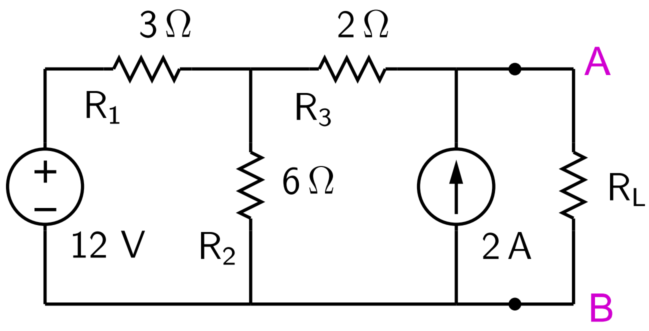
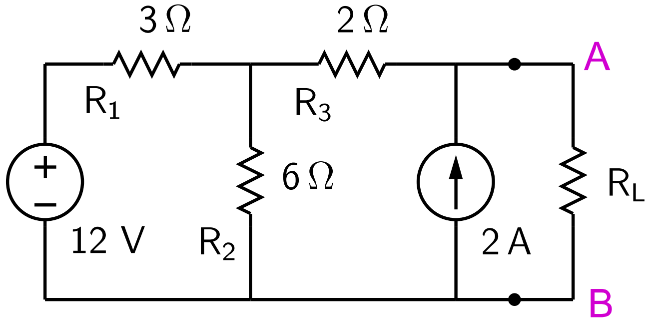
Maximum power transfer: example

Find R_L for which P_L is maximum.

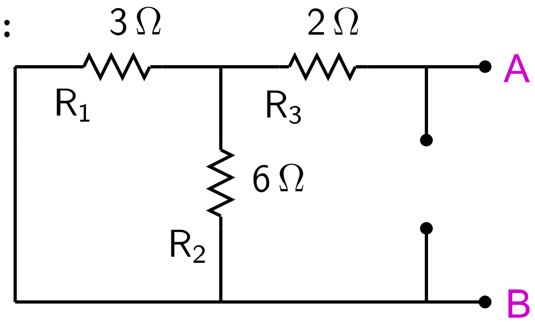


Maximum power transfer: example

Find R_L for which P_L is maximum.

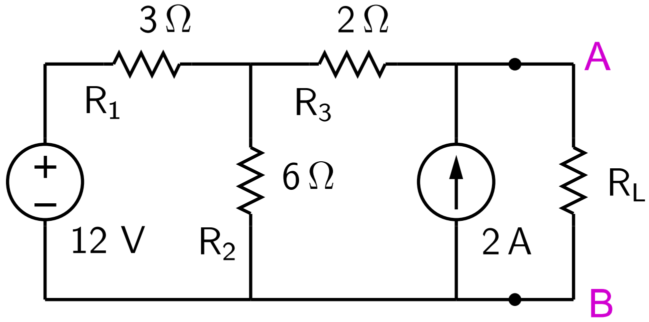


R_{Th}:

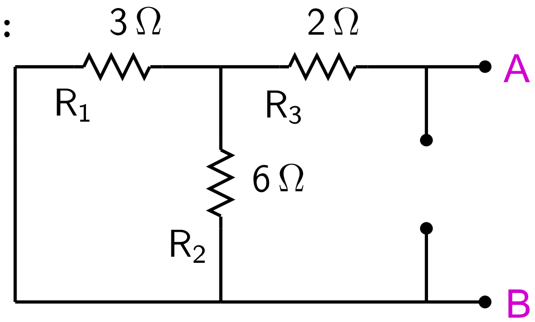


Maximum power transfer: example

Find R_L for which P_L is maximum.



R_{Th}:

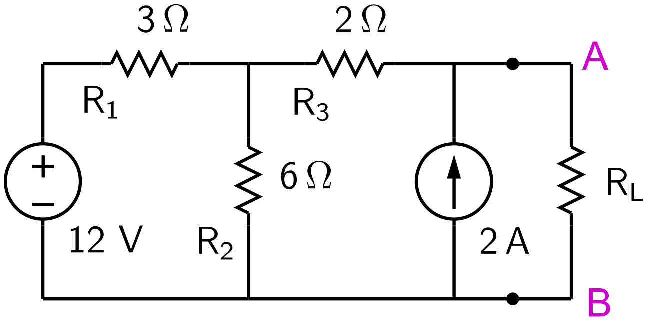


$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

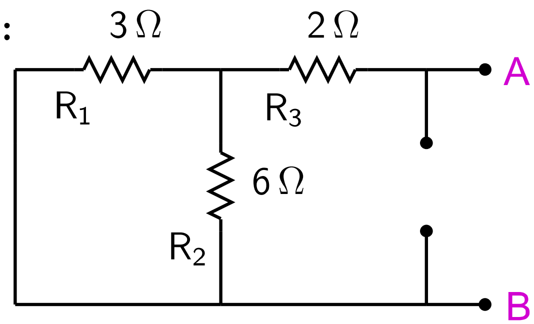
$$= 3 \times \left(\frac{1 \times 2}{1+2}\right) + 2 = 4\,\Omega$$

Maximum power transfer: example

Find R_L for which P_L is maximum.



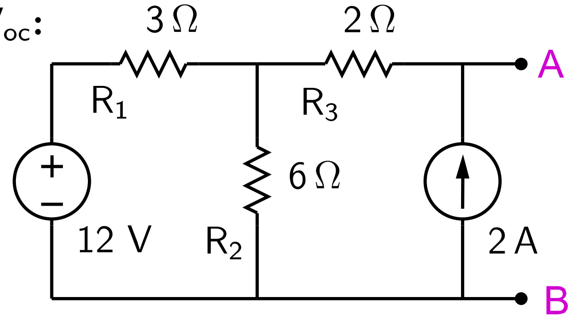
R_{Th}:



$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

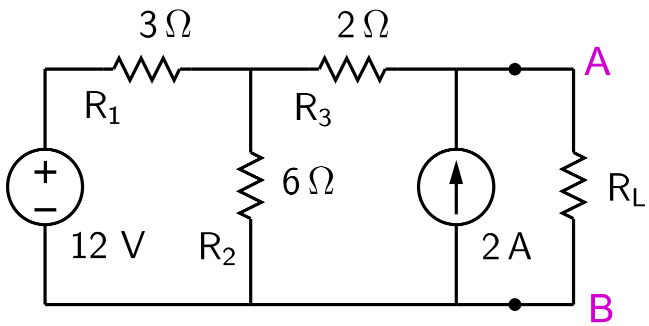
$$= 3 \times \left(\frac{1 \times 2}{1 + 2}\right) + 2 = 4\,\Omega$$

V_{oc}:

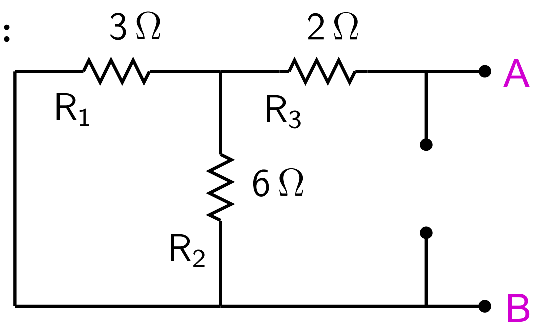


Maximum power transfer: example

Find R_L for which P_L is maximum.



R_{Th}:



$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

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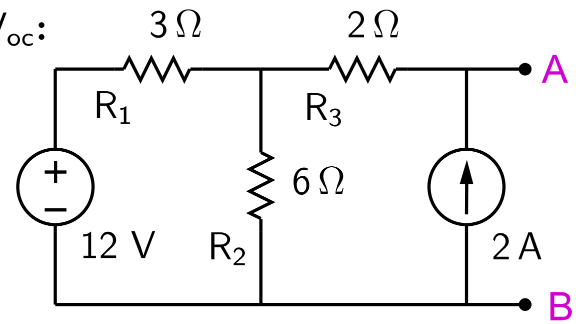
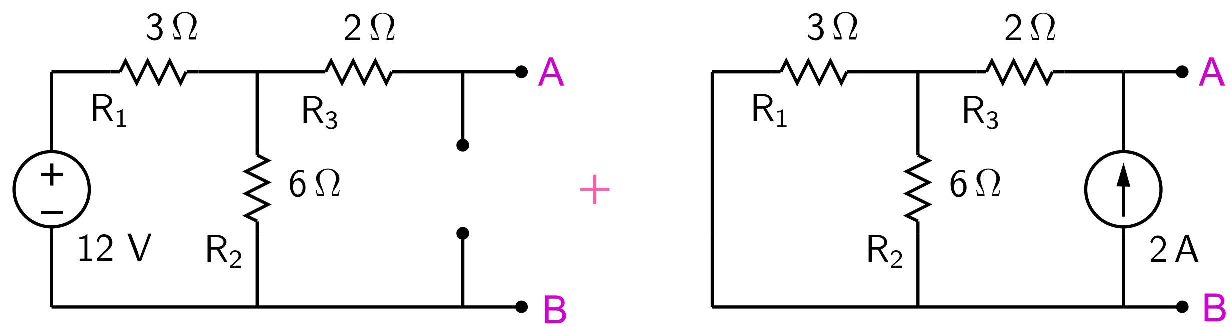
V_{oc}:

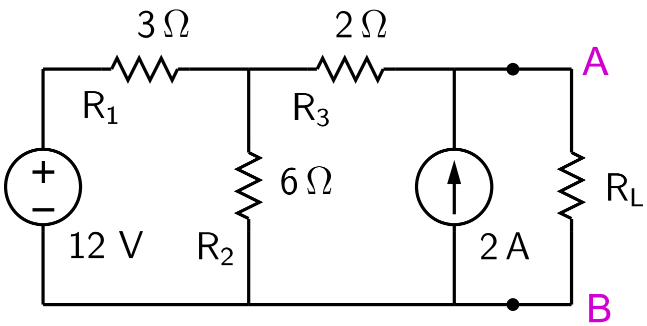


Use superposition to find V_{oc}:

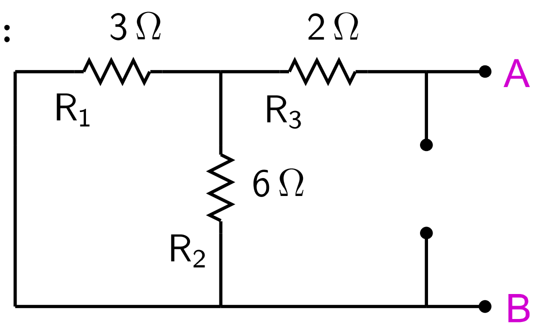


Maximum power transfer: example

Find R_L for which P_L is maximum.



