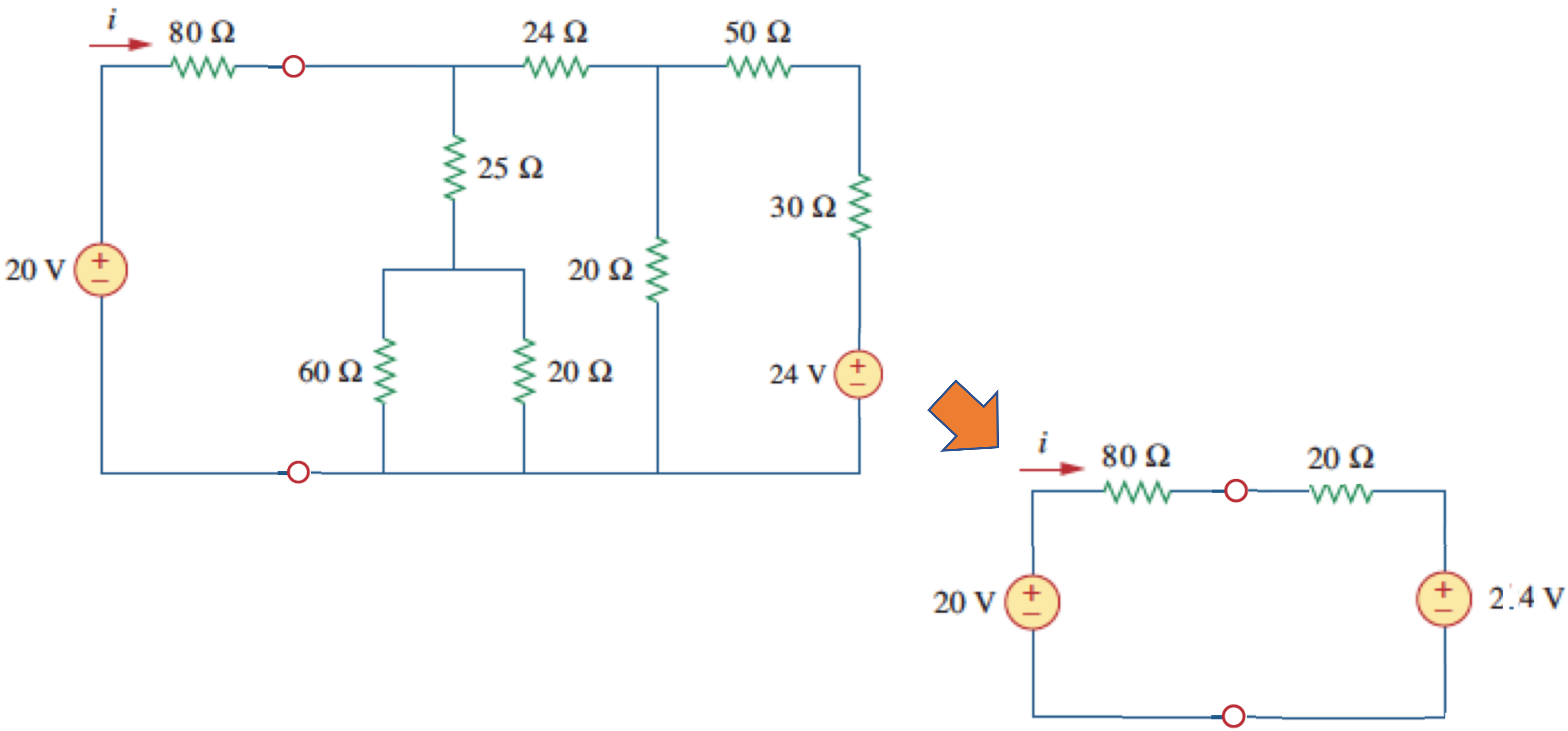
Theorems – 2

Thévenin

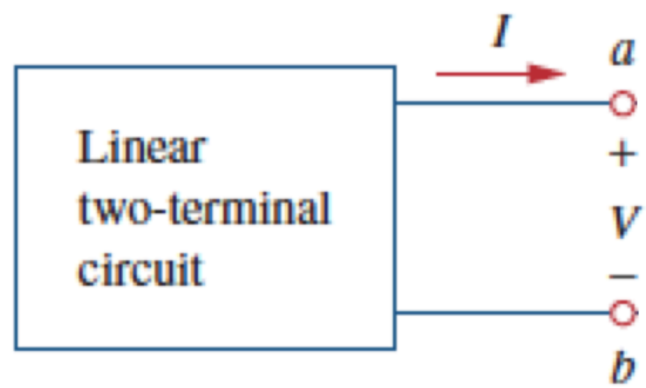
Thévenin Models

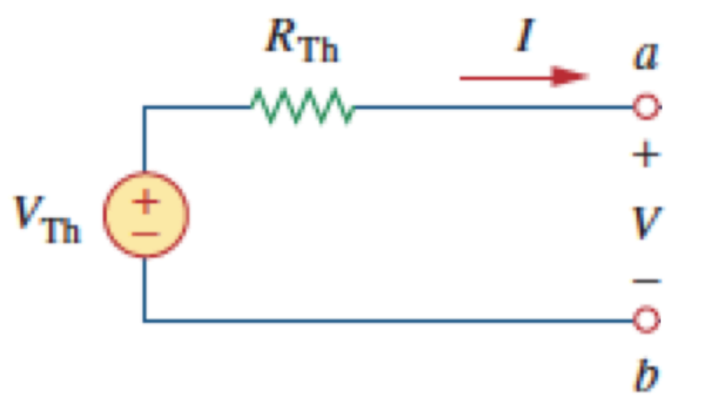
- Application – recall combining transformations and series/parallel methods:



