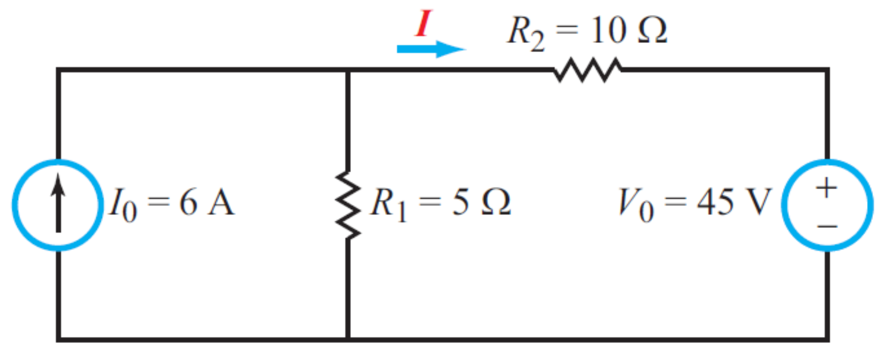
Outline

- Linearity property
- Superposition
- Thevenin's theorem
- Source transformation
- Norton's theorem
- Power transfer

Example



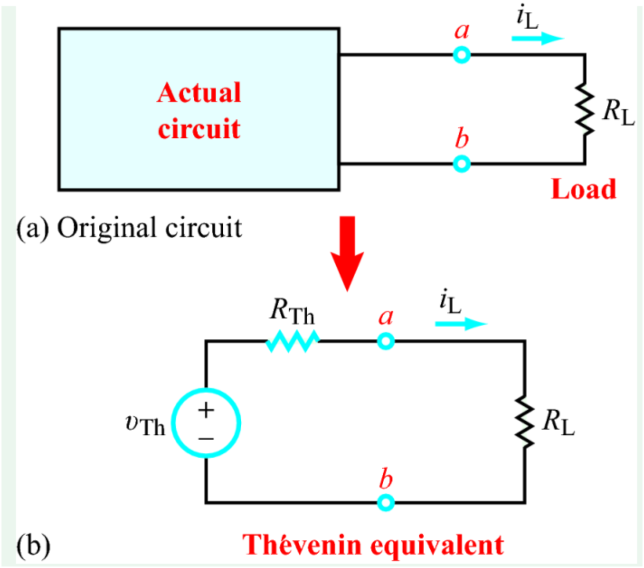
- Q1: If $R_2 = 1\Omega, I = ?$
- Q2: What if $R_2 = 5\Omega, I = ?$
- ??

