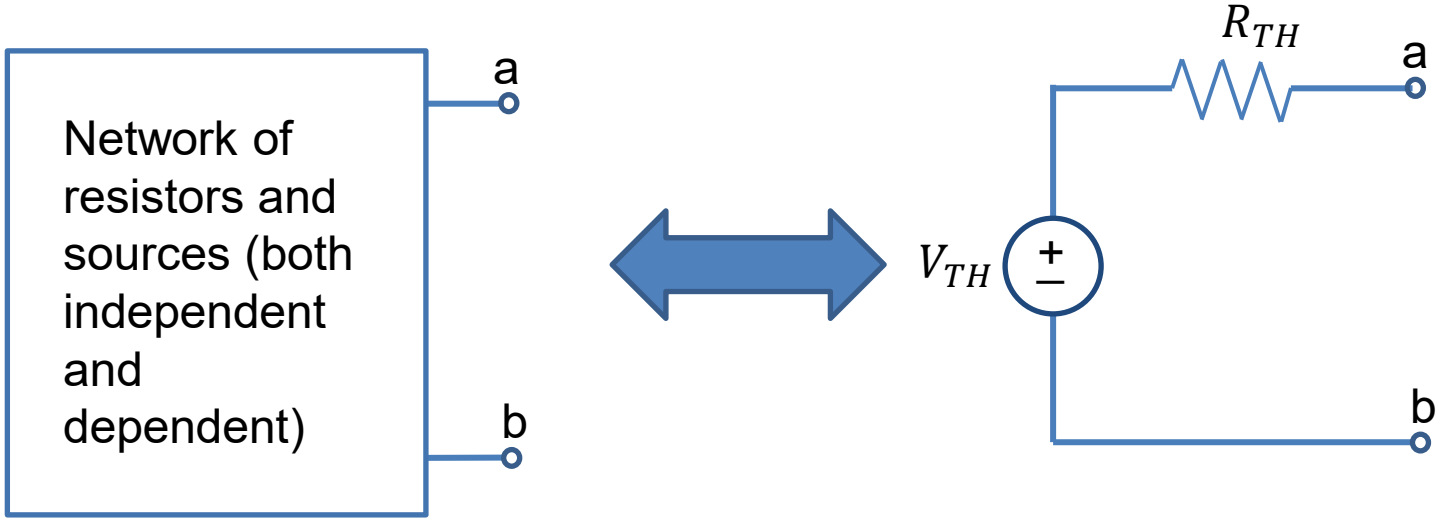
# Thevenin Equivalent Circuits

A complicated circuit of sources and resistive elements can be reduced to a single voltage source in series with a resistor to study how the circuit will behave with respect to a load. This is known as a **Thevenin equivalent circuit**.

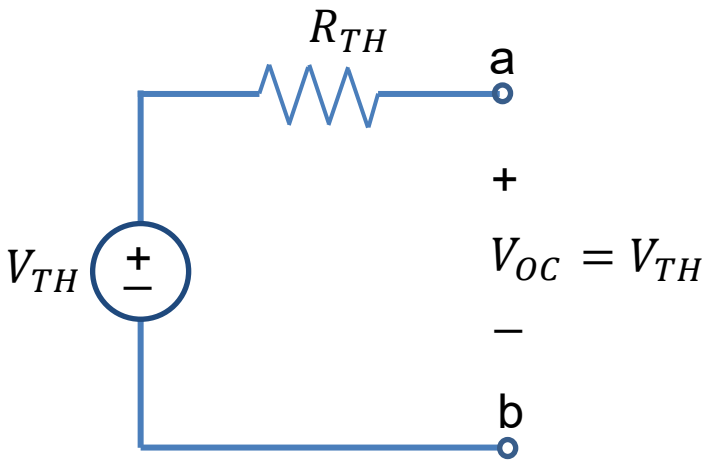



**Q:** How do we find the values of $V_{TH}$ and $R_{TH}$ so the equivalence holds?

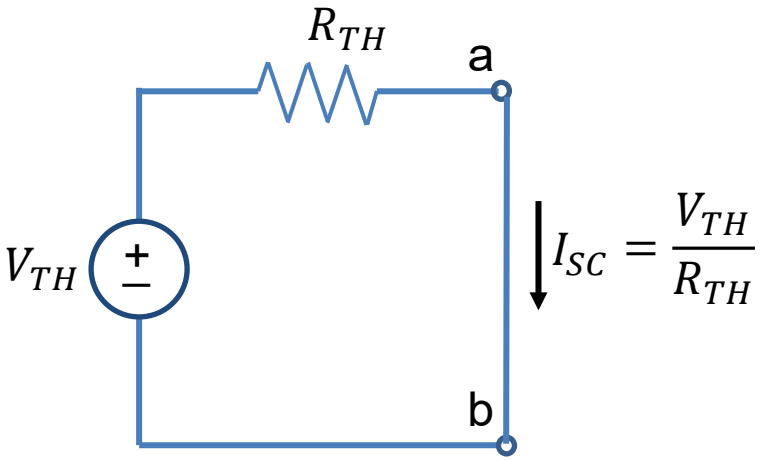
**A:** Since there are only two unknowns, any two measurements that we can make on our circuit, should provide enough information to infer the Thevenin Equivalent circuit.

