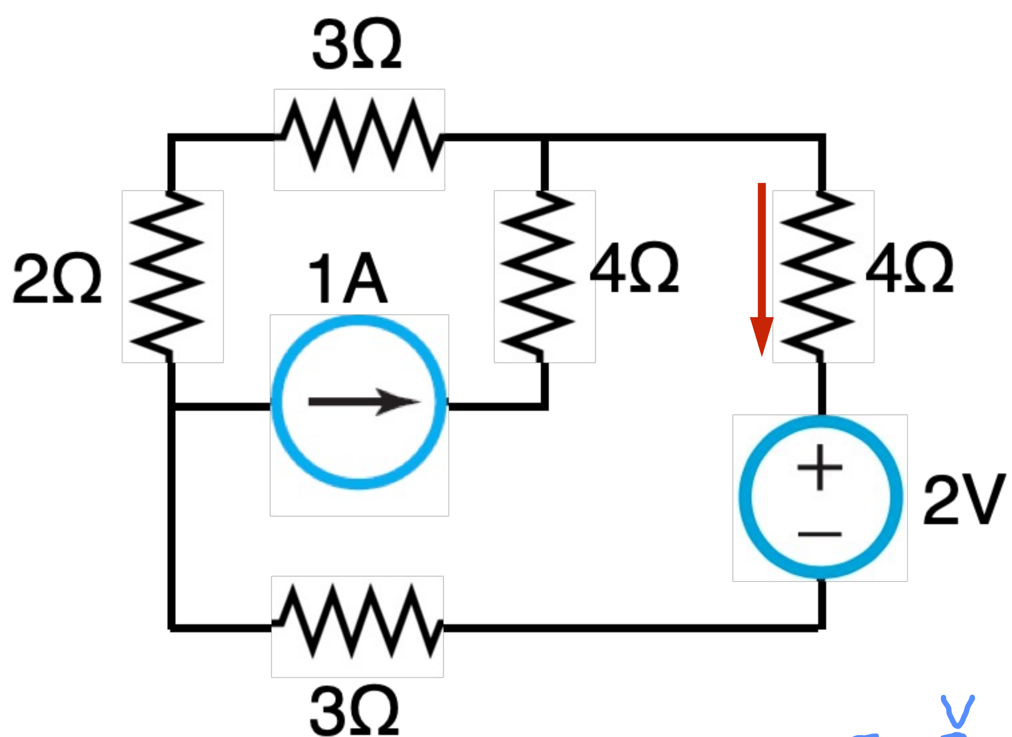
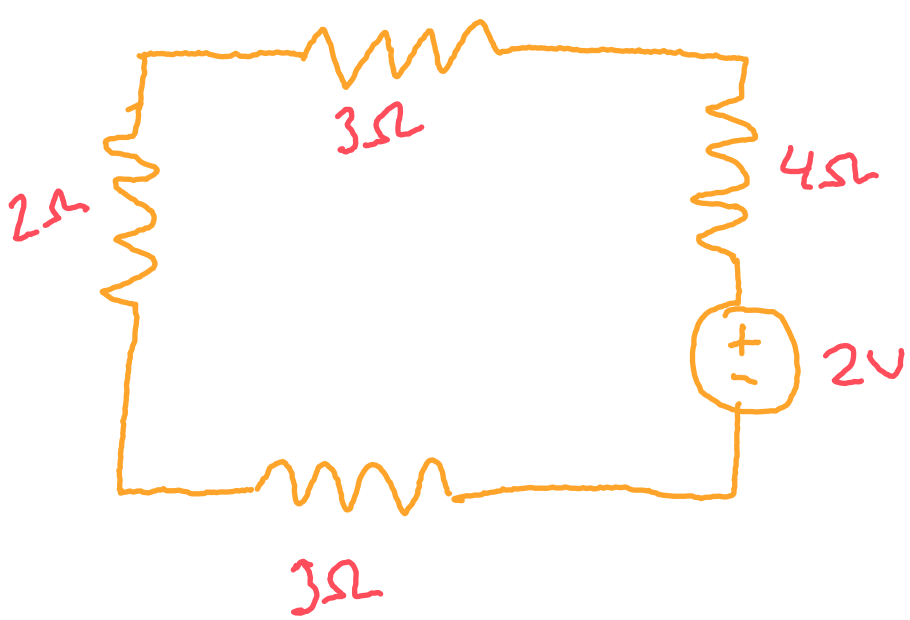
Last Class…

Use the principle of superposition to find the current i.