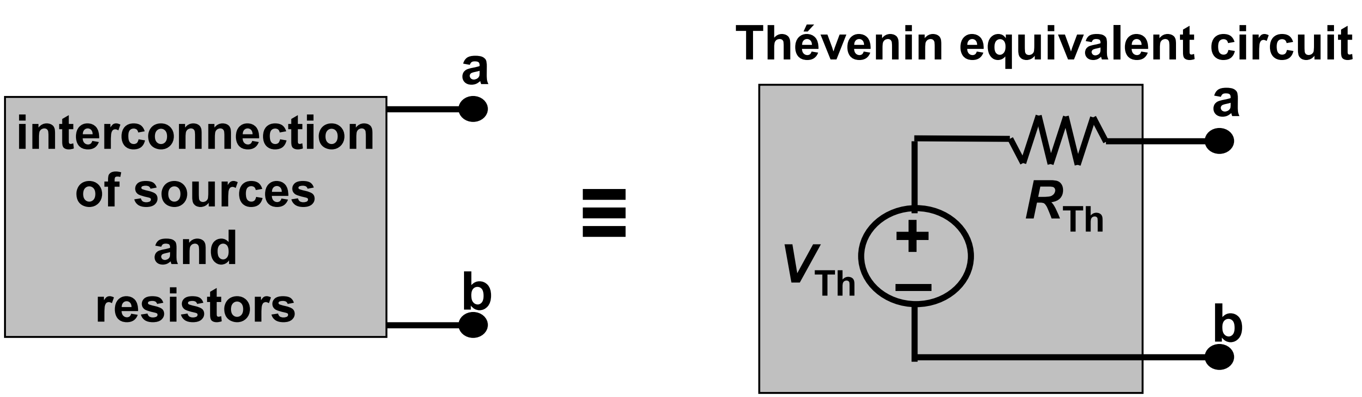
Thevenin's Theorem – Motivation

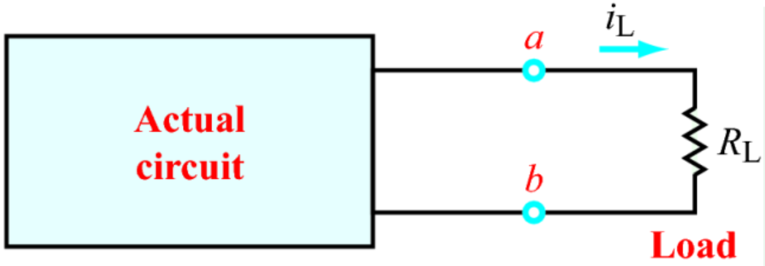
- In many circuits, it is quite common that only one element (called *the load*) is variable while others are fixed.
  - An example is the household outlet: different appliances may be plugged into the outlet, each presenting a different resistance.
  - Ordinarily one has to re-analyze the circuit upon changing load.
  - This complexity can be simplified by circuit theorem (e.g. Thevenin's theorem), which provides a technique to replace the fixed part of the circuit with an **equivalent** circuit.

Thevenin's Theorem (1880s, Leon Thevenin, French)

- Thevenin's theorem states that a two terminal circuit (including resistors, linear dependent sources, and independent sources.) may be replaced with a voltage source in series with a resistor:

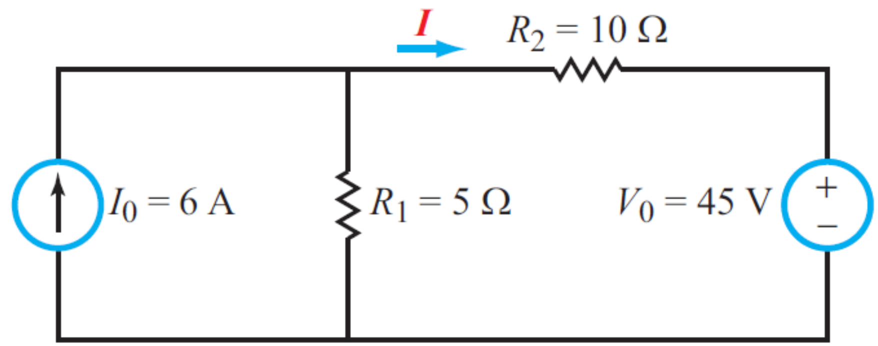





Actual circuit
a
b
i_L
R_L
Load

Example

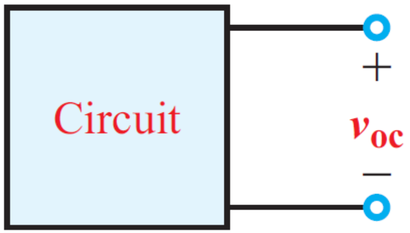
- Use Thévenin Equivalent Circuits
- Q1: If $R_2 = 1\Omega, I = ?$
- Q2: What if $R_2 = 5\Omega, I = ?$



How Do We Find Thévenin Equivalent Circuits?

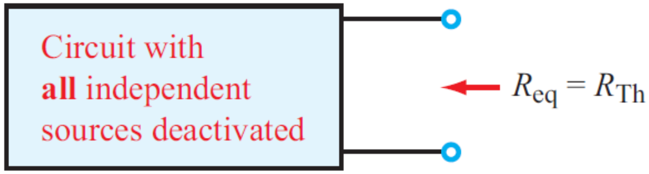
Method 1: Equivalent Resistance

1. Analyze circuit to find v_{oc}
2. Deactivate all **independent** sources by replacing voltage sources with short circuits and current sources with open circuits.
3. Simplify circuit to find equivalent resistance.



(a) $v_{Th} = v_{oc}$

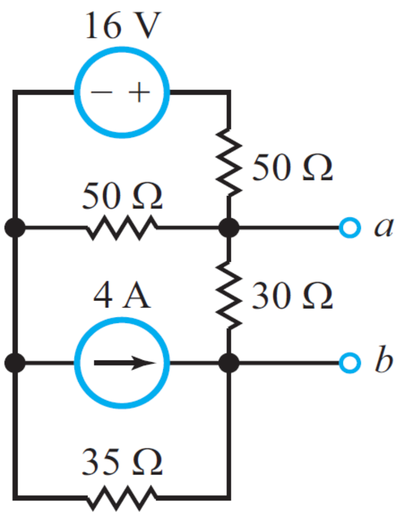
Equivalent-Resistance Method

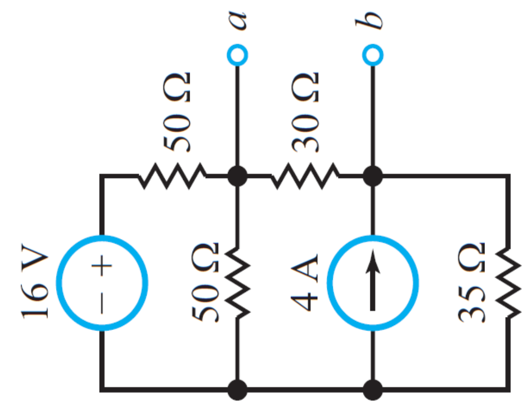


Note: This method does not apply to circuits that contain dependent sources.