R_{Th}:



$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

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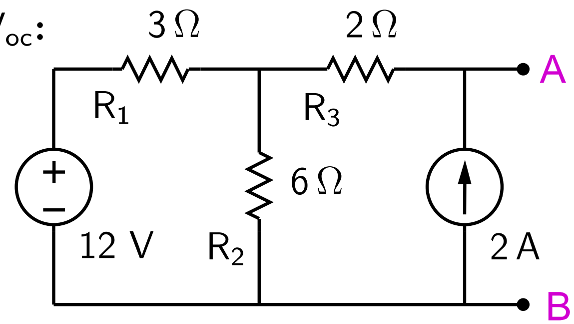
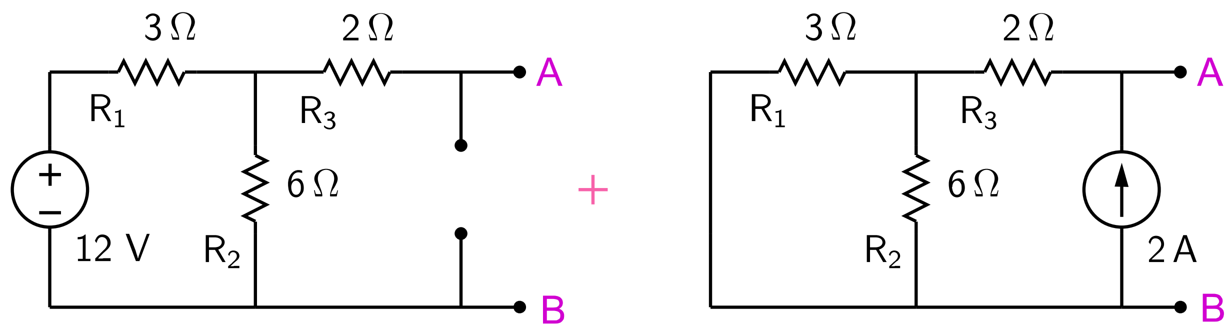
V_{oc}:



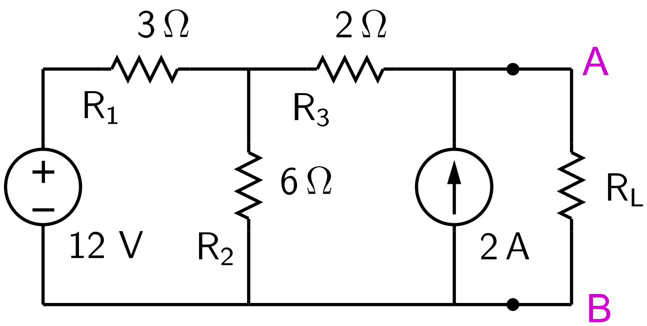
Use superposition to find V_{oc}:



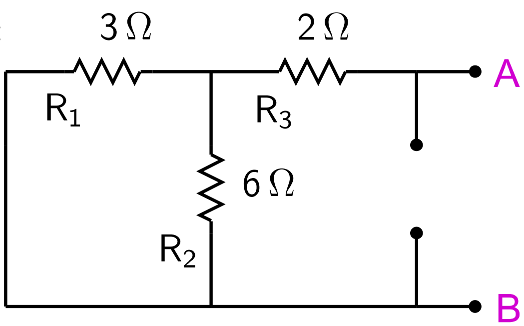
$$V_{oc}^{(1)} = 12 \times \frac{6}{9} = 8\ \text{V}$$

Maximum power transfer: example

Find R_L for which P_L is maximum.



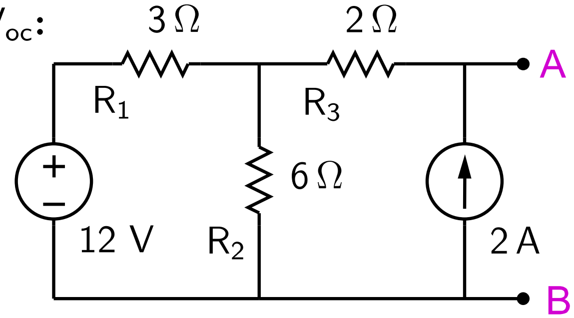
R_{Th}:



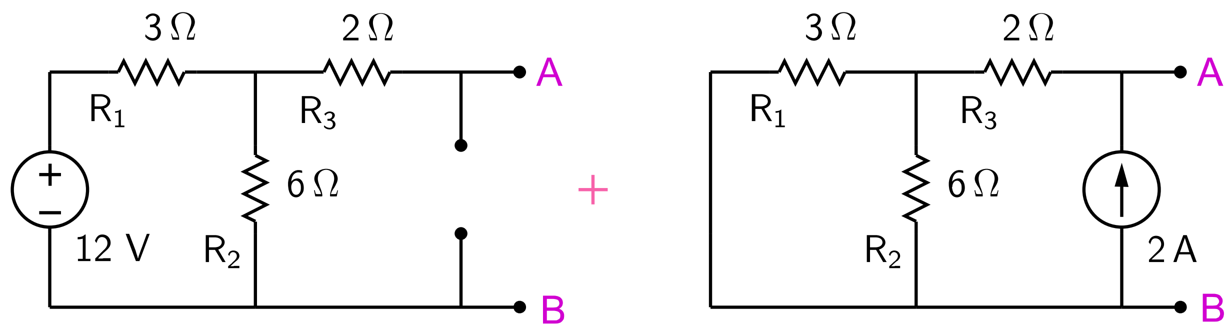
$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

$$= 3 \times \left(\frac{1 \times 2}{1 + 2} \right) + 2 = 4\,\Omega$$

V_{oc}:



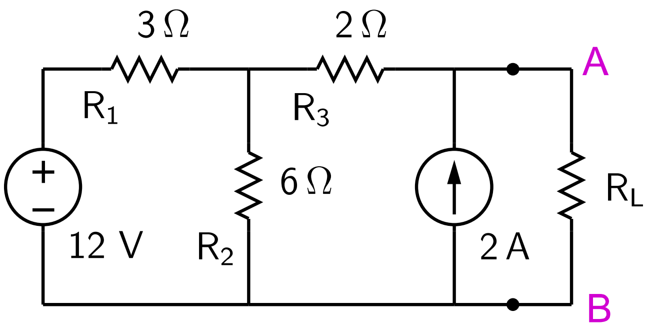
Use superposition to find V_{oc}:



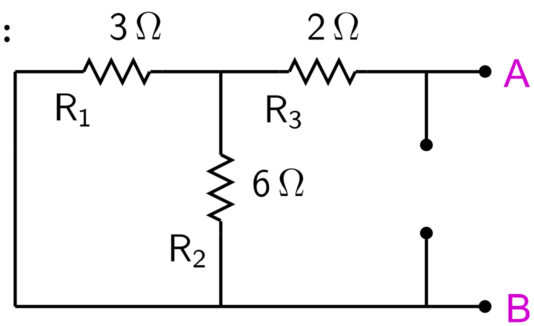
$$V_{oc}^{(1)} = 12 \times \frac{6}{9} = 8 \text{ V} \qquad V_{oc}^{(2)} = 4\,\Omega \times 2\,A = 8\,\text{V}$$

Maximum power transfer: example

Find R_L for which P_L is maximum.



R_{Th}:



$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

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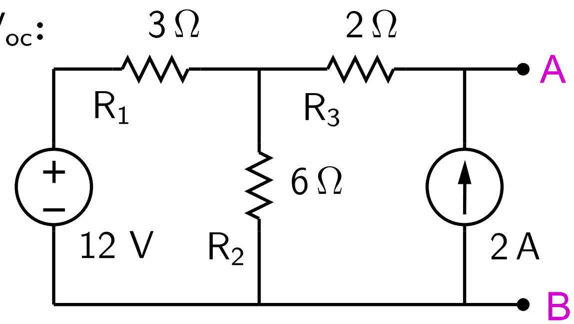
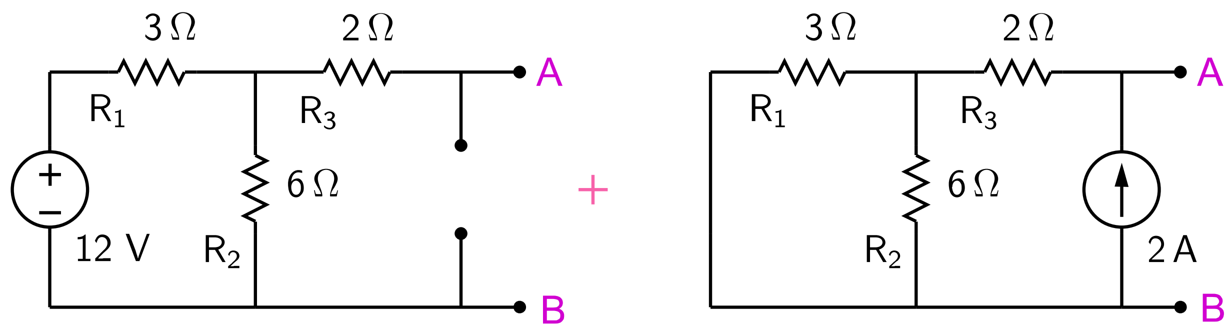


Use superposition to find V_{oc}:



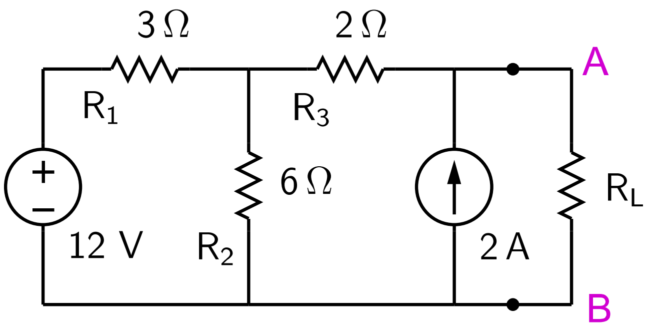
$$V_{oc}^{(1)} = 12 \times \frac{6}{9} = 8 \text{ V}$$

$$V_{oc}^{(2)} = 4\,\Omega \times 2\,A = 8\,\text{V}$$

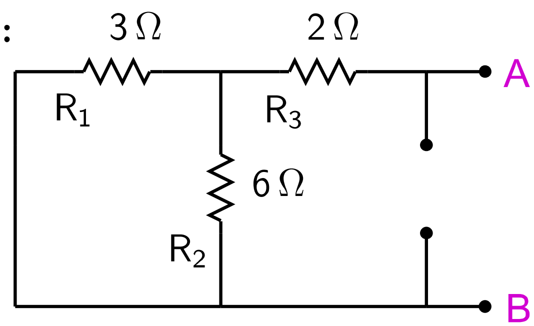
$$V_{oc} = V_{oc}^{(1)} + V_{oc}^{(2)} = 8 + 8 = 16\,\text{V}$$

Maximum power transfer: example

Find R_L for which P_L is maximum.