$$I = \frac{V}{R}$$

$$I = \frac{2}{12}$$

$$\boxed{I = \frac{1}{6}\,A}$$

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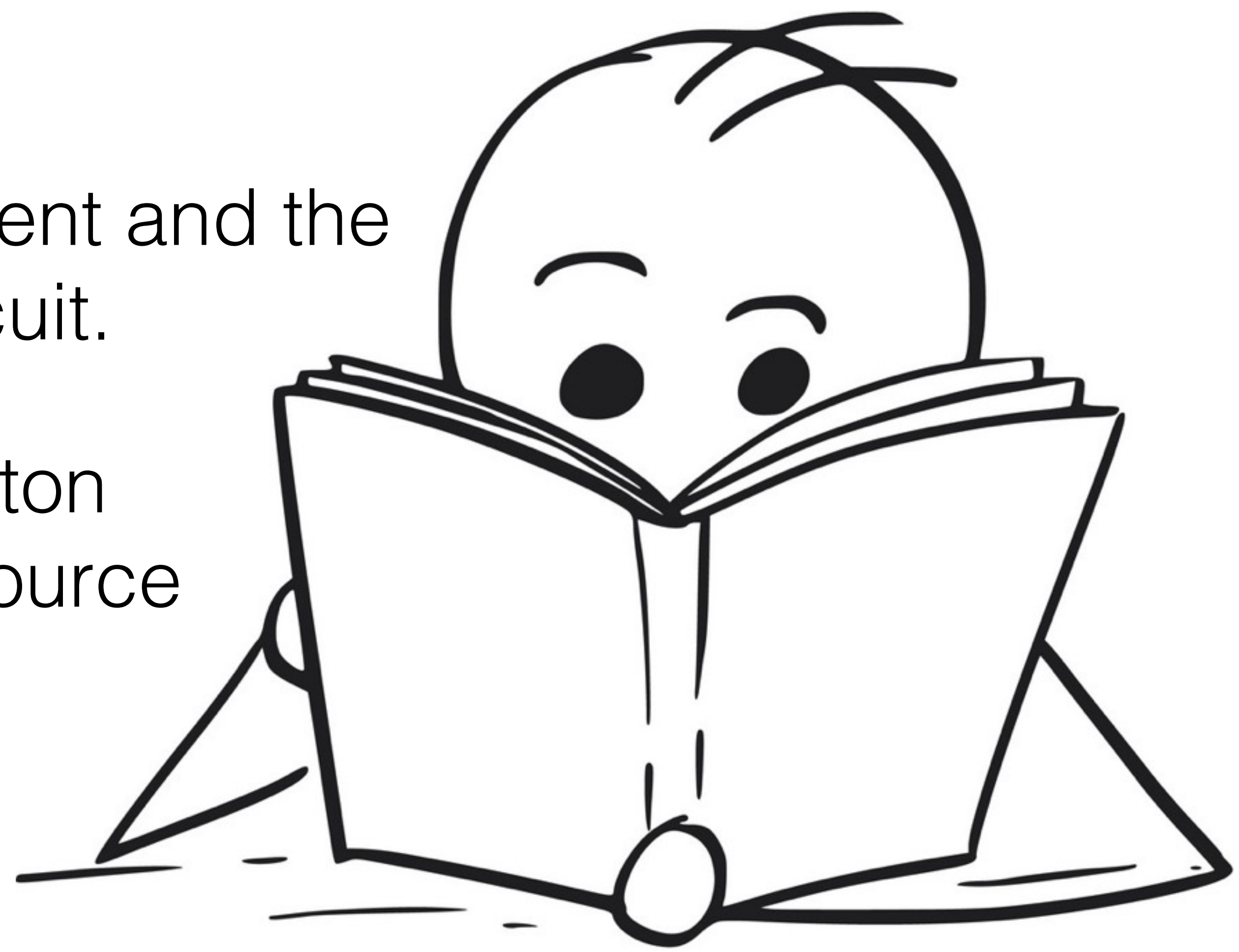
Equivalent Circuits