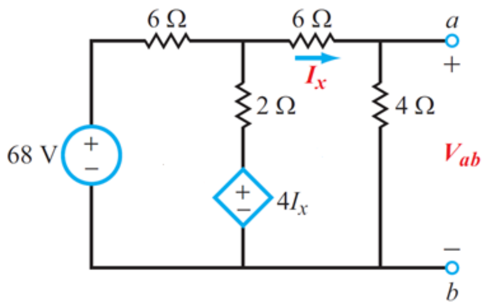
Example
Thévenin Equivalent Circuit

(Circuit has no dependent sources)





How Do We Find Thévenin Equivalent Circuits ?



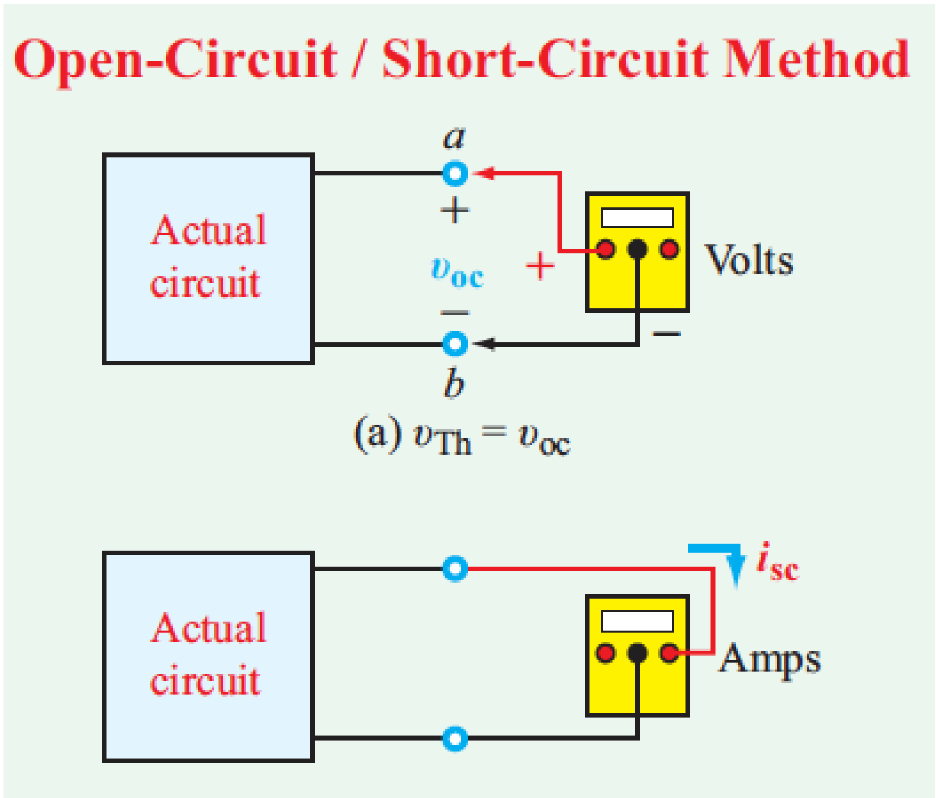
Method 2: Open/short circuit

1. Analyze circuit to find v_{oc}
2. Analyze circuit to find i_{sc}

$$v_{\text{Th}} = v_{\text{oc}}$$

$$R_{\text{Th}} = \frac{v_{\text{oc}}}{i_{\text{sc}}}$$

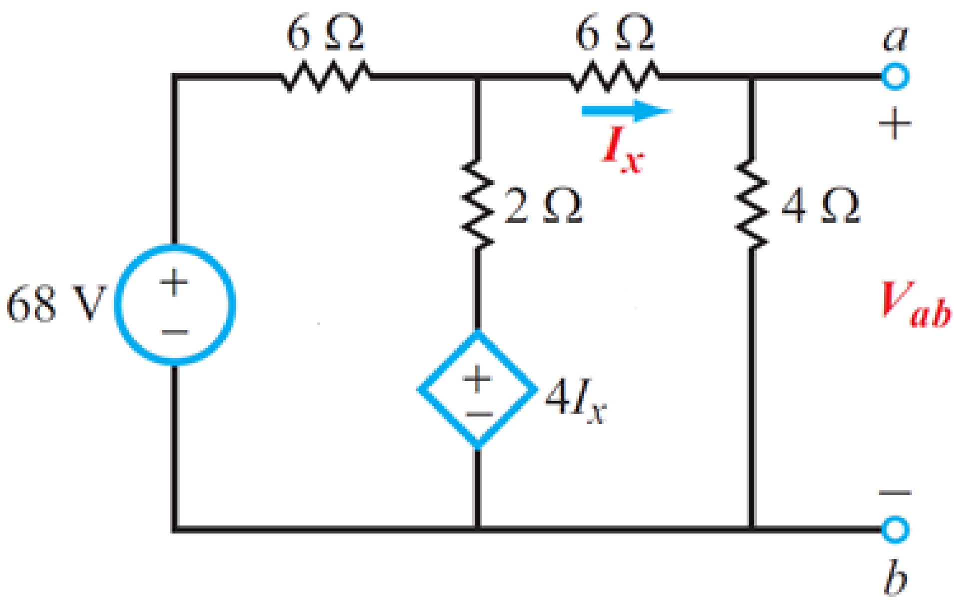
Note: This method is applicable to any linear circuit, whether or not it contains dependent sources.