# Thevenin Equivalent Circuits

In order to find the appropriate values of $V_{TH}$ and $R_{TH}$, consider loading the circuit with either an open circuit or a short circuit.




Open circuit load



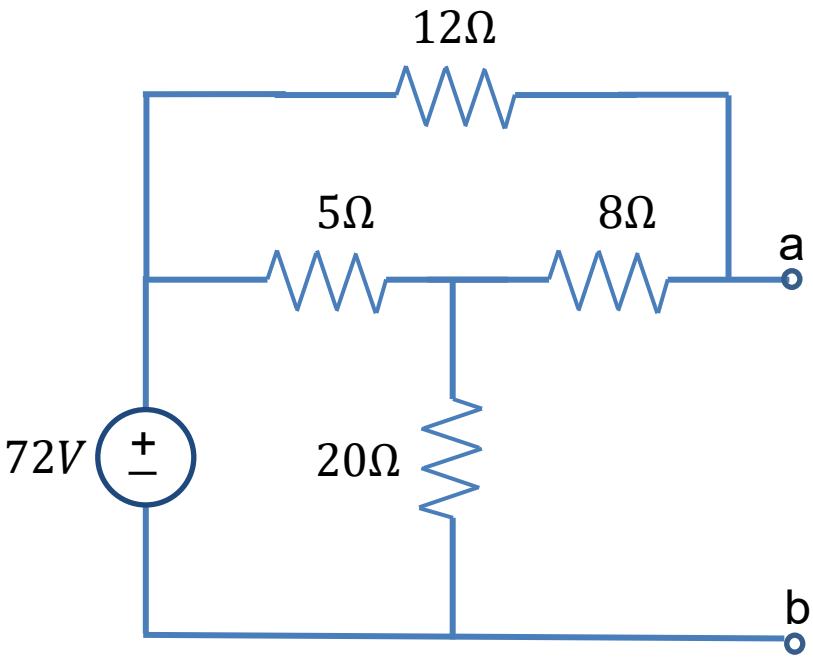

Short circuit load

From the two relationships above, the Thevenin equivalent circuit can be found from the open circuit voltage, $V_{OC}$, and the short circuit current, $I_{SC}$.

$$V_{TH} = V_{OC} \text{ and } R_{TH} = \frac{V_{OC}}{I_{SC}}$$

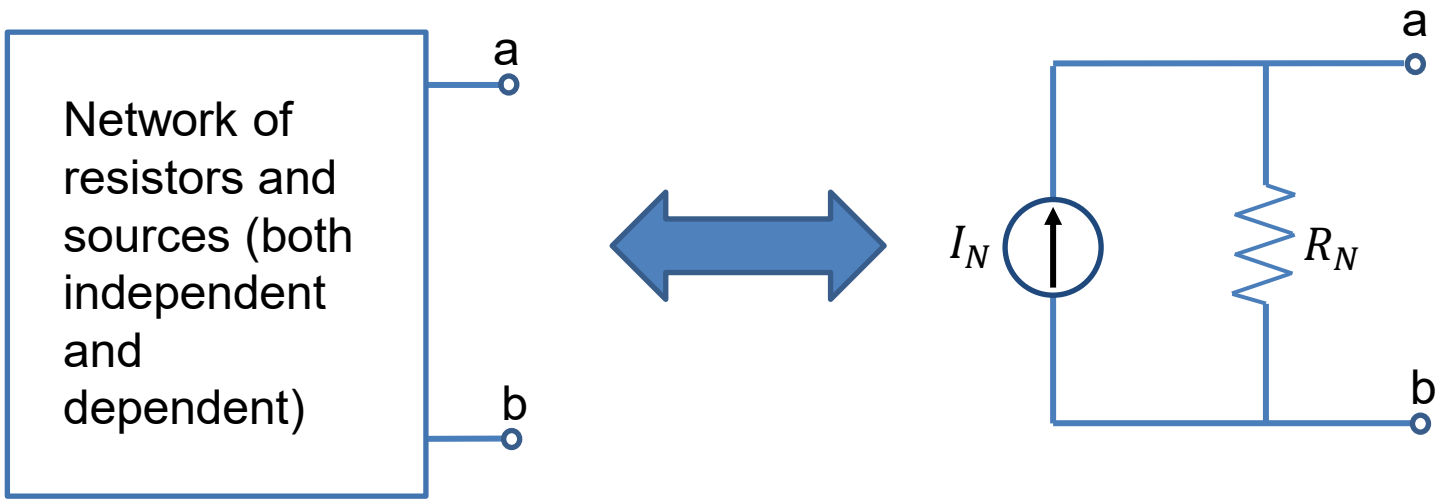
# Example

Find the Thevenin equivalent with respect to the terminals a-b.