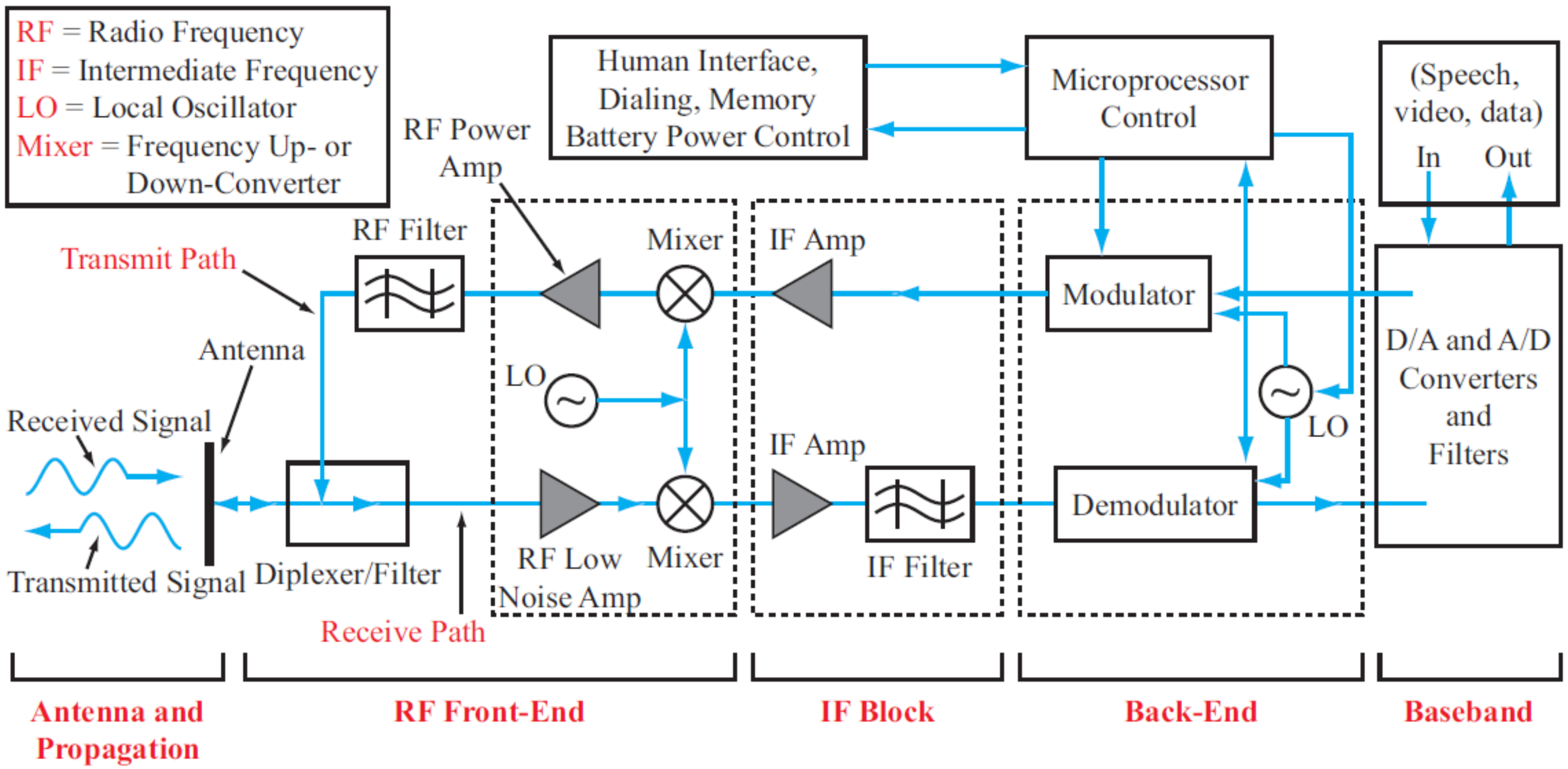
This Lecture…

- Learning Objectives:
  - Understand the importance and application of equivalent circuits.
  - Determine the Thévenin voltage and the Thevenin resistance of a circuit.
  - Determine the Norton current and the Norton resistance of a circuit.
  - Given the Thévenin or Norton equivalent circuit, apply source transformation.



Cell Phone

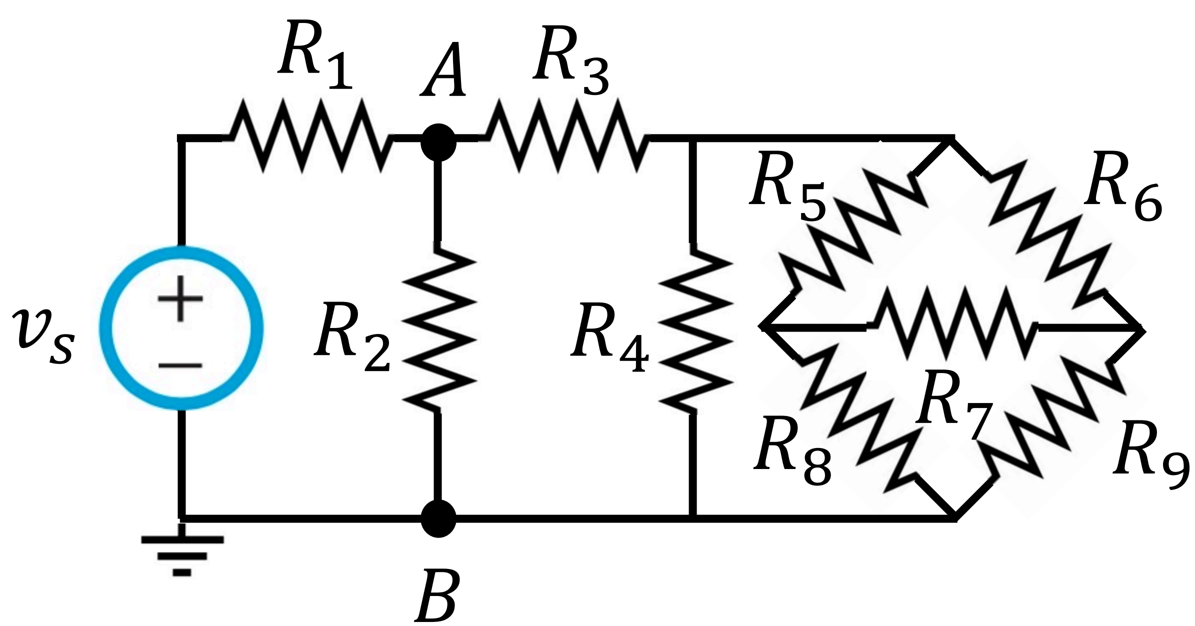
- Today's systems are complex. We use a block diagram approach to represent circuit sections.