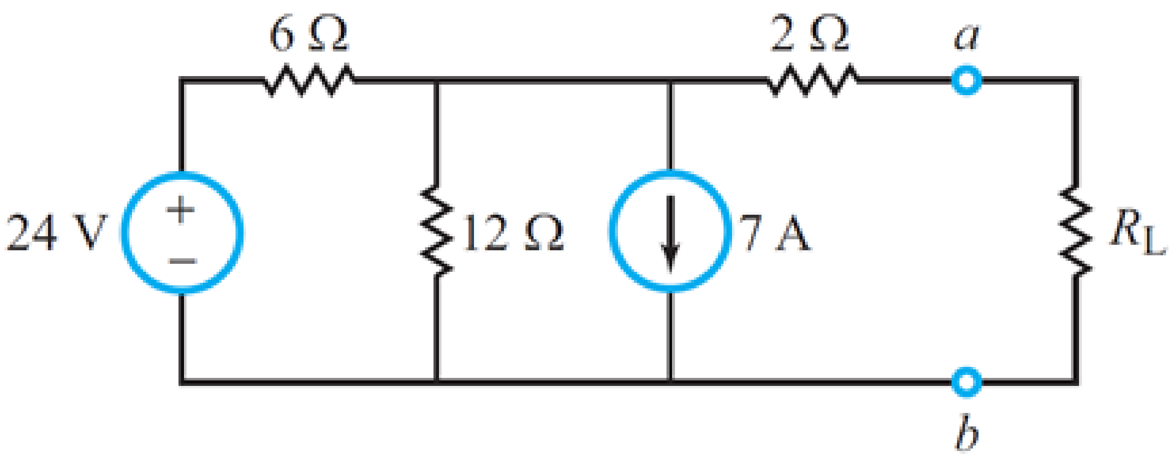
(a) $v_{\text{Th}} = v_{\text{oc}}$

(b) $R_{\text{Th}} = v_{\text{oc}} / i_{\text{sc}}$

Example



Practice

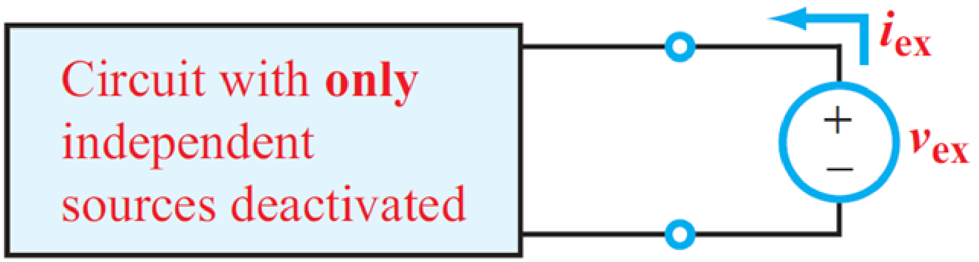


How Do We Find Thévenin Equivalent Circuits?

Method 3:

Step 1. **Again** $v_{\mathrm{Th}} = v_{\mathrm{OC}}$

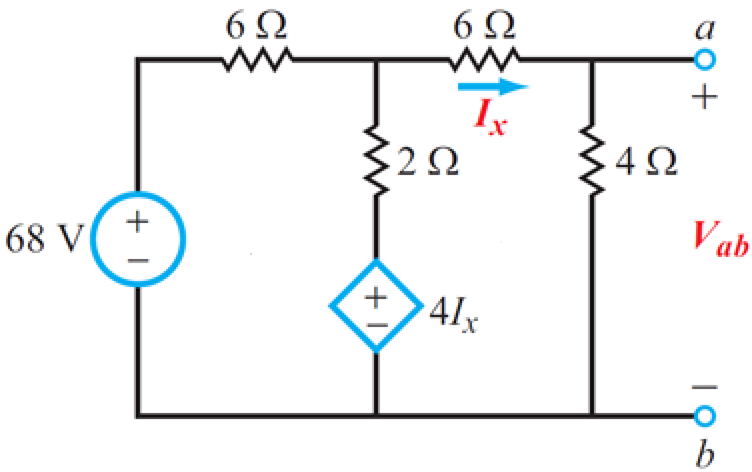
Step 2. **External-Source Method**

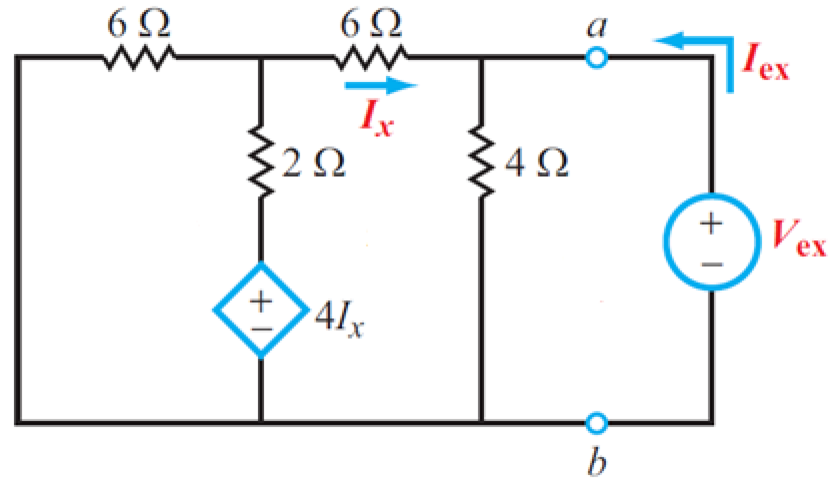


If a circuit contains both dependent and independent sources, R_{Th} can be determined by (a) deactivating independent sources (only), (b) adding an external source v_{ex}, and then (c) solving the circuit to determine i_{ex}. The solution is $R_{\mathrm{Th}} = v_{\mathrm{ex}}/i_{\mathrm{ex}}$.

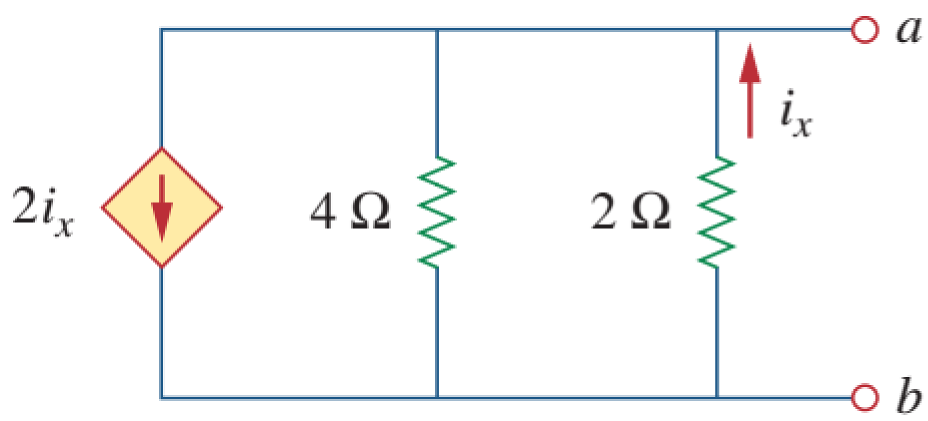
[Source: Berkeley]