- Thévenin Equivalent Circuit ≡ electrical equivalence at any pair of terminals

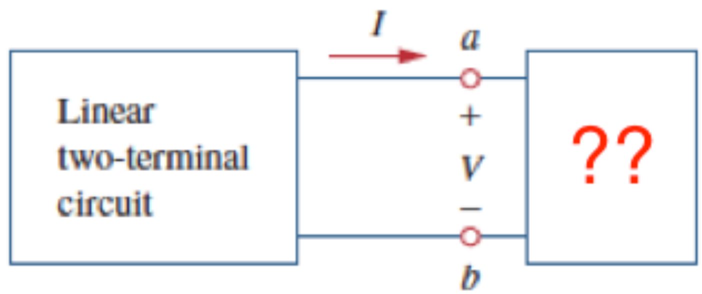
- 2 parameters:
  - V_{Th}
  - R_{Th}



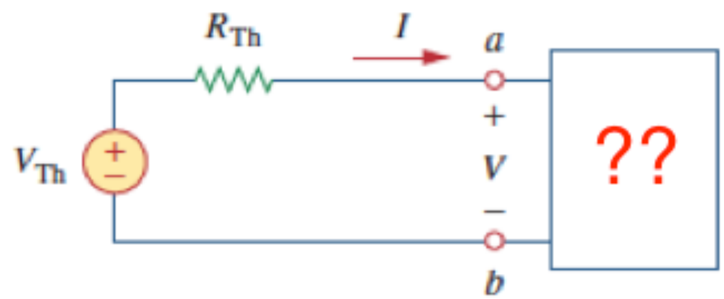


How to find V_{Th} and R_{Th} ?