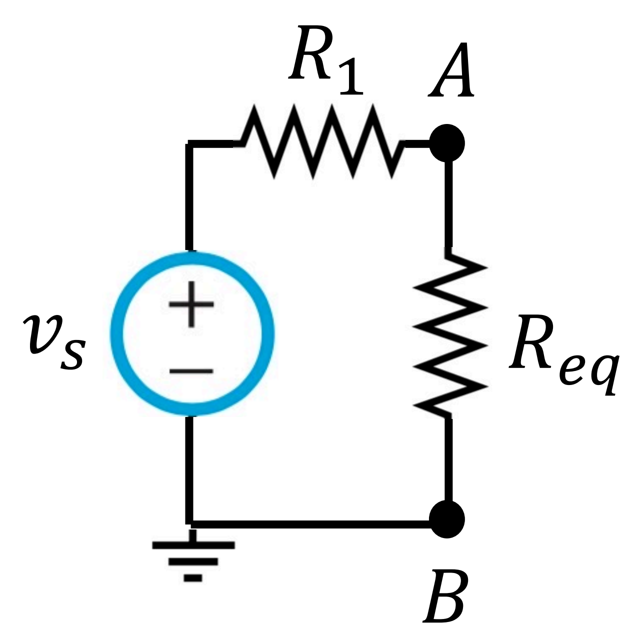


Equivalent Circuit

Recall that:

- Simplify analysis.
- Voltage and Current between A and B do not change.

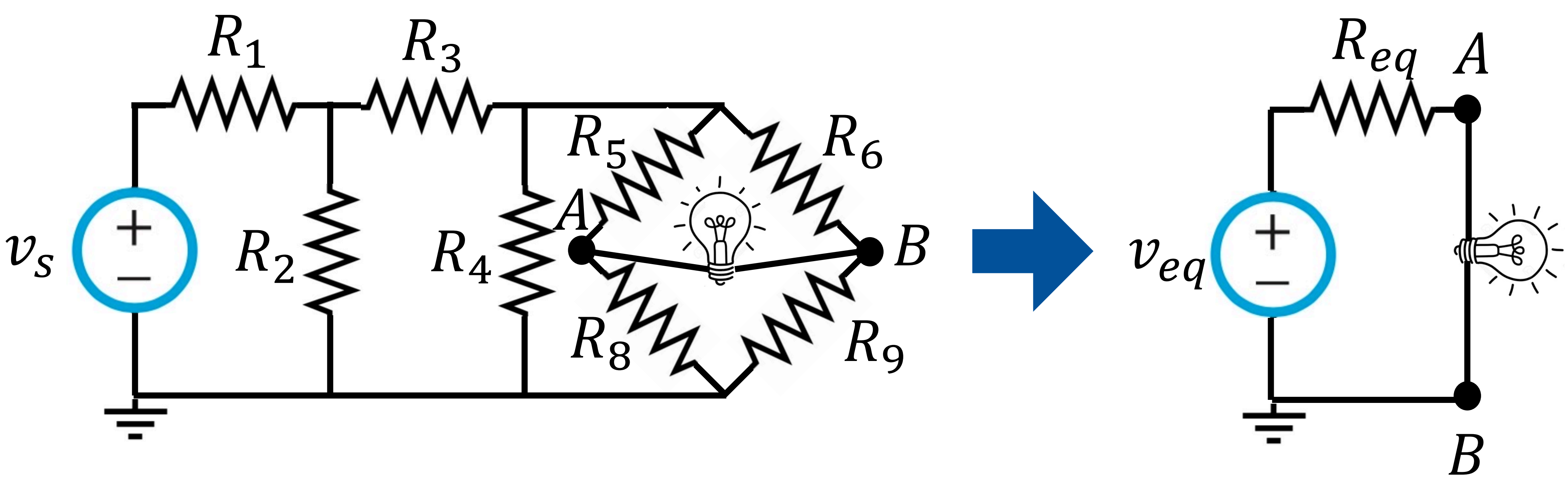




Equivalent Circuit

Recall that:

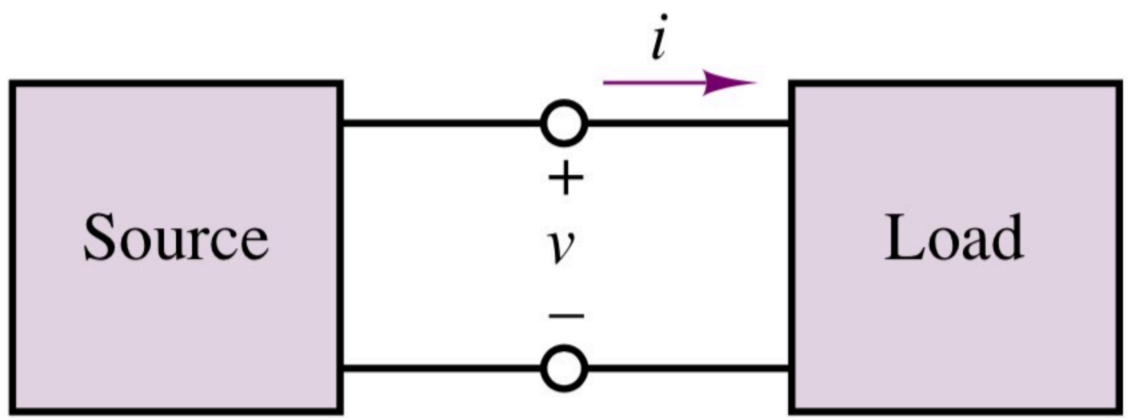
- Simplify analysis.
- Voltage and Current between A and B do not change.