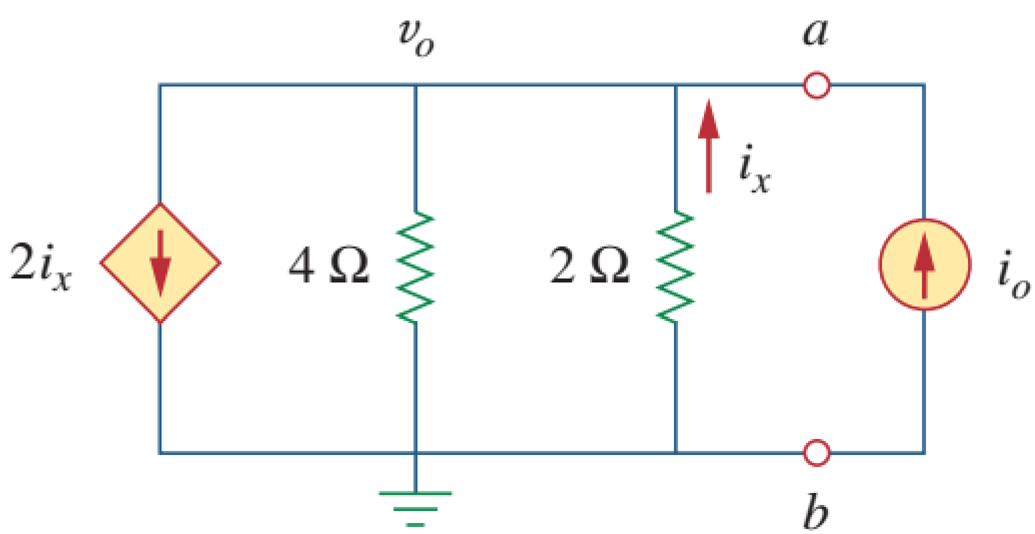
Example





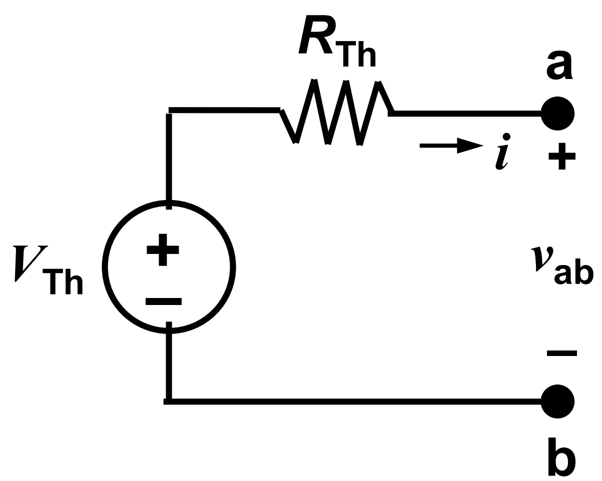
Example

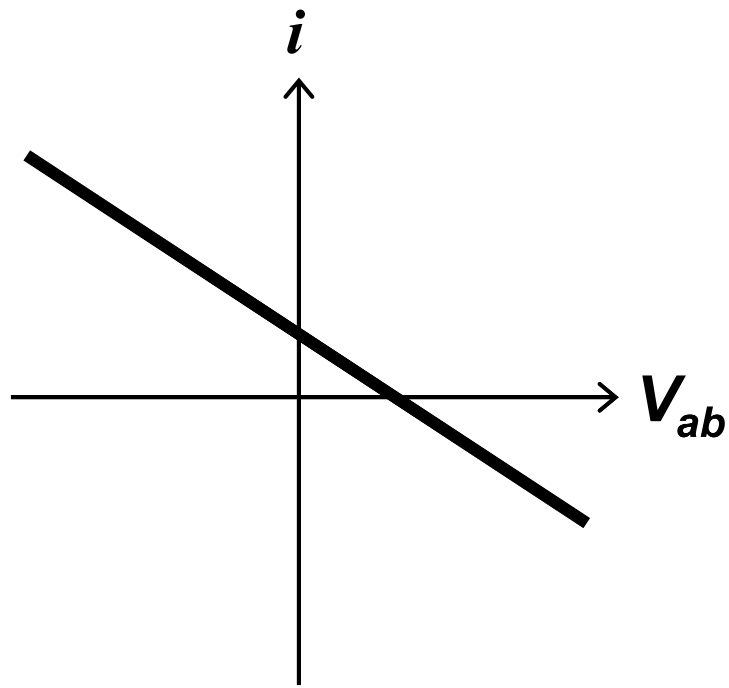




(b)

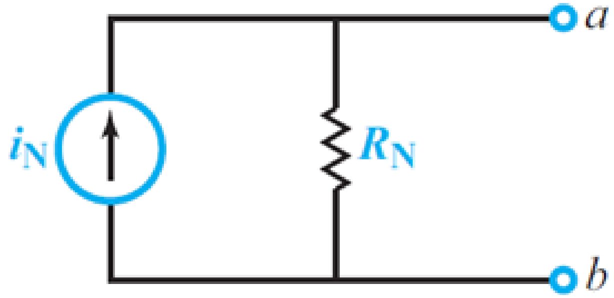
I-V Characteristic of Thévenin Equivalent