- Concept: both the circuit and the model should behave the same way **no matter what** is connected at a-b



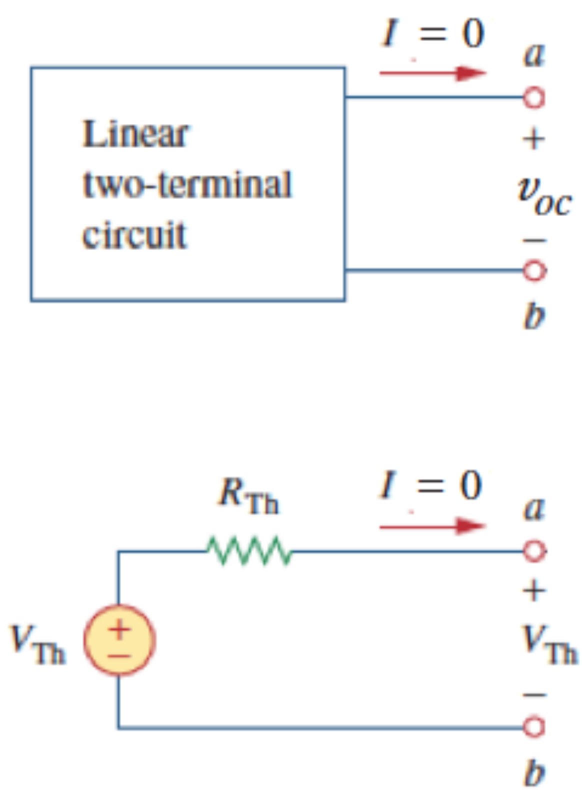
  - With only 2 variables in the model, we need only check 2 load situations



  - Need only match one of the V or I variables in each

Thevenin: Most Common Approach

- Connect nothing – “open circuit” test



Clearly

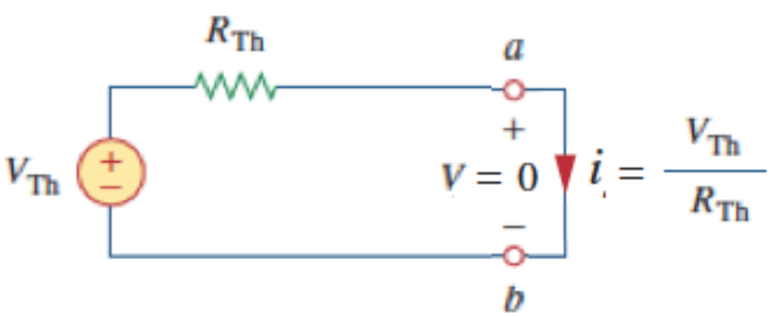
$$V_{Th} = V_{OC}$$

Another popular approach

- Connect a wire – “short circuit” test – popular on paper

$$i_{SC} = \frac{V_{Th}}{R_{Th}}$$

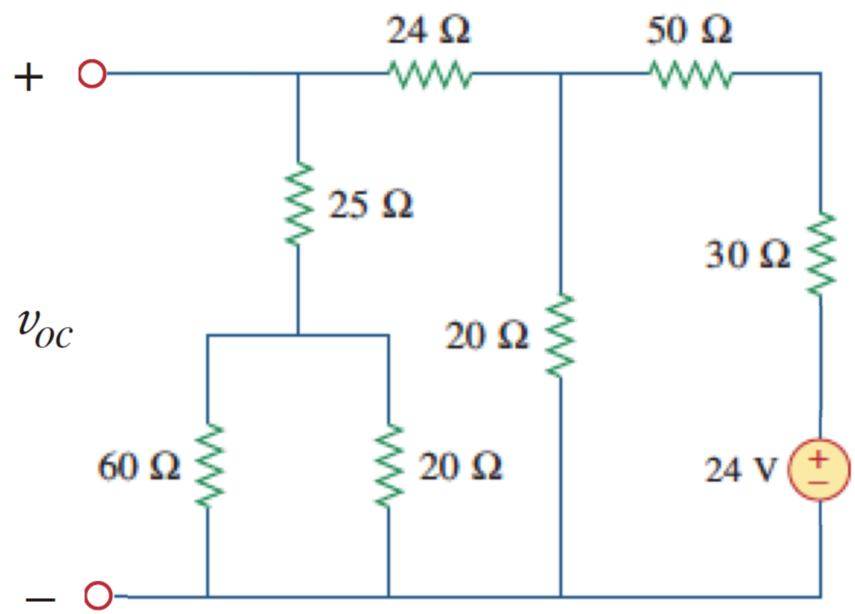
So



$$R_{Th} = \frac{V_{Th}}{i_{SC}} = \frac{V_{OC}}{i_{SC}}$$

Example:

Use node analysis:

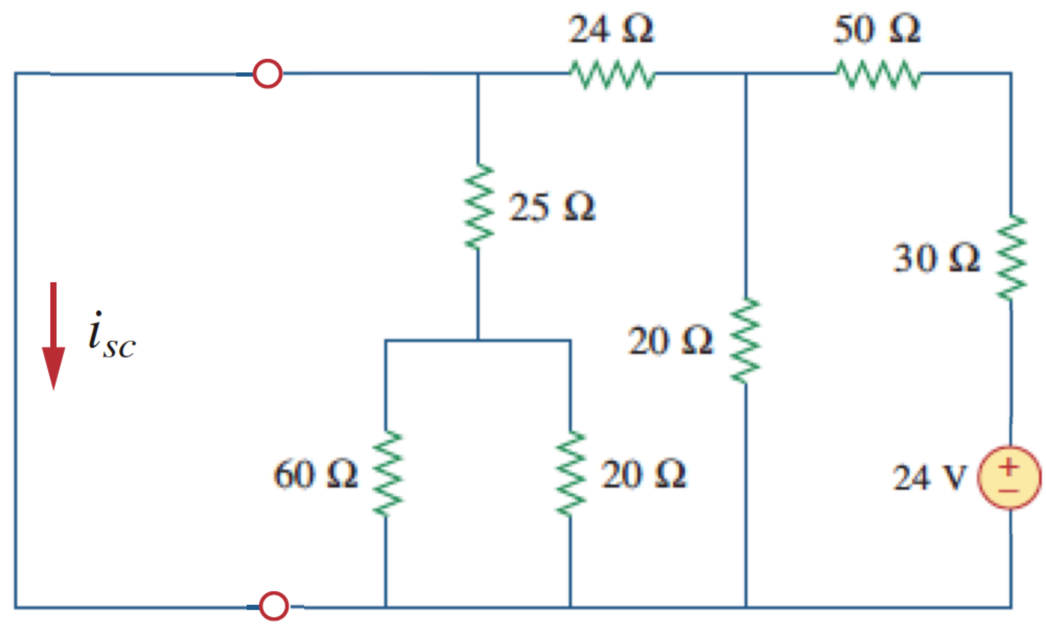


$$\frac{v}{20} + \frac{v-24}{80} + \frac{v}{64} = 0 \quad \Rightarrow \quad v = \frac{96}{25}$$

Then voltage division:

$$v_{OC} = \frac{40}{64} v \quad \Rightarrow \quad V_{Th} = v_{OC} = 2.4 \text{ volts}$$

Note how the short changes the circuit



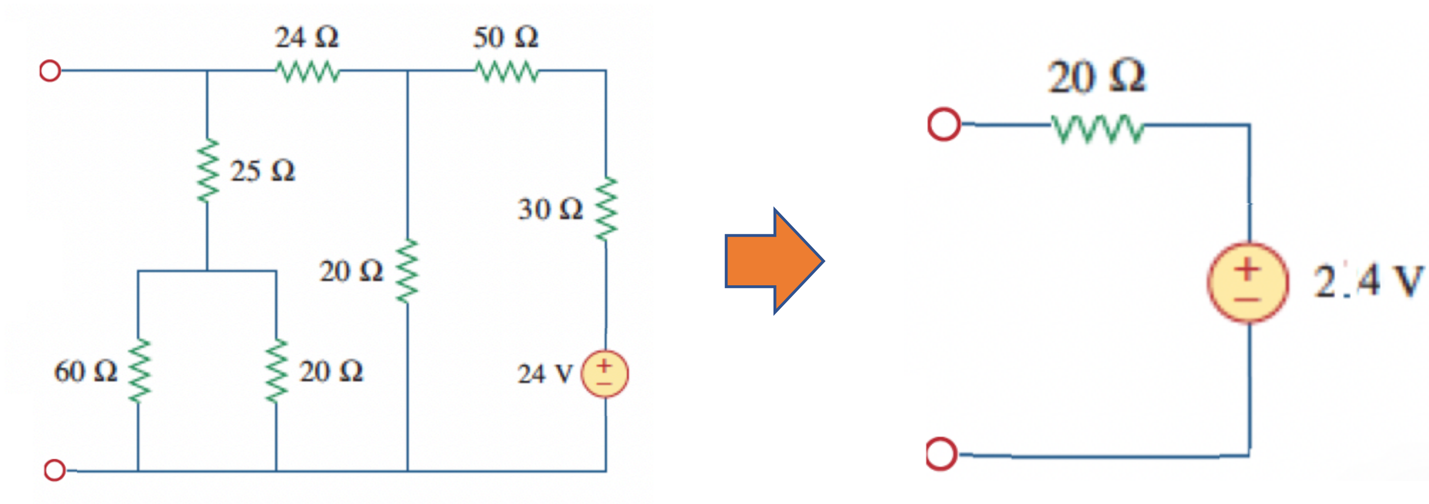
- Use node analysis:

$$\frac{v}{20} + \frac{v-24}{80} + \frac{v}{\mathbf{24}} = 0 \quad \Rightarrow \quad v = \frac{72}{25}$$

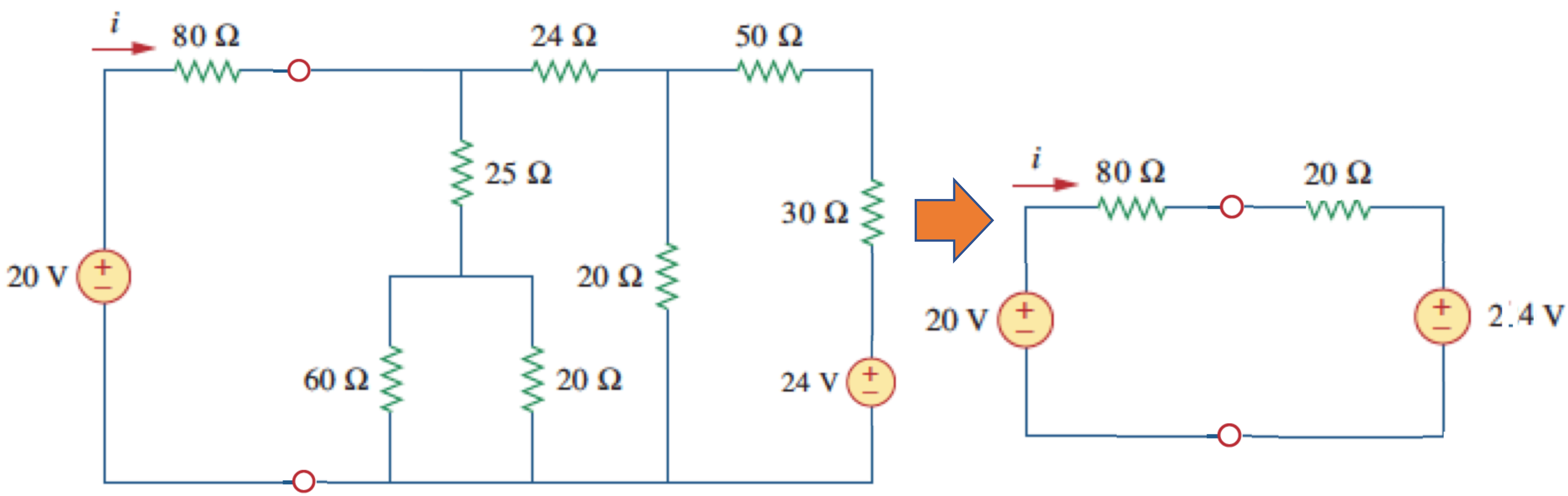
- Then Ohm's Law:

$$i_{SC} = \frac{v}{24} = 0.12 \quad \Rightarrow \quad R_{Th} = \frac{v_{OC}}{i_{SC}} = \frac{2.4}{0.12} = 20\ \Omega$$