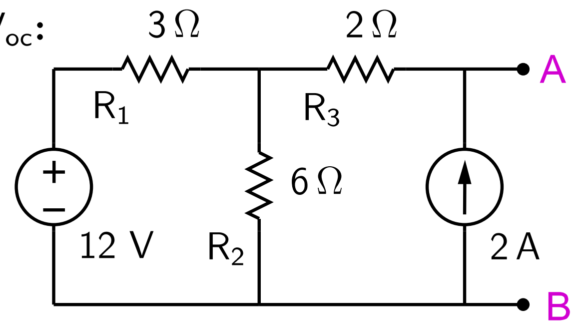
R_{Th}:



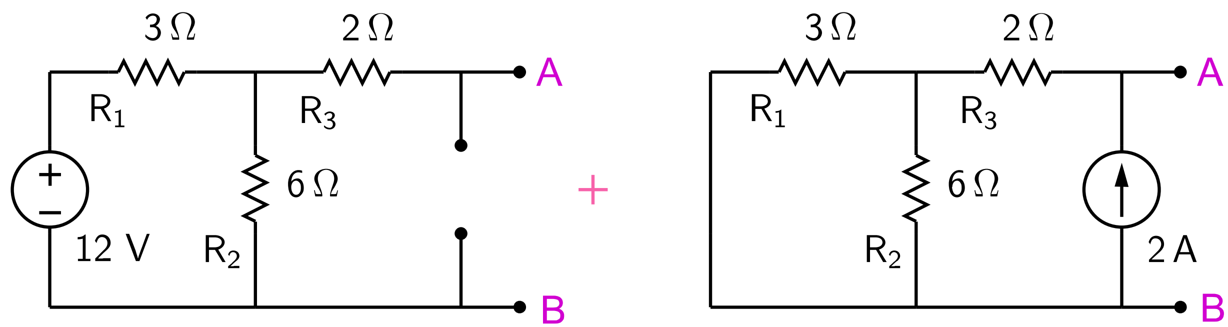
$$R_{Th} = (R_1 \parallel R_2) + R_3 = (3 \parallel 6) + 2$$

$$= 3 \times \left(\frac{1 \times 2}{1 + 2}\right) + 2 = 4\,\Omega$$

V_{oc}:



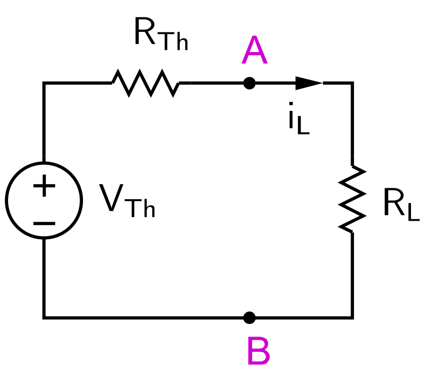
Use superposition to find V_{oc}:



$V_{oc}^{(1)} = 12 \times \dfrac{6}{9} = 8\ \text{V}$

$V_{oc}^{(2)} = 4\,\Omega \times 2\,A = 8\,\text{V}$

$$V_{oc} = V_{oc}^{(1)} + V_{oc}^{(2)} = 8 + 8 = 16\,\text{V}$$

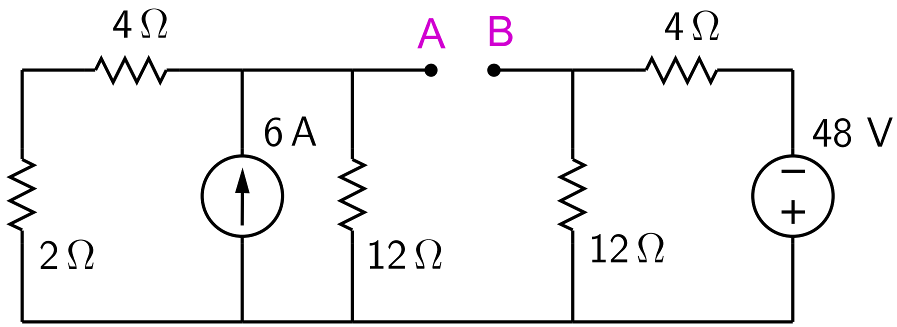


P_L is maximum when $R_L = R_{Th} = 4\,\Omega$

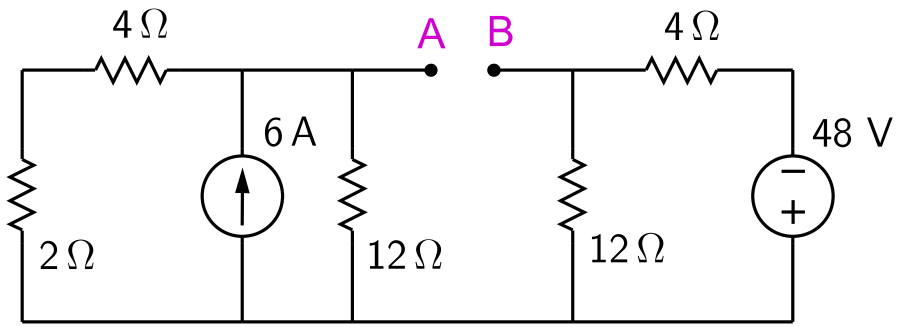
$\Rightarrow i_L = V_{Th}/(2\,R_{Th}) = 2\,\text{A}$

$P_L^{max} = 2^2 \times 4 = 16\,\text{W}$.

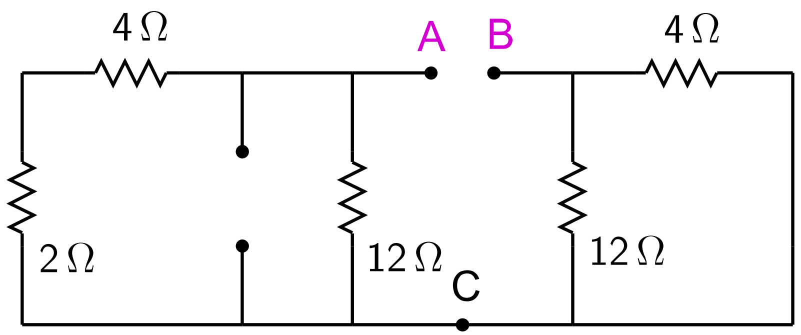
Thevenin's theorem: example



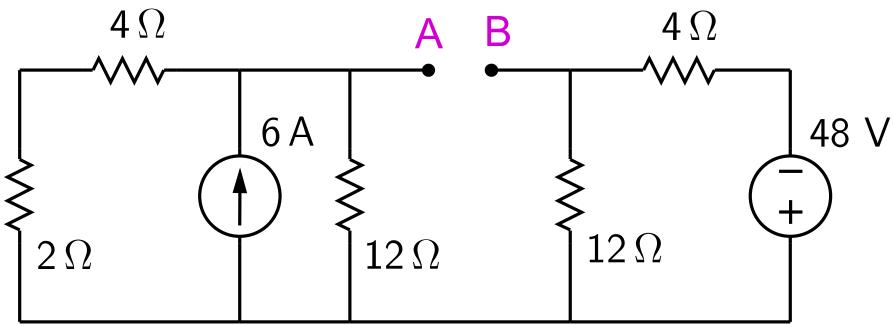
Thevenin's theorem: example



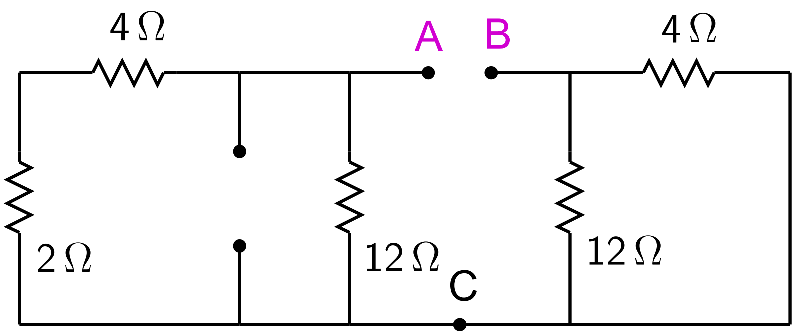
R_{Th}:



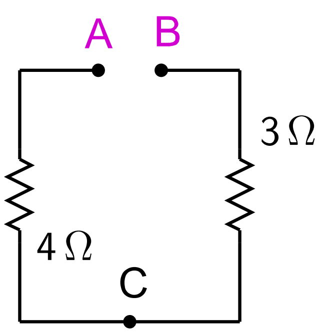
Thevenin's theorem: example



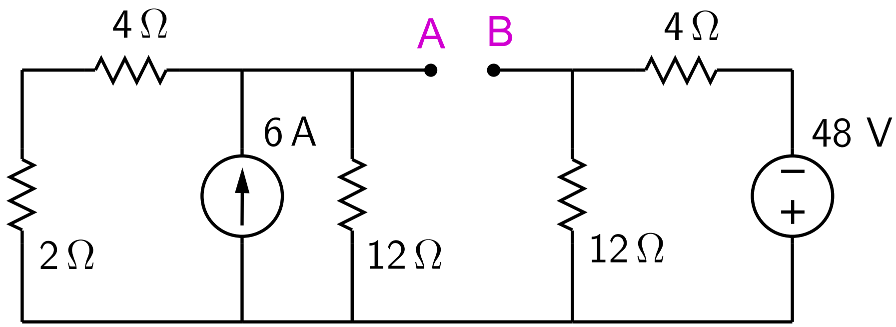
R_{Th}:



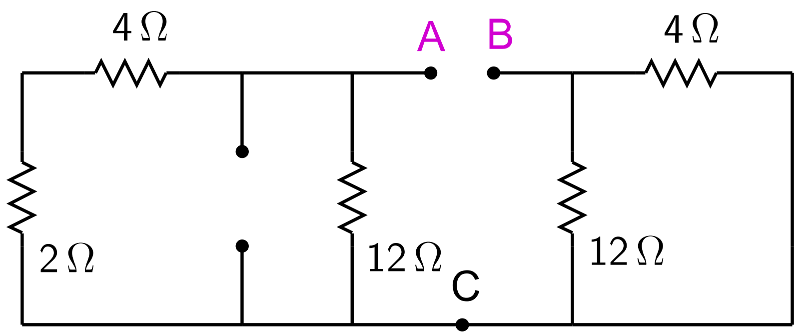
$\equiv$



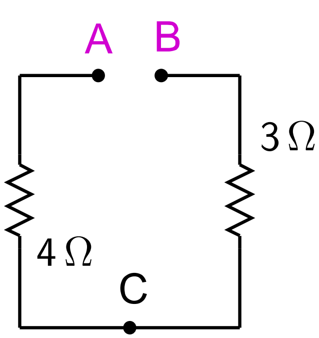
Thevenin's theorem: example



R_{Th}:

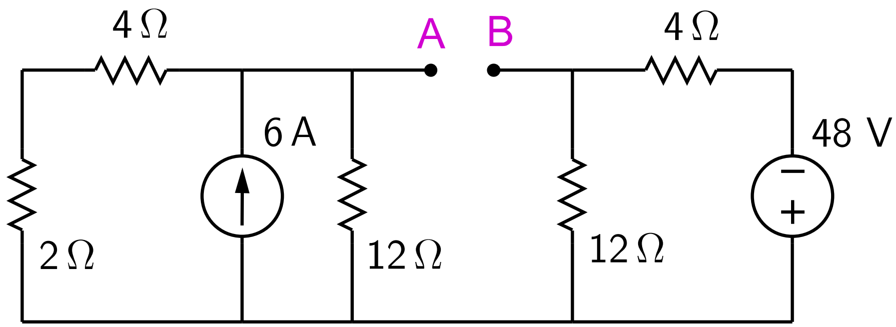


$\equiv$

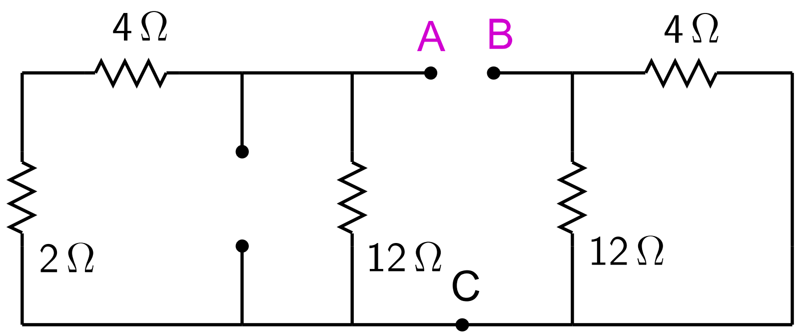


$\Rightarrow R_{Th} = 7\,\Omega$

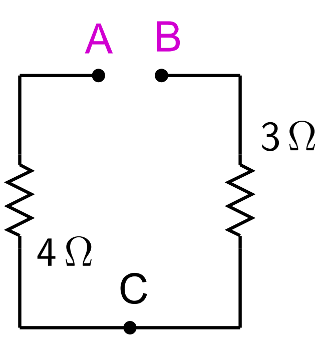
Thevenin's theorem: example



R_{Th}:

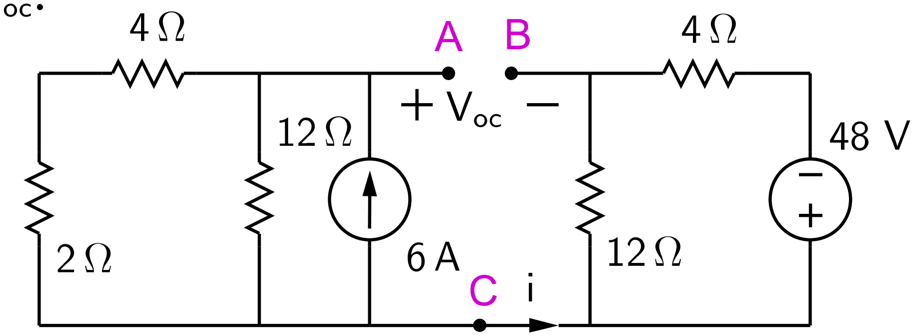


$\equiv$

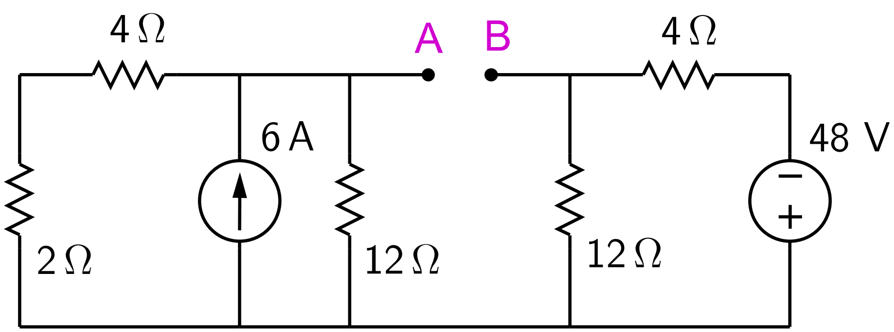


$\Rightarrow \quad R_{Th} = 7\,\Omega$

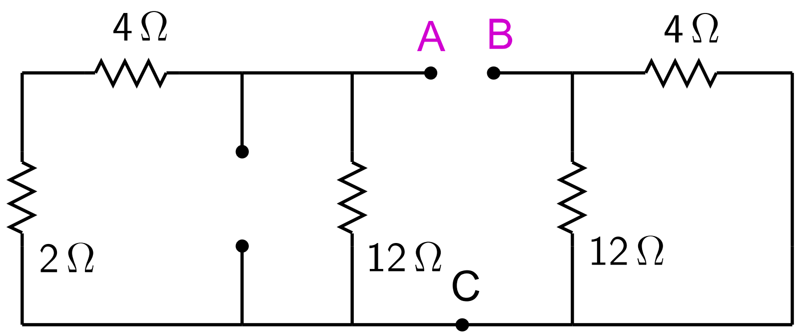
V_{oc}:



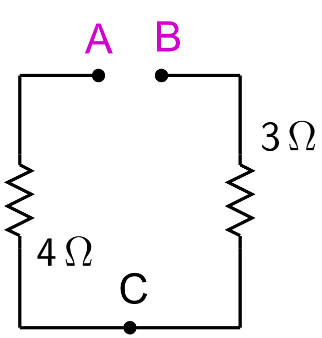
Thevenin's theorem: example



R_{Th}:

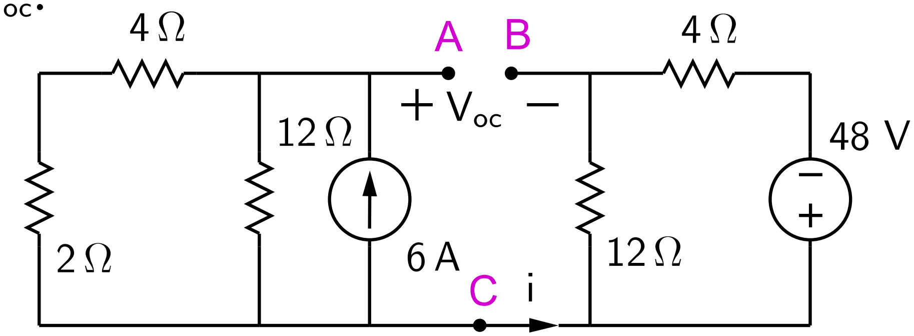


$\equiv$



$\Rightarrow \quad R_{Th} = 7\,\Omega$

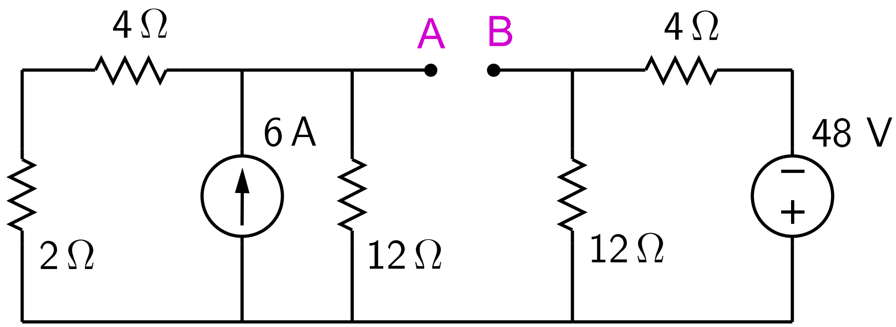
V_{oc}:



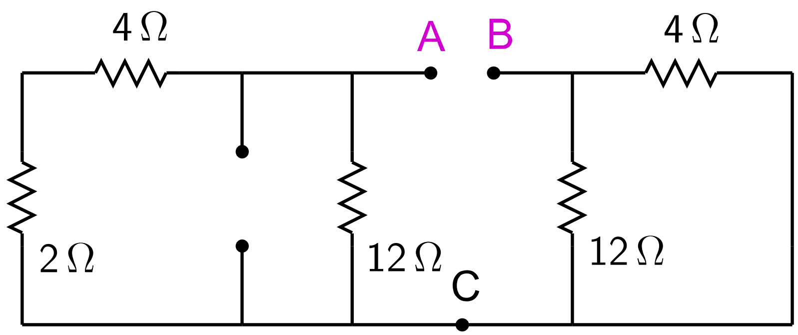
Note: $i = 0$ (since there is no return path).

$$\begin{aligned} V_{AB} &= V_A - V_B \\ &= (V_A - V_C) + (V_C - V_B) \\ &= V_{AC} + V_{CB} \\ &= 24\,V + 36\,V = 60\,V \end{aligned}$$

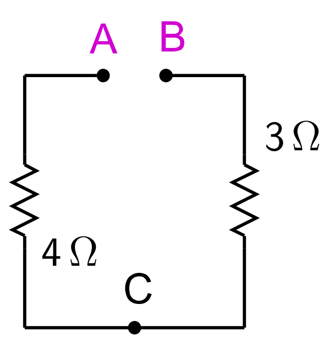
Thevenin's theorem: example



R_{Th}:

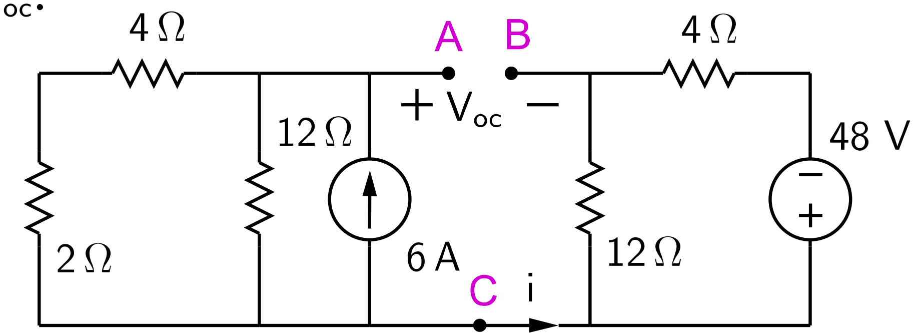


$\equiv$



$\Rightarrow$ $R_{Th} = 7\,\Omega$

V_{oc}:

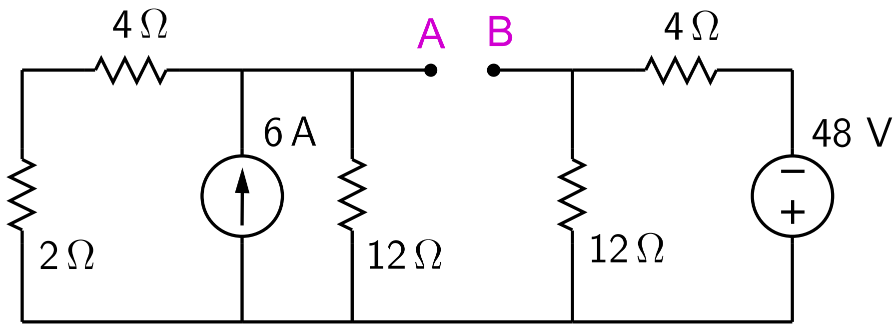


Note: $i = 0$ (since there is no return path).