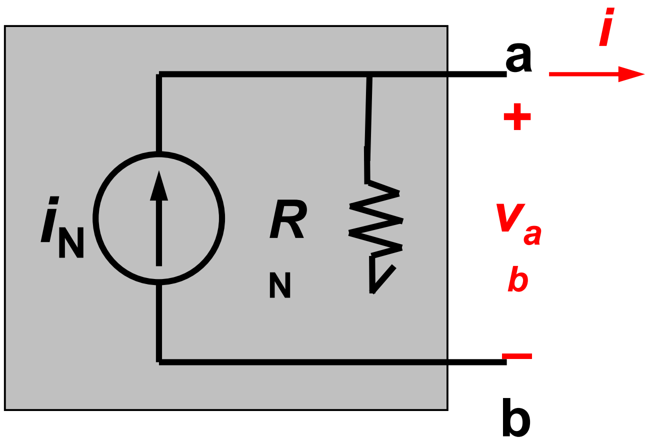


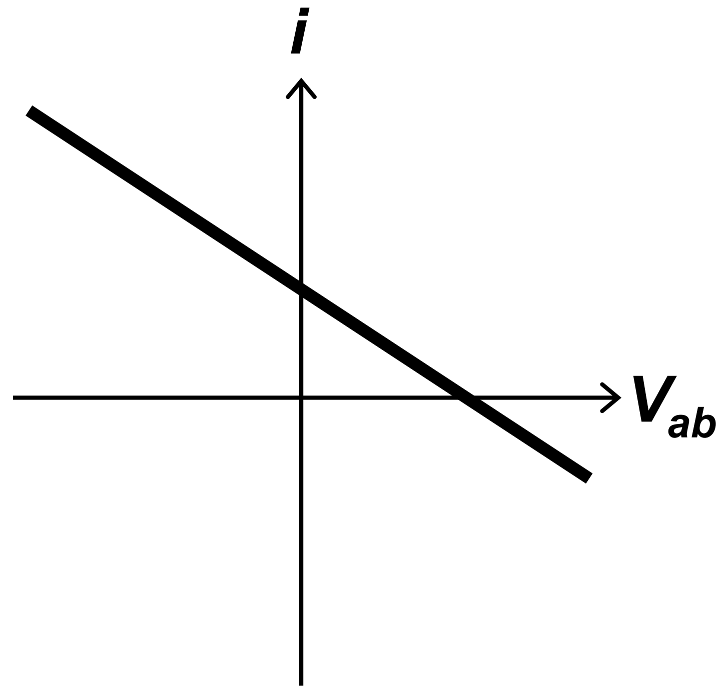
Norton’s Theorem

Norton equivalent circuit

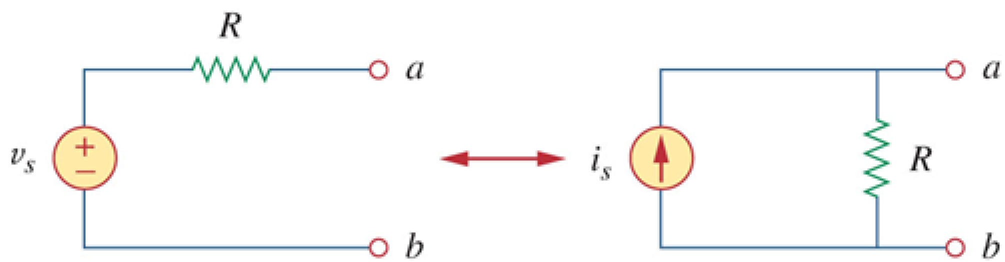


I-V Characteristic of Norton Equivalent



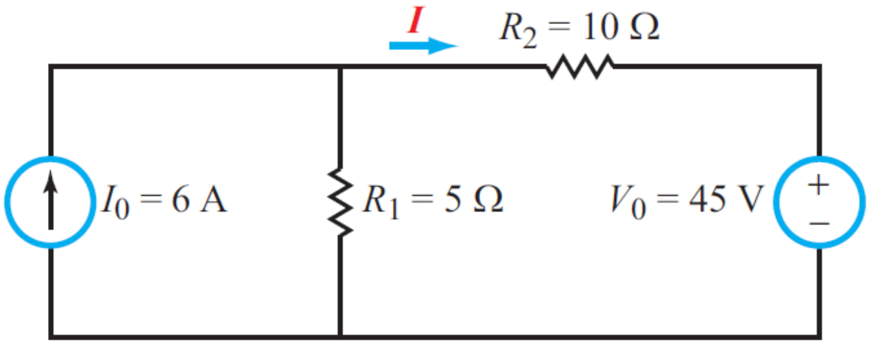


Source Transformation



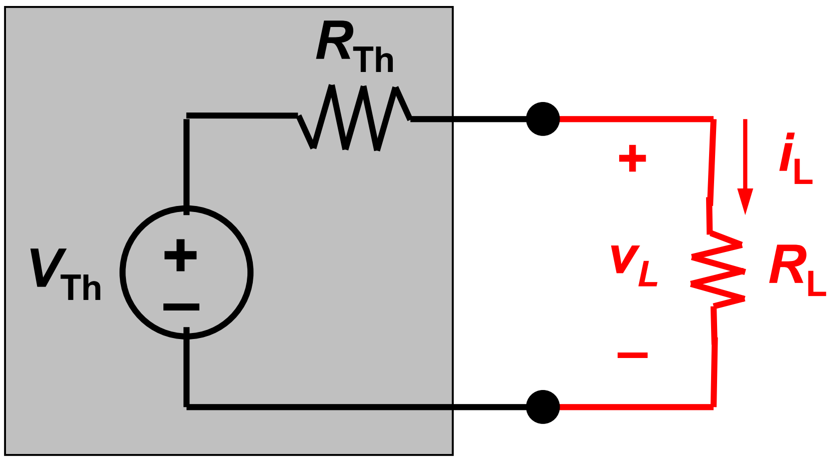
- A source transformation is the process of replacing "a voltage source v_s in series with a resistor *R*" **by** "a current source i_s in parallel with a resistor *R*", or vice versa. $\boldsymbol{V_s/i_s = R}$