Our ability to develop equivalent-circuit representations is made possible (in part) by a pair of theorems of fundamental significance known as Thévenin's and Norton's theorems.

Thevenin and Norton Equivalent

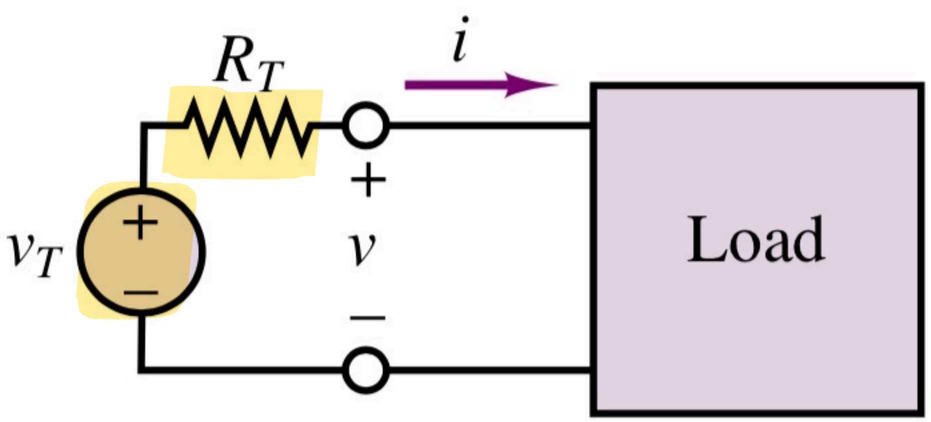
- Linear two-terminal circuit can be replaced by an equivalent circuit:

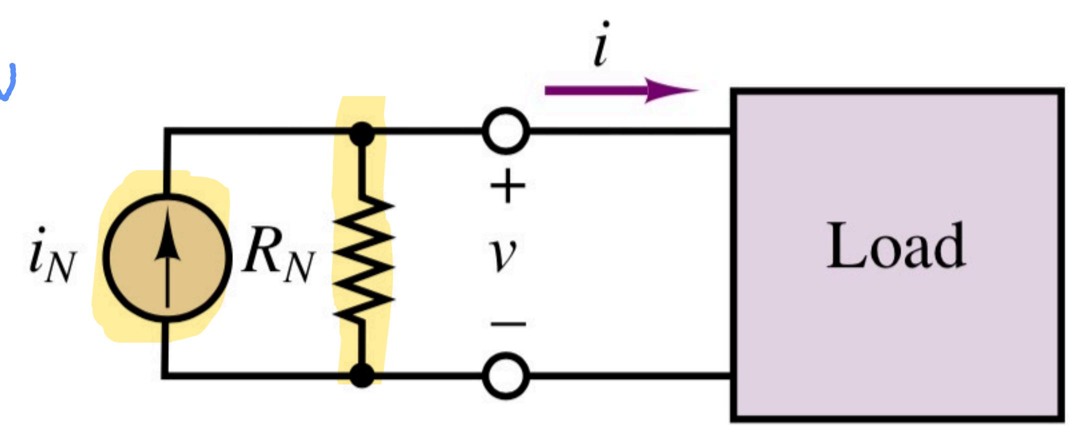


Thévenin equivalent

Norton equivalent

$R_T = R_N$





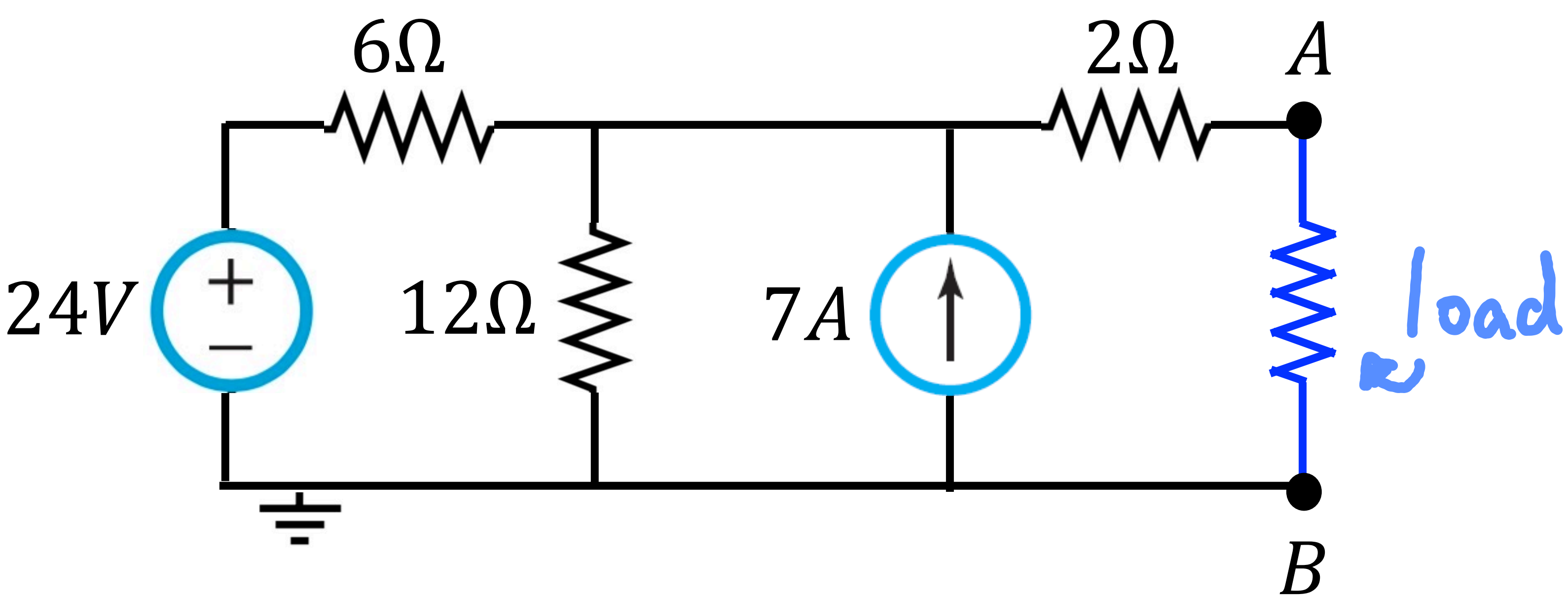
Composed of a voltage source and a series resistor.