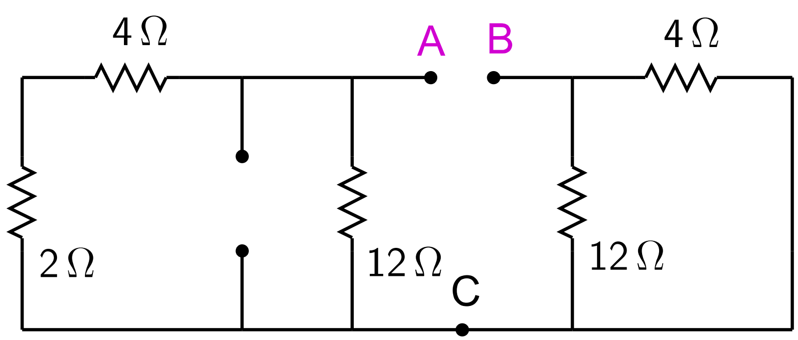
$$
\begin{aligned}
V_{AB} &= V_A - V_B \\
&= (V_A - V_C) + (V_C - V_B) \\
&= V_{AC} + V_{CB} \\
&= 24\,\text{V} + 36\,\text{V} = 60\,\text{V}
\end{aligned}
$$

$$\boxed{\begin{aligned} V_{Th} &= 60\,\text{V} \\ R_{Th} &= 7\,\Omega \end{aligned}}$$

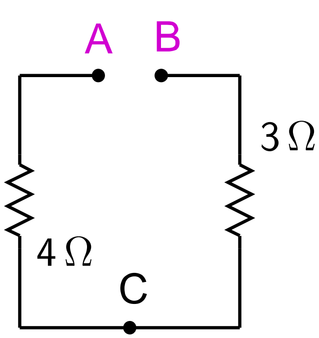
Thevenin's theorem: example



R_{Th}:

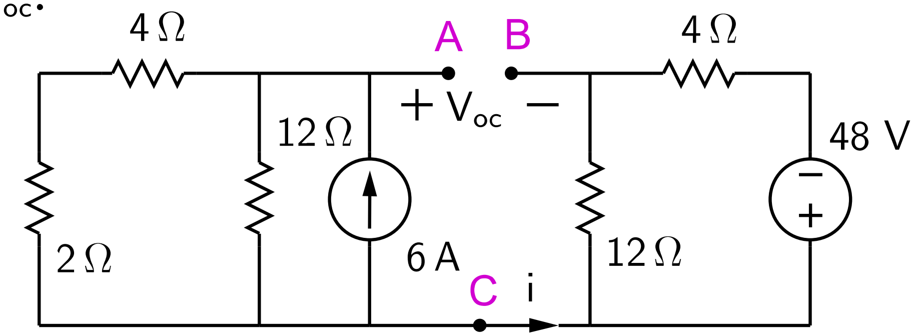


$\equiv$



$\Rightarrow \quad R_{Th} = 7\,\Omega$

V_{oc}:

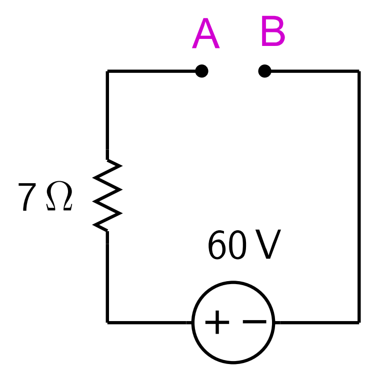


Note: $i = 0$ (since there is no return path).

$$
\begin{aligned}
V_{AB} &= V_A - V_B \\
&= (V_A - V_C) + (V_C - V_B) \\
&= V_{AC} + V_{CB} \\
&= 24\,\text{V} + 36\,\text{V} = 60\,\text{V}
\end{aligned}
$$

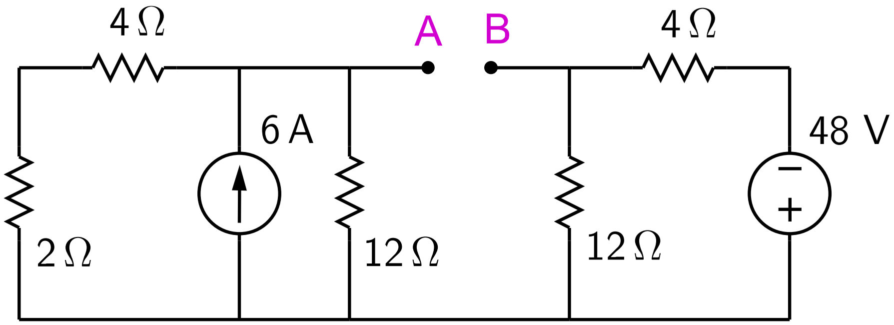
$V_{Th} = 60\,\text{V}$

$R_{Th} = 7\,\Omega$



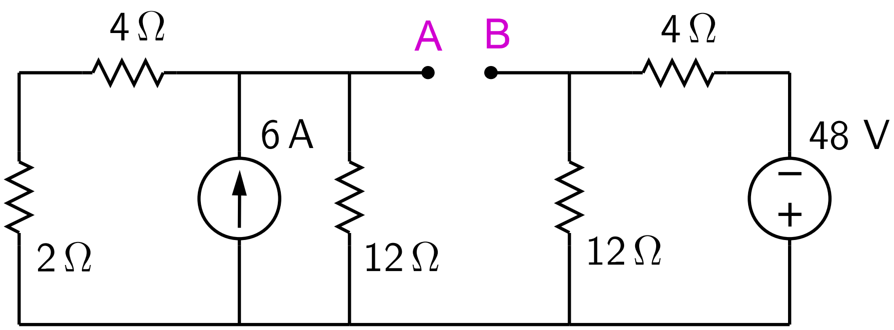
Graphical method for finding V_{Th} and R_{Th}

SEQUEL file: ee101_thevenin_1.sqproj



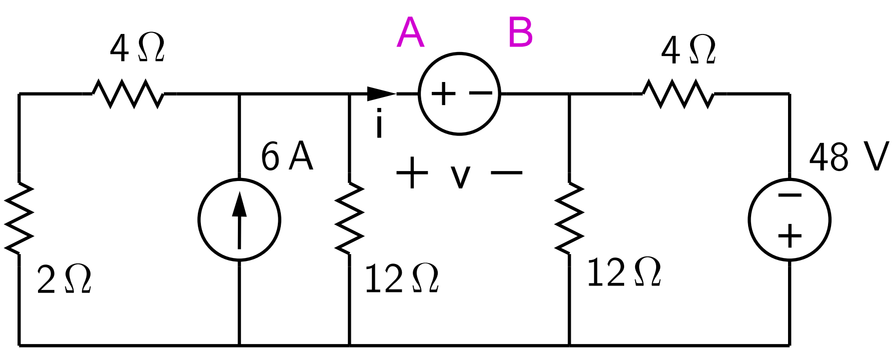
Graphical method for finding V_{Th} and R_{Th}

SEQUEL file: ee101_thevenin_1.sqproj



Connect a voltage source between A and B.

Plot i versus v.

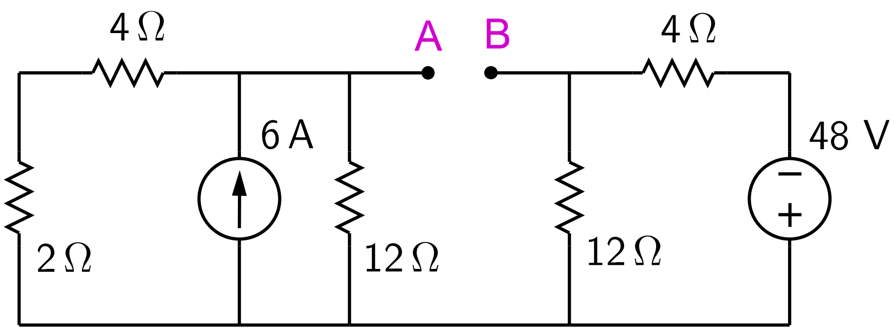


V_{oc} = intercept on the v-axis.

I_{sc} = intercept on the i-axis.

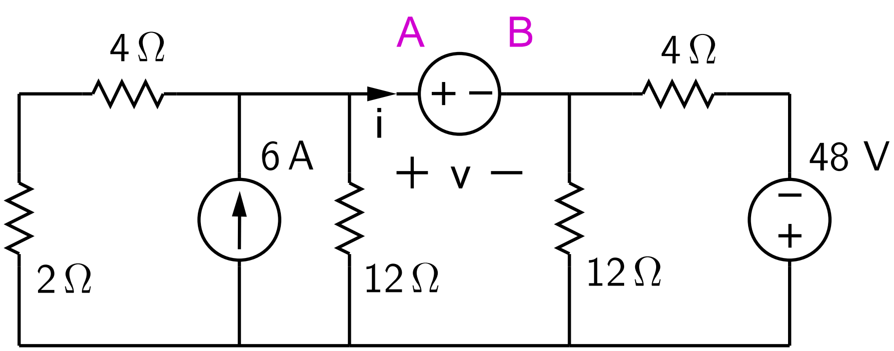
Graphical method for finding V_{Th} and R_{Th}

SEQUEL file: ee101_thevenin_1.sqproj



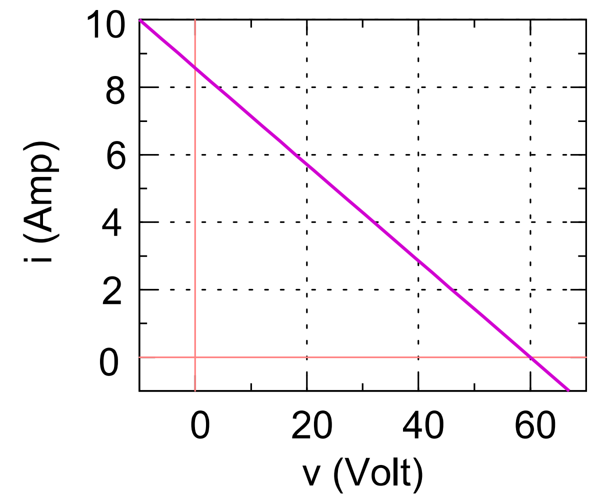
Connect a voltage source between A and B.

Plot i versus v.