# Norton Equivalent Circuits

Similar to a Thevenin equivalent circuit, we can also construct a **Norton equivalent circuit** which consists of a current source in parallel with a resistor.




$$V_{OC} = I_N R_N$$

$$I_{SC} = I_N$$

$$I_N = I_{SC}$$

$$R_N = \frac{V_{OC}}{I_{SC}}$$

same as $R_{TH}$

# Thevenin/Norton Equivalent Circuits

There are a number of techniques we can use to find a Thevenin/Norton equivalent circuit.

**Method 1:** Use source transformations and serial/parallel combinations to reduce the circuit to its Thevenin or Norton equivalent.

**Method 2:** Find the open circuit voltage and the short circuit current. Then use:

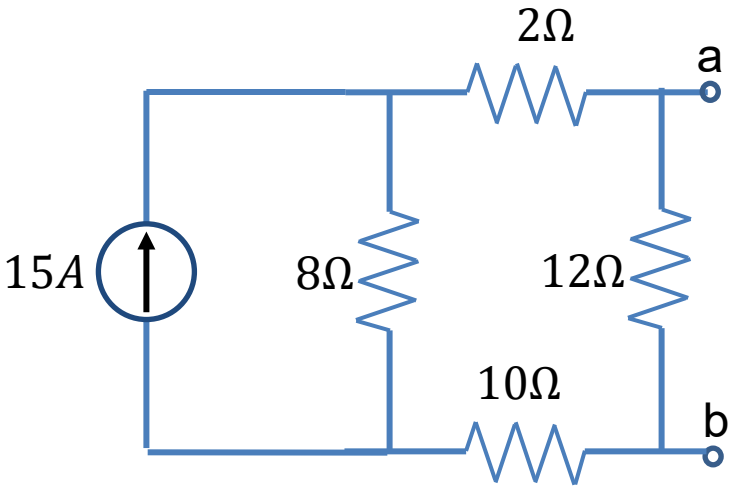
$$V_{TH} = V_{OC},\ I_N = I_{SC},\ R_{TH} = R_N = \frac{V_{OC}}{I_{SC}}$$

**Method 3:** For circuits with no dependent sources, $R_{TH}$ can be found by disabling all independent sources ($V = 0$→short, $I = 0$→open) and computing the equivalent resistance as seen across the load terminals.

**Note:** Method 3 does not actually find the entire equivalent circuit. It only provides a shortcut for finding $R_{TH}$ so that you only need to find $V_{OC}$ **or** $I_{SC}$ (not both) when using Method 2.

# Example

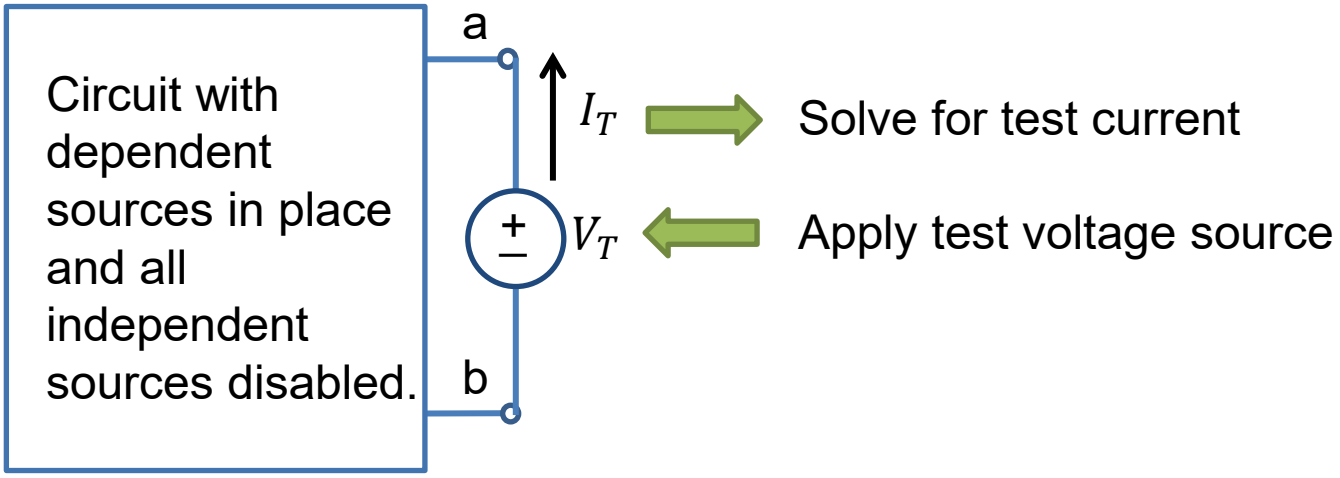
Find the Thevenin and Norton equivalent circuits with respect to the terminals a-b.



# Thevenin/Norton Equivalent Circuits

For circuits with dependent sources, a modified version of Method 3 can be used.

**Method 3 (modified):** Disable all independent sources. Apply a test source to the load (either $V_T$ or $I_T$) and then find $I_T$ or $V_T$ so that $R_{TH} = \frac{V_T}{I_T}$.




$$R_{TH} = \frac{V_T}{I_T}$$

# Example

Find the Thevenin equivalent with respect to the terminals a-b.