Composed of a current source and parallel resistor.

Computation of R_{TH}

1. Remove the load and set all independent sources to zero.

turn off current
and voltage sources



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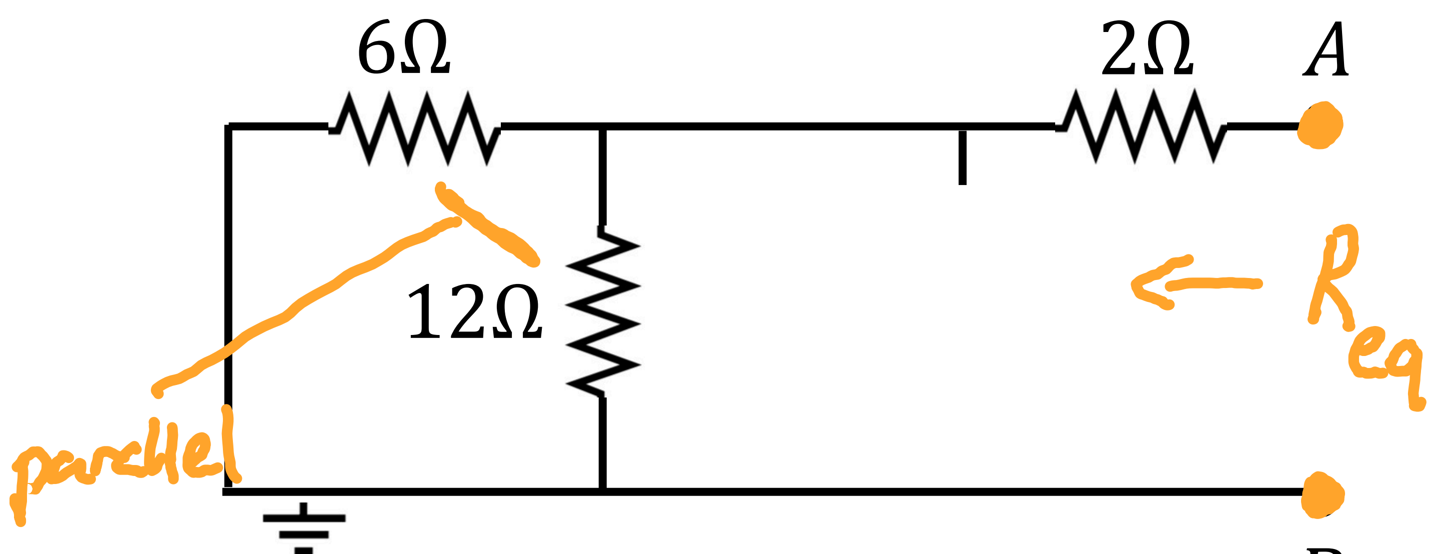
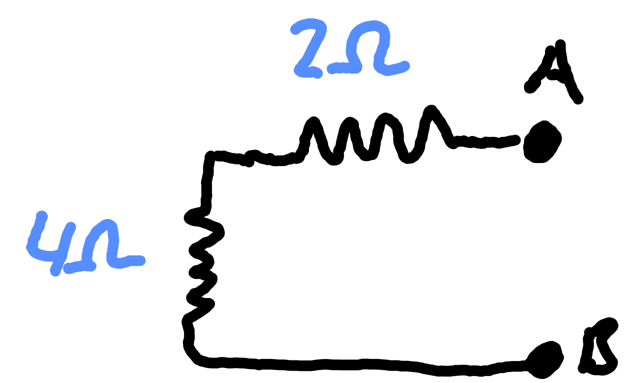
Computation of R_{TH}

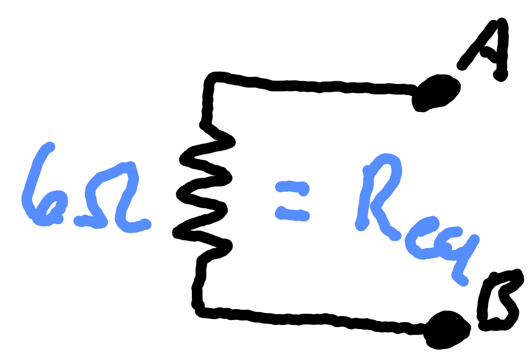
1. Remove the load and set all independent sources to zero.