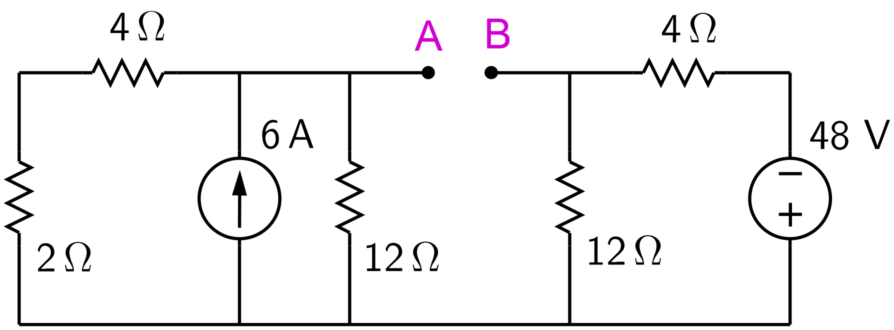
V_{oc} = intercept on the v-axis.

I_{sc} = intercept on the i-axis.



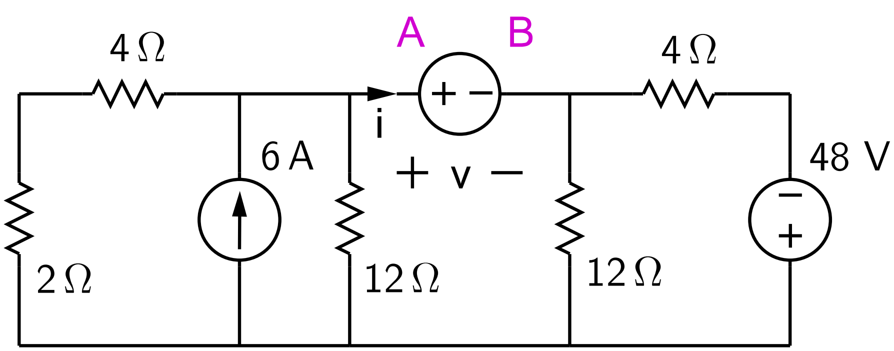
Graphical method for finding V_{Th} and R_{Th}

SEQUEL file: ee101_thevenin_1.sqproj



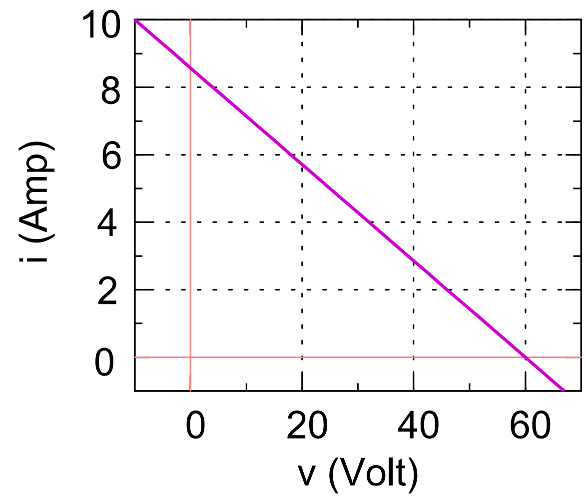
Connect a voltage source between A and B.

Plot i versus v.



V_{oc} = intercept on the v-axis.

I_{sc} = intercept on the i-axis.

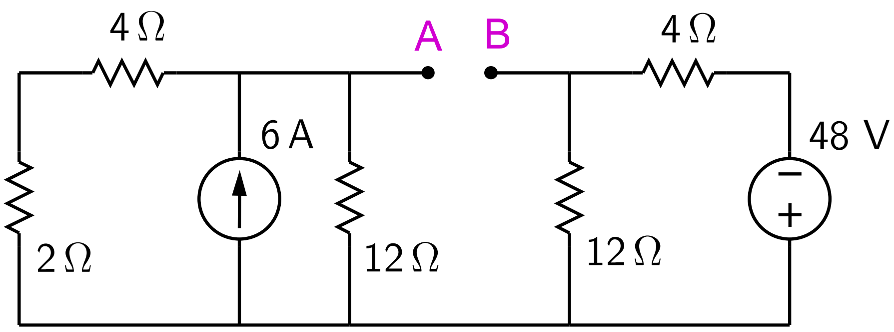


$V_{oc} = 60$ V, $I_{sc} = 8.57$ A

$R_{Th} = V_{sc}/I_{sc} = 7\ \Omega$

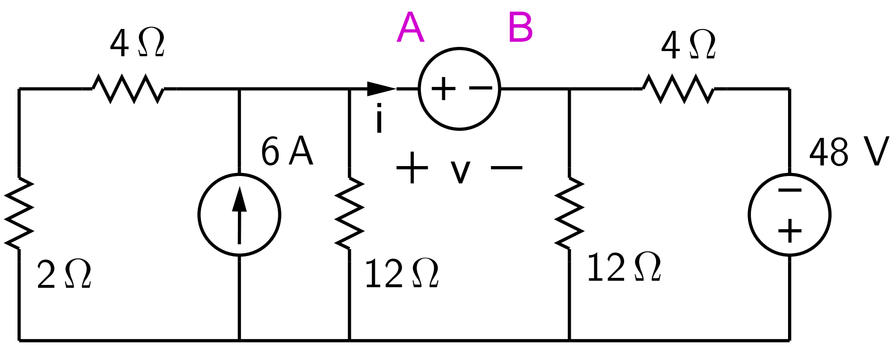
Graphical method for finding V_{Th} and R_{Th}

SEQUEL file: ee101_thevenin_1.sqproj



Connect a voltage source between A and B.

Plot i versus v.



V_{oc} = intercept on the v-axis.

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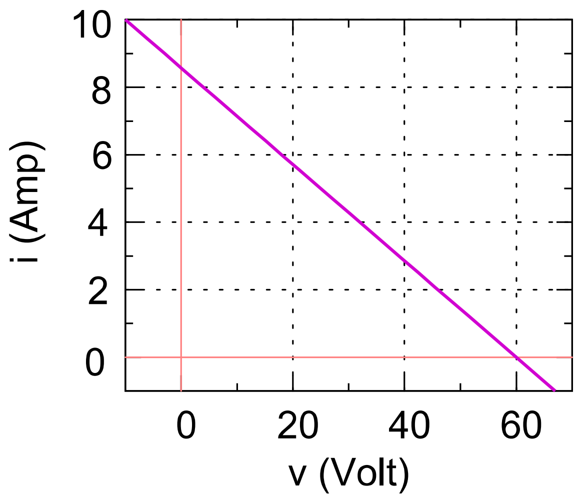
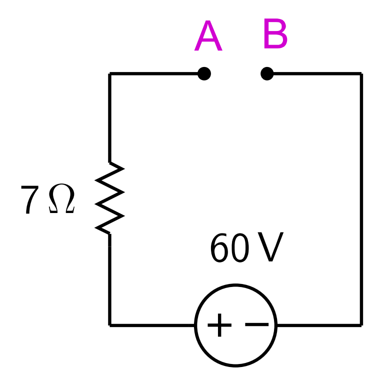


$V_{oc} = 60$ V, $I_{sc} = 8.57$ A

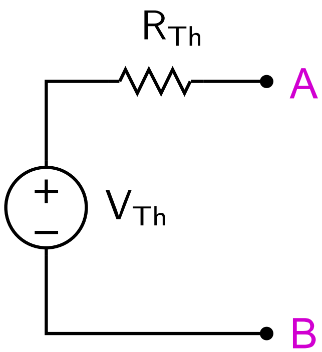
$R_{Th} = V_{sc}/I_{sc} = 7\ \Omega$

$V_{Th} = 60\,\text{V}$

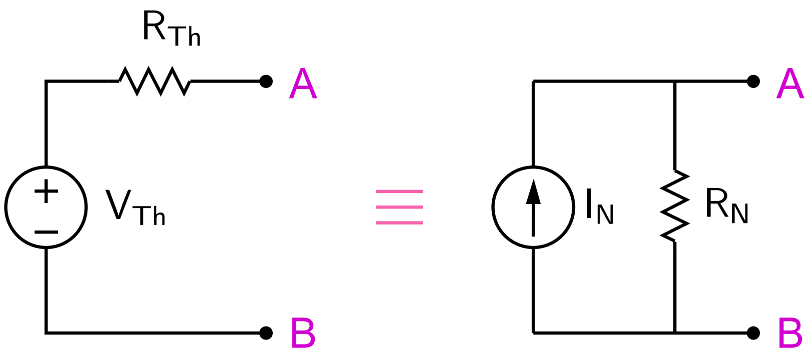
$R_{Th} = 7\,\Omega$



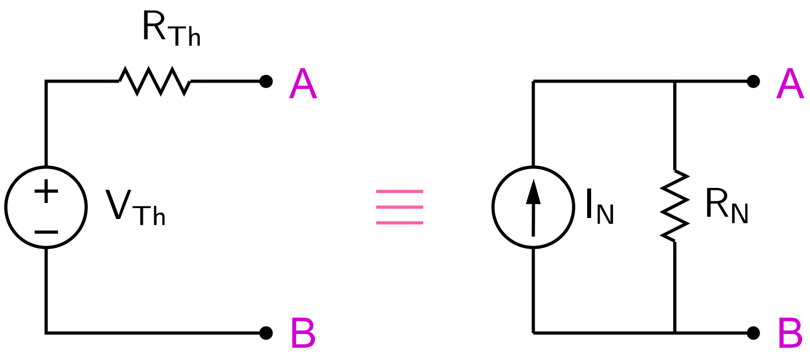
Norton equivalent circuit



Norton equivalent circuit

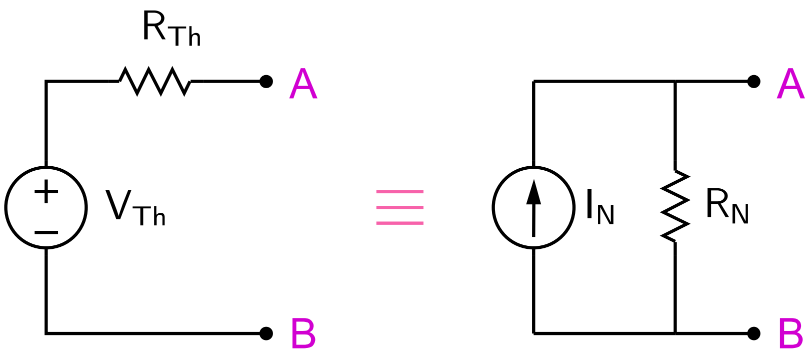


Norton equivalent circuit



* Consider the open circuit case.