So $V_{Th} = 2.4$ volts and $R_{Th} = 20\ \Omega$

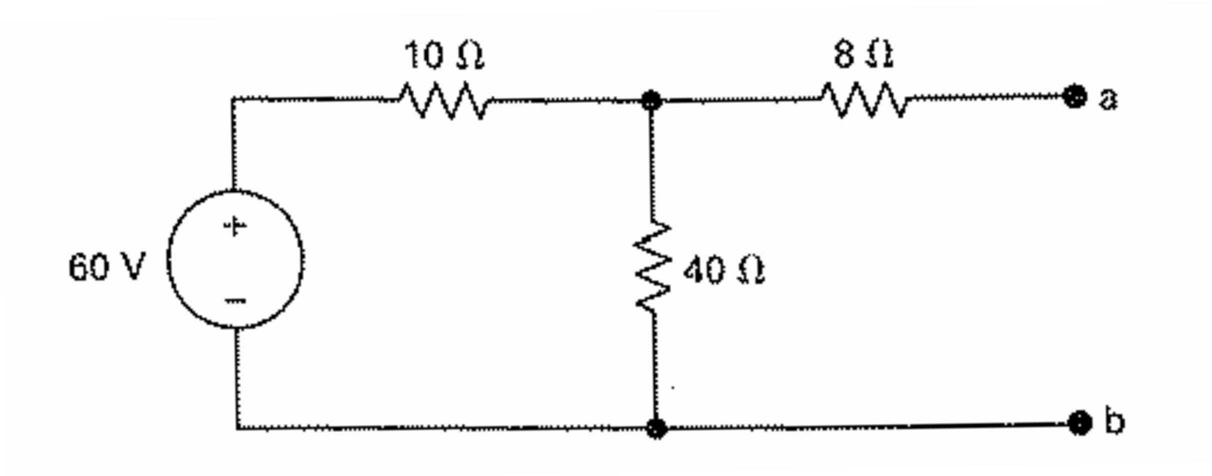


and



Example:

Find V_{th} and R_{Th}

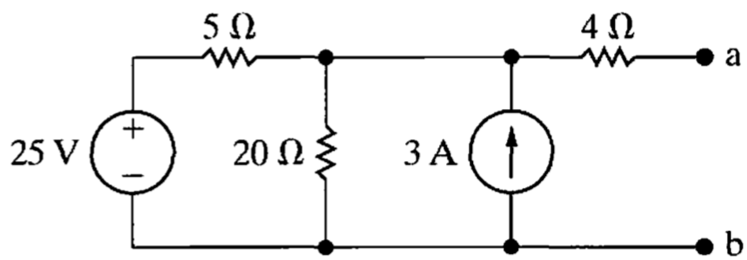


Example:

Find V_{th} and R_{Th}

$V_{Th} = v_{OC}$

$R_{Th} = \dfrac{v_{OC}}{i_{SC}}$

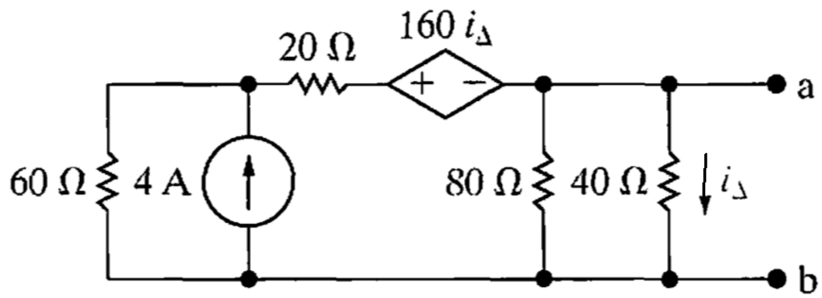


$32\ V, 8\ \Omega$

Example:

Find V_{th} and R_{Th}

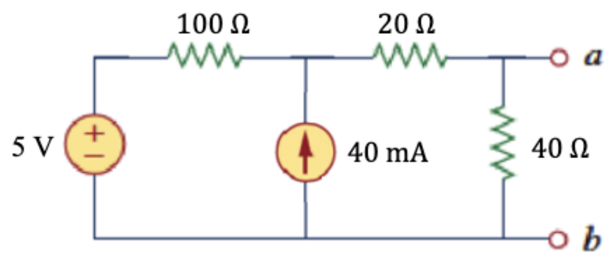
$$V_{Th} = v_{OC}$$
$$R_{Th} = \frac{v_{OC}}{i_{SC}}$$



$30\ V, 10\ \Omega$

Practice Problem:

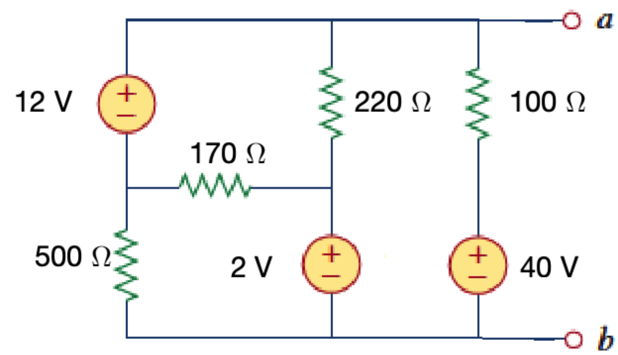
Find V_{th} and R_{Th}



$\frac{9}{4}\ V, 30\ \Omega$

Practice Problem:

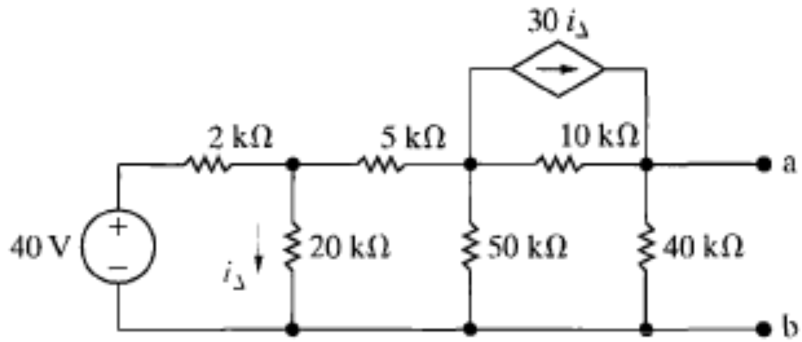
Find V_{th} and R_{Th}



$23.0\ V, 44.6\ \Omega$

Practice Problem:

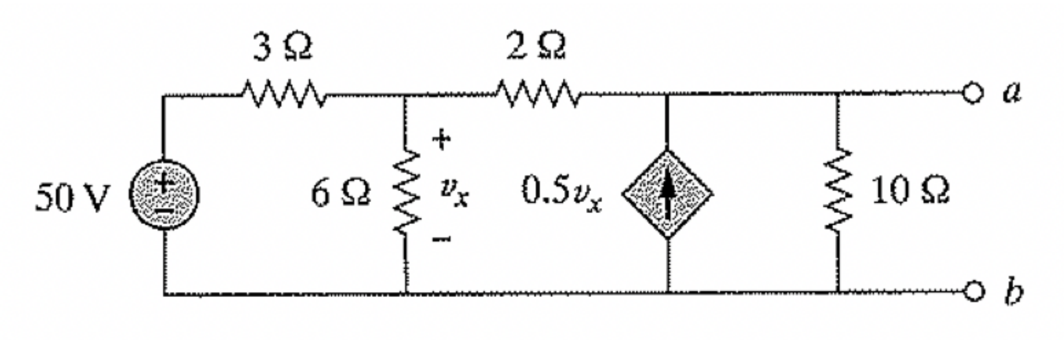
Find V_{th} and R_{Th}



$200\ V, 14{,}3\ k\ \Omega$

Practice Problem:

Find V_{th} and R_{Th}



$\frac{500}{3}\ V, 10\ \Omega$