2. Apply series and parallel equivalent resistance substitutions to find effective equivalent resistance.
   - Sometimes may need to attach independent voltage source to the terminals (e.g., when there is a dependent source).



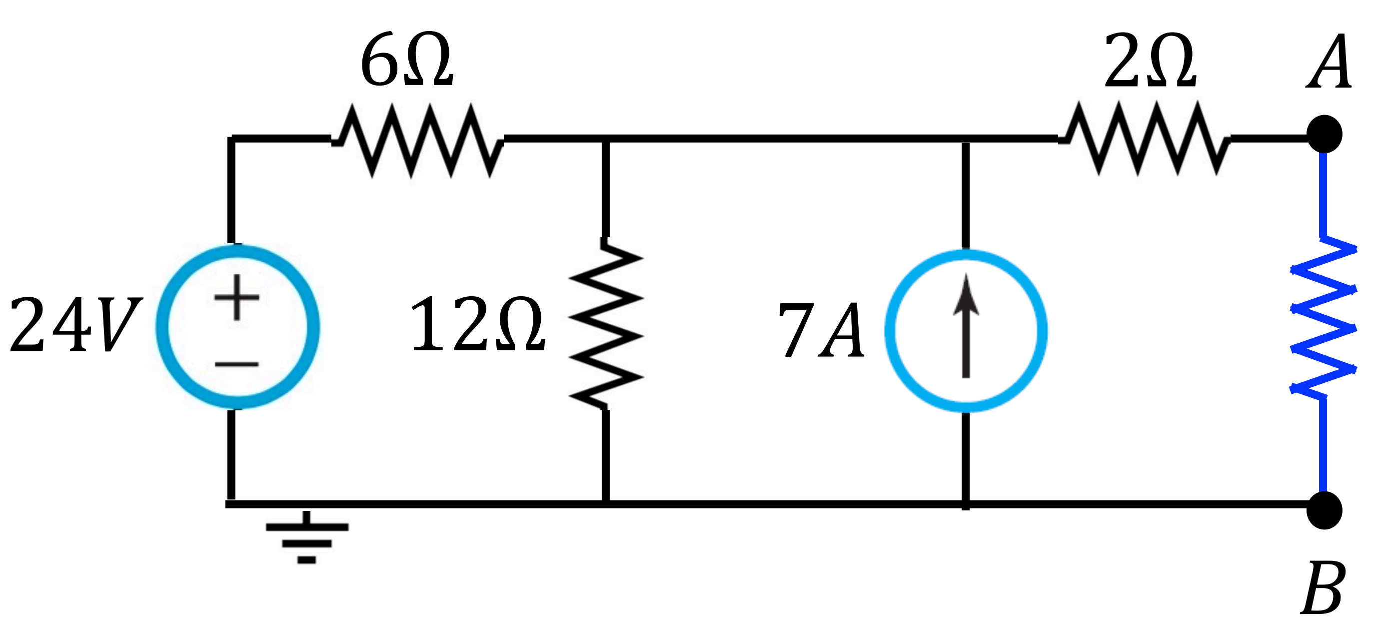
$$\frac{6(12)}{6+12} = \frac{72}{18} = \frac{36}{9} = 4\Omega$$





Thévenin Voltage

1. Remove the load, leaving the load terminals open-circuited.



Thévenin Voltage

1. Remove the load, leaving the load terminals open-circuited.
2. Define the open-circuit voltage v_{TH} across the open load terminals.
3. Apply any preferred method (e.g., nodal analysis, mesh analysis) to solve for v_{TH}.