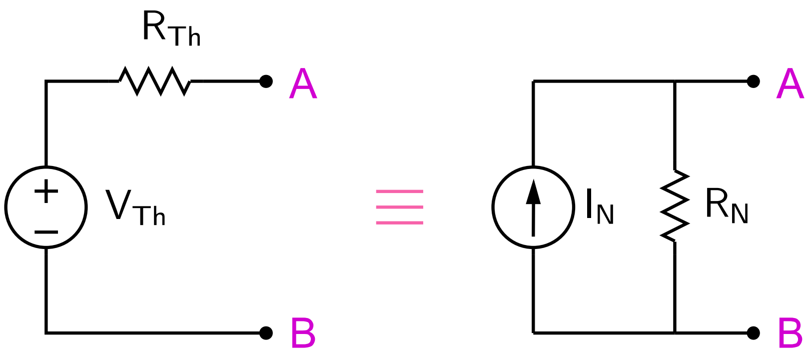
Norton equivalent circuit



* Consider the open circuit case.

  Thevenin circuit: $V_{AB} = V_{Th}$.

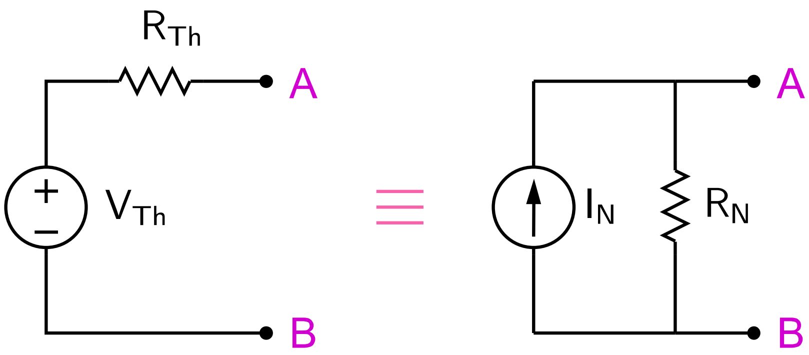
Norton equivalent circuit



* Consider the open circuit case.

Thevenin circuit: $V_{AB} = V_{Th}$.
Norton circuit: $V_{AB} = I_N \, R_N$.

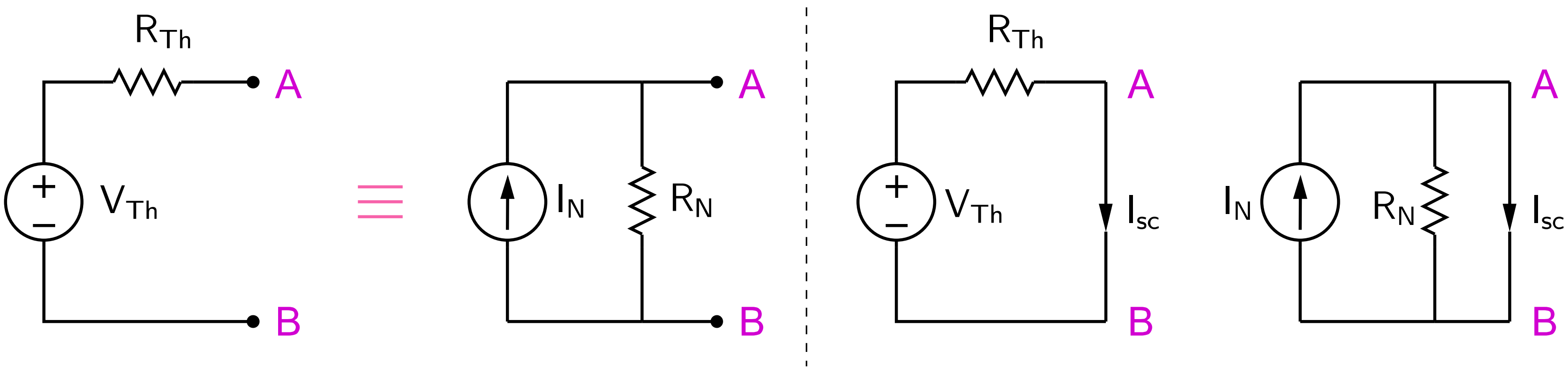
Norton equivalent circuit



* Consider the open circuit case.

  Thevenin circuit: $V_{AB} = V_{Th}$.
  Norton circuit: $V_{AB} = I_N\, R_N$.
  $\Rightarrow V_{Th} = I_N\, R_N$.

Norton equivalent circuit

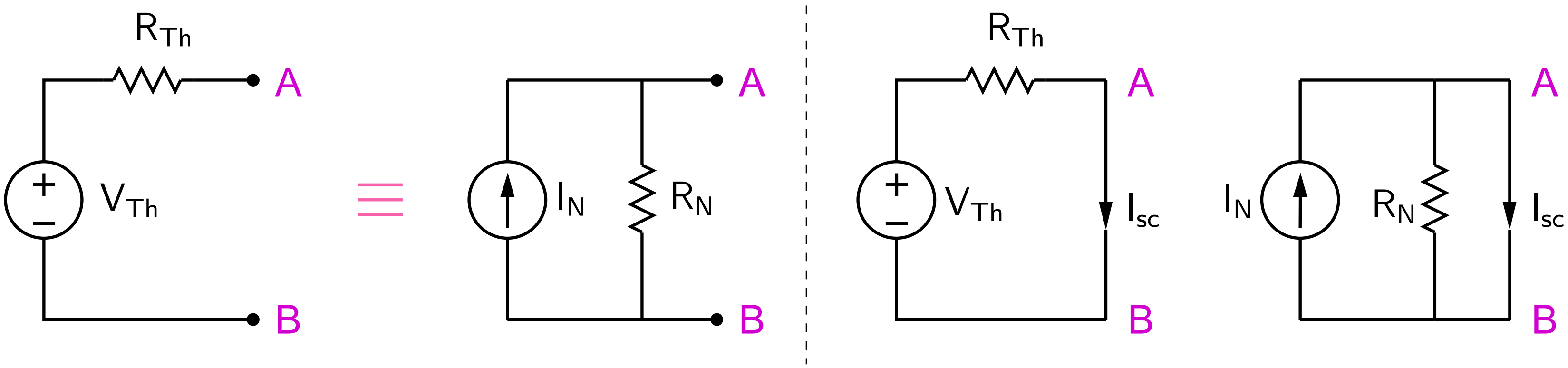


∗ Consider the open circuit case.

Thevenin circuit: $V_{AB} = V_{Th}$.
Norton circuit: $V_{AB} = I_N \, R_N$.
$\Rightarrow V_{Th} = I_N \, R_N$.

∗ Consider the short circuit case.

Norton equivalent circuit



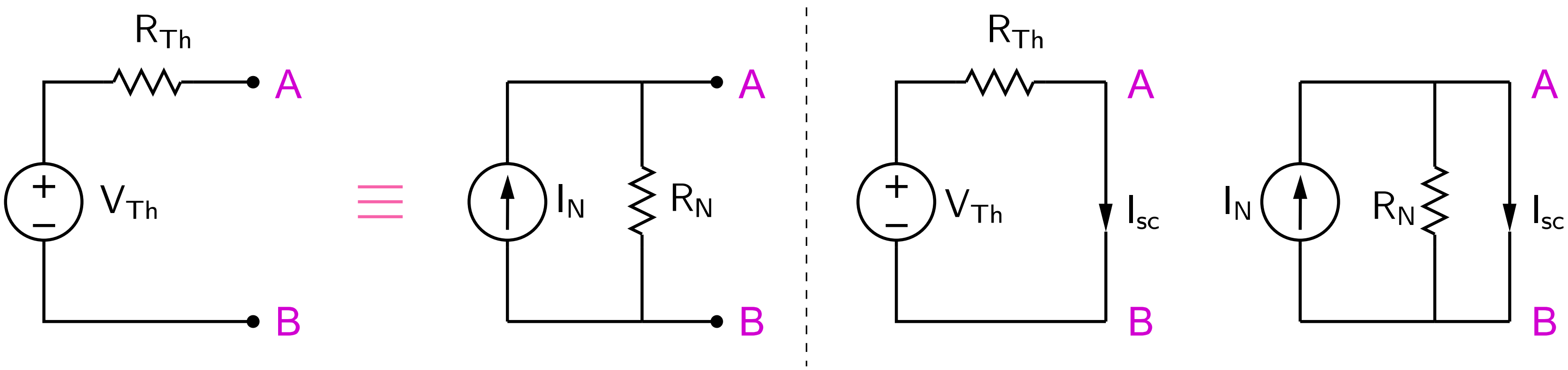
* Consider the open circuit case.

  Thevenin circuit: $V_{AB} = V_{Th}$.
  Norton circuit: $V_{AB} = I_N \, R_N$.
  $\Rightarrow V_{Th} = I_N \, R_N$.

* Consider the short circuit case.

  Thevenin circuit: $I_{sc} = V_{Th}/R_{Th}$.

Norton equivalent circuit



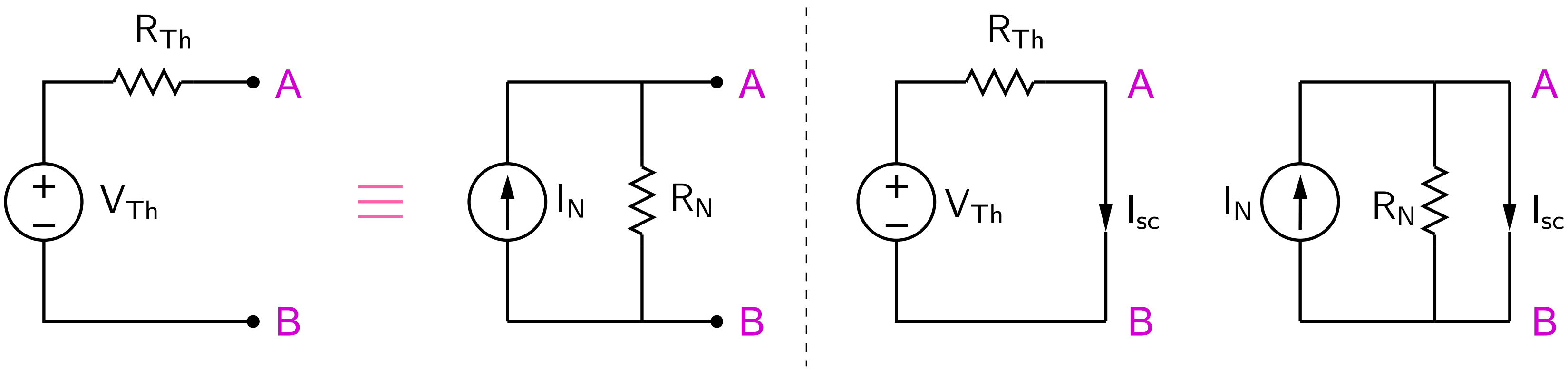
- Consider the open circuit case.

  Thevenin circuit: $V_{AB} = V_{Th}$.
  Norton circuit: $V_{AB} = I_N \, R_N$.
  $\Rightarrow V_{Th} = I_N \, R_N$.