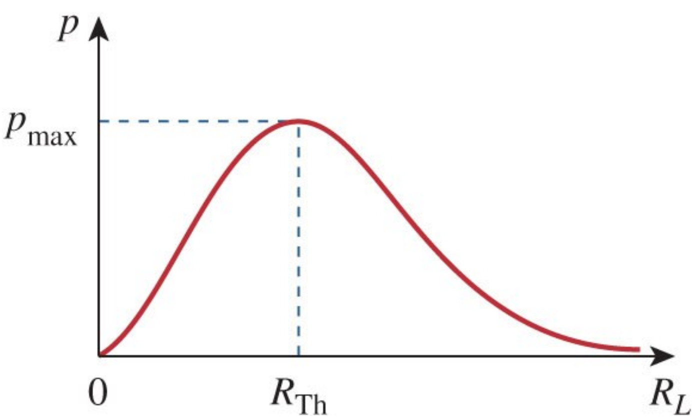
- These transformations work because the two sources have equivalent behavior at their terminals:
  - If the sources are turned off, resistance at the terminals are both R
  - If the terminals are short circuited, the currents is the same.



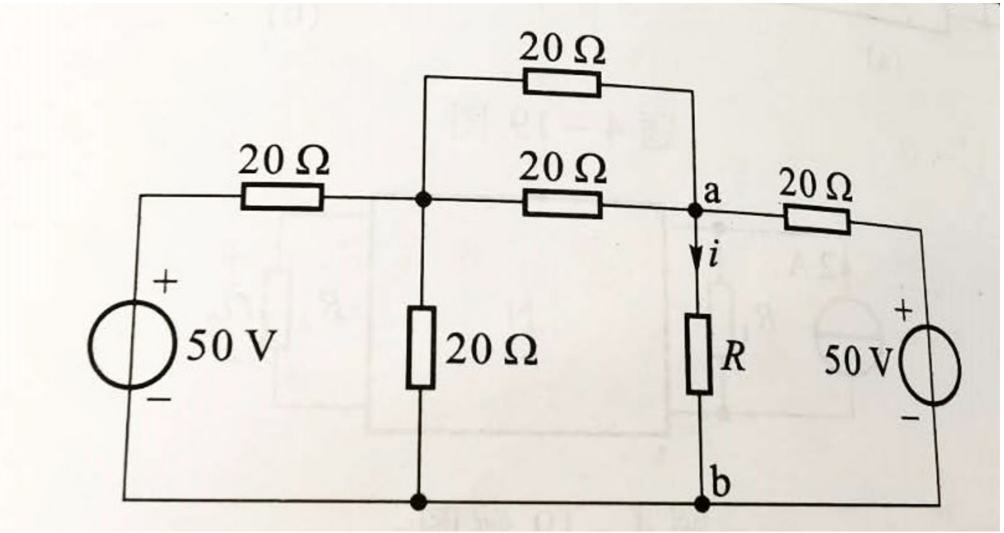
- Q1: If $R_2 = 1\Omega, I = ?$
- Q2: What if $R_2 = 5\Omega$?

Max Power Transfer



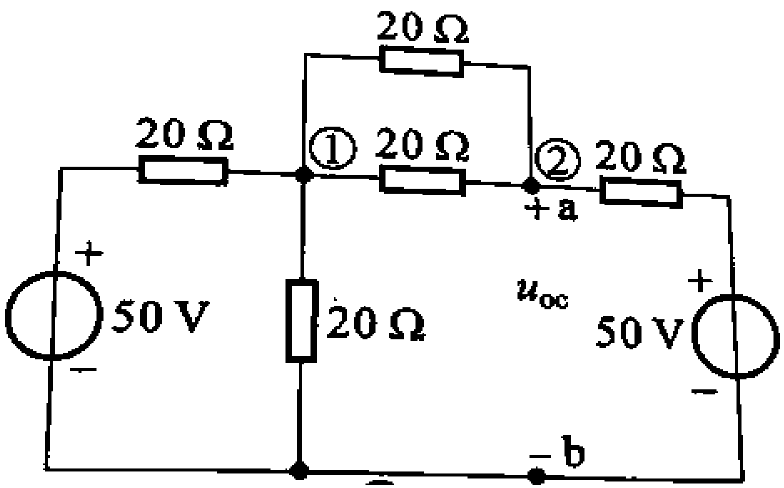


Example



(1) Calculate the value of R, at which maximum power transferred to R holds.

(2) Calculate the percentage/ratio: P_R/P_{total}


20 Ω
20 Ω
① 20 Ω
② 20 Ω
+ a
+
50 V
−
20 Ω
u_{oc}
+
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−
− b