- Consider the short circuit case.

  Thevenin circuit: $I_{sc} = V_{Th}/R_{Th}$.
  Norton circuit: $I_{sc} = I_N$.

Norton equivalent circuit



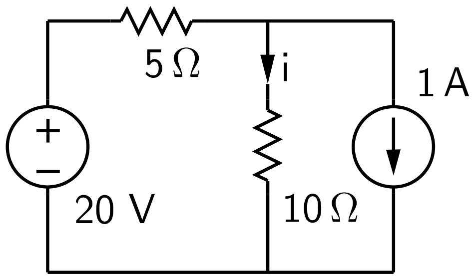
* Consider the open circuit case.

  Thevenin circuit: $V_{AB} = V_{Th}$.
  Norton circuit: $V_{AB} = I_N \, R_N$.
  $\Rightarrow V_{Th} = I_N \, R_N$.

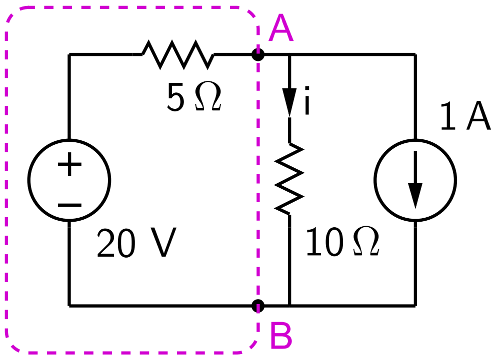
* Consider the short circuit case.

  Thevenin circuit: $I_{sc} = V_{Th}/R_{Th}$.
  Norton circuit: $I_{sc} = I_N$.
  $\Rightarrow R_{Th} = R_N$.

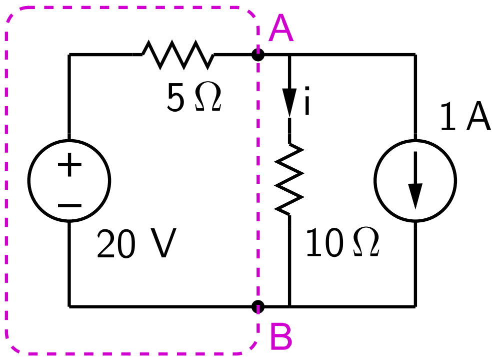
Example



Example



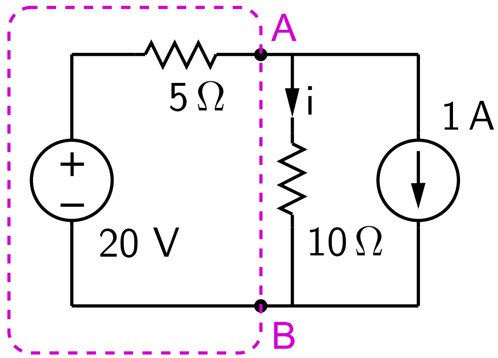
Example



$$R_N = 5\,\Omega$$

$$I_N = \frac{20\,\text{V}}{5\,\Omega} = 4\,\text{A}$$

Example



$$R_N = 5\,\Omega$$

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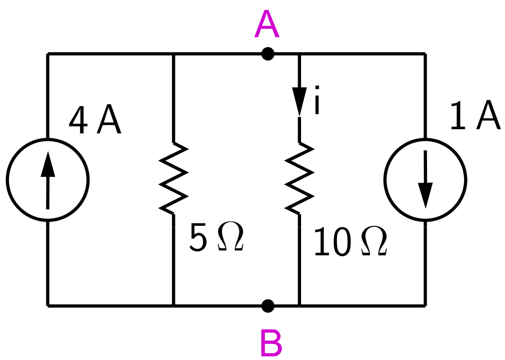
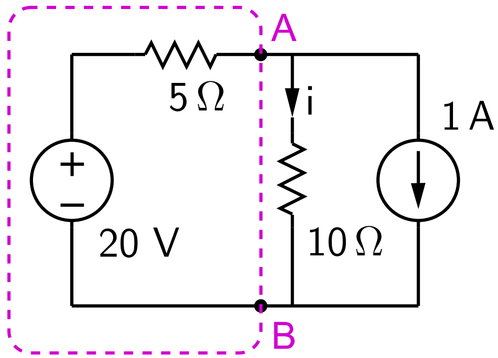


Example



$$R_N = 5\,\Omega$$

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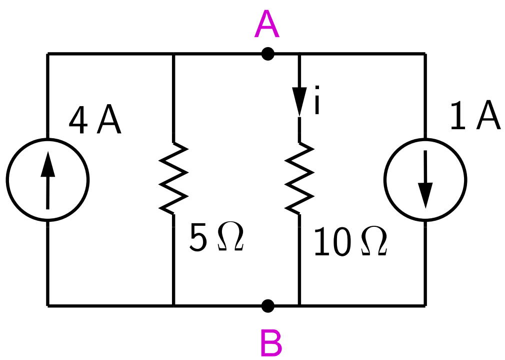
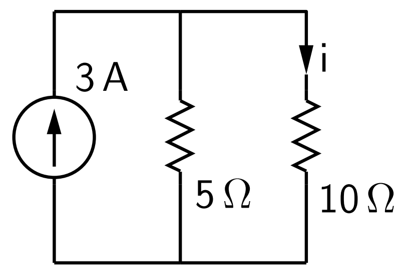
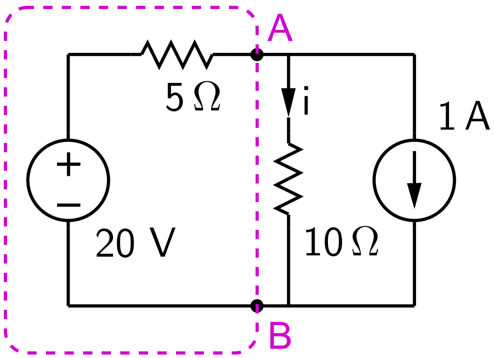




Example



$$R_N = 5\,\Omega$$

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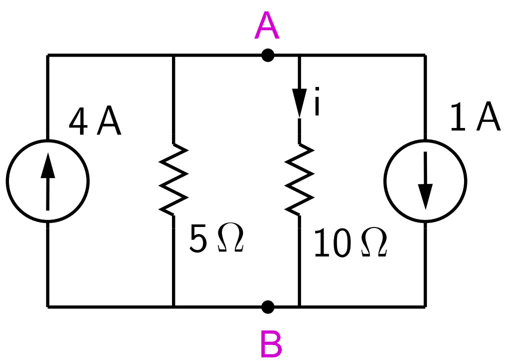
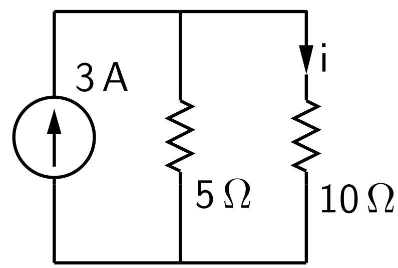
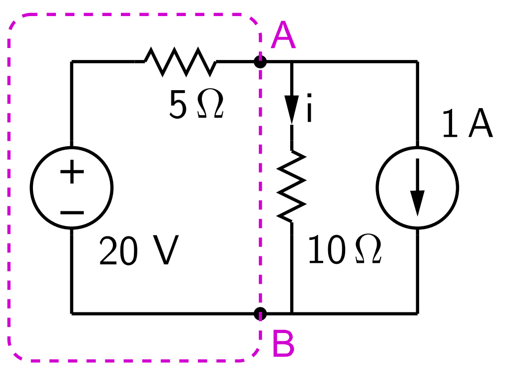




$$i = 3\,\text{A} \times \frac{5}{5+10}$$

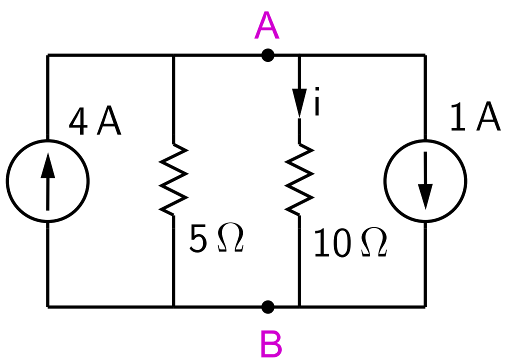
$$= 1\,\text{A}$$

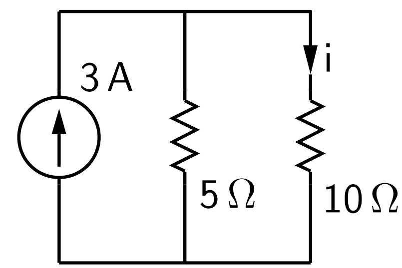
Example



$$R_N = 5\,\Omega$$

$$I_N = \frac{20\,\mathrm{V}}{5\,\Omega} = 4\,\mathrm{A}$$





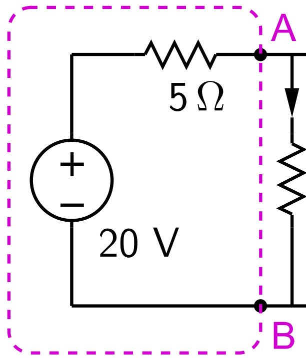
$$i = 3\,\mathrm{A} \times \frac{5}{5+10}$$

$$= 1\,\mathrm{A}$$

Home work:

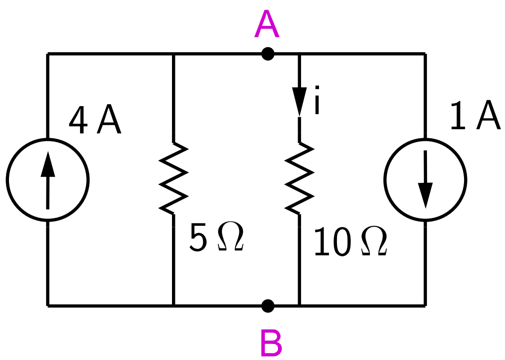
* Find *i* by superposition and compare.

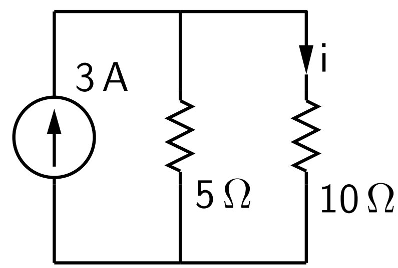
Example



$$R_N = 5\,\Omega$$

$$I_N = \frac{20\,\text{V}}{5\,\Omega} = 4\,\text{A}$$





$$i = 3\,\text{A} \times \frac{5}{5+10}$$

$$= 1\,\text{A}$$

Home work:

- ∗ Find i by superposition and compare.
- ∗ Compute the power absorbed by each element, and verify that $\sum P_i = 0$.