$V_B = 0V$

$V_C = 24V$

KCL @ A: $7 + i_6 = i_{12}$

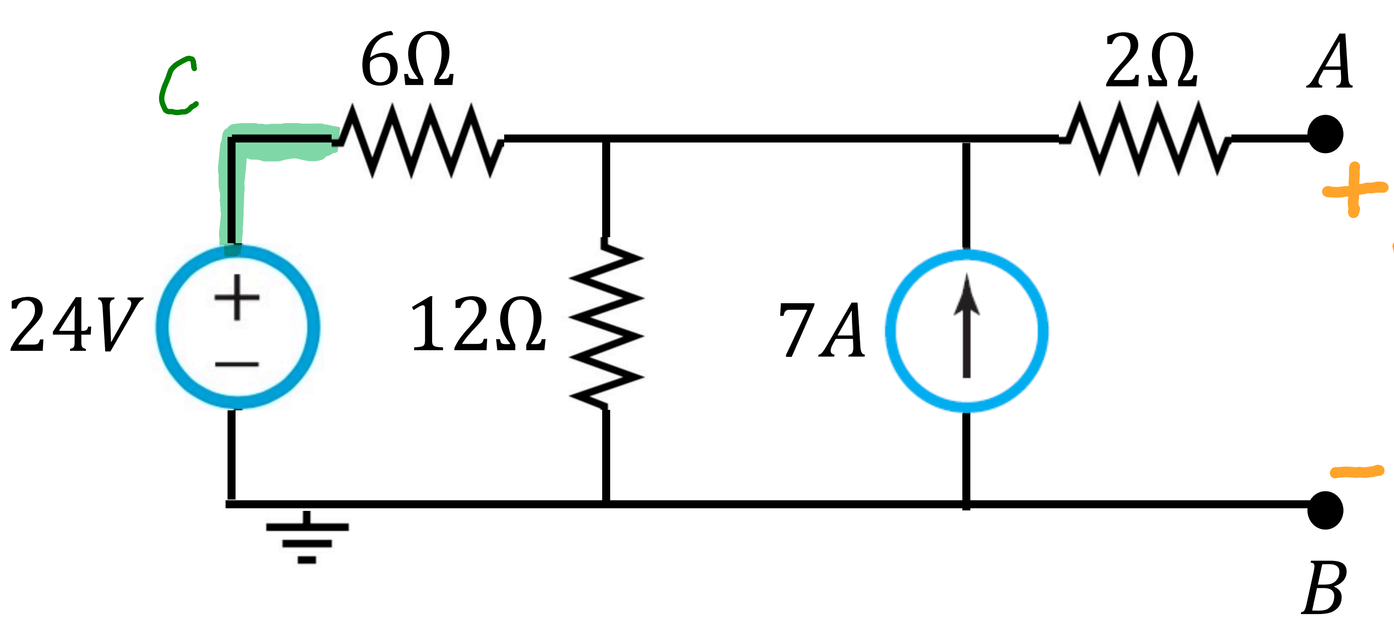
$$7 + \frac{V_6}{6} = \frac{V_{12}}{12}$$

$$84 + 2V_6 = V_{12}$$

$$84 + 2(24 - V_A) = V_A$$

$$84 + 48 = 3V_A$$

$$V_A = \frac{132}{3} = 44V$$



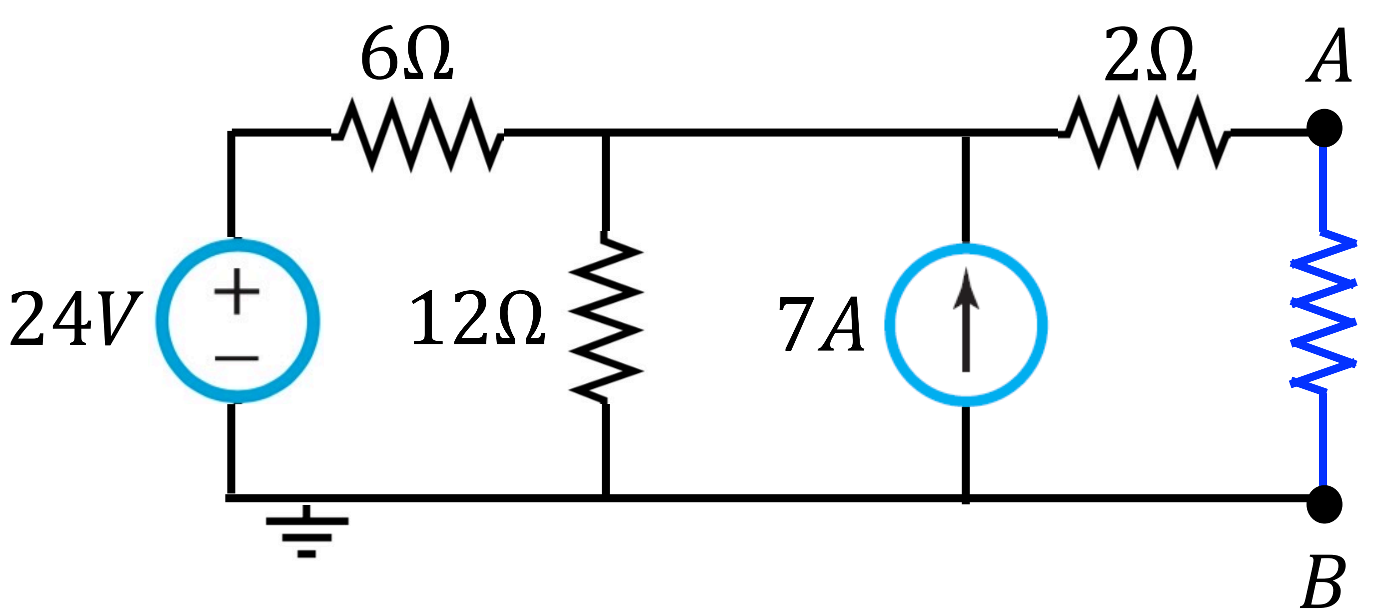
$V_{TH} = V_A - V_B$

$i = 0$

$$\boxed{V_{TH} = 44V}$$

Norton Current

1. Replace the load with a short circuit.



Norton Current

1. Replace the load with a short circuit.

2. Define the short circuit current, i_N, to be the Norton equivalent current.

3. Apply any preferred method (e.g., nodal analysis) to solve for i_N.

$V_B = 0V$

$V_C = 24V$

$i_N = i_2 = \frac{V_2}{2} = \frac{V_D}{2}$

$$\boxed{i_N = \frac{\frac{44}{3}}{2} = \frac{22}{3}A}$$

KCL@D: $7 + i_6 = i_{12} + i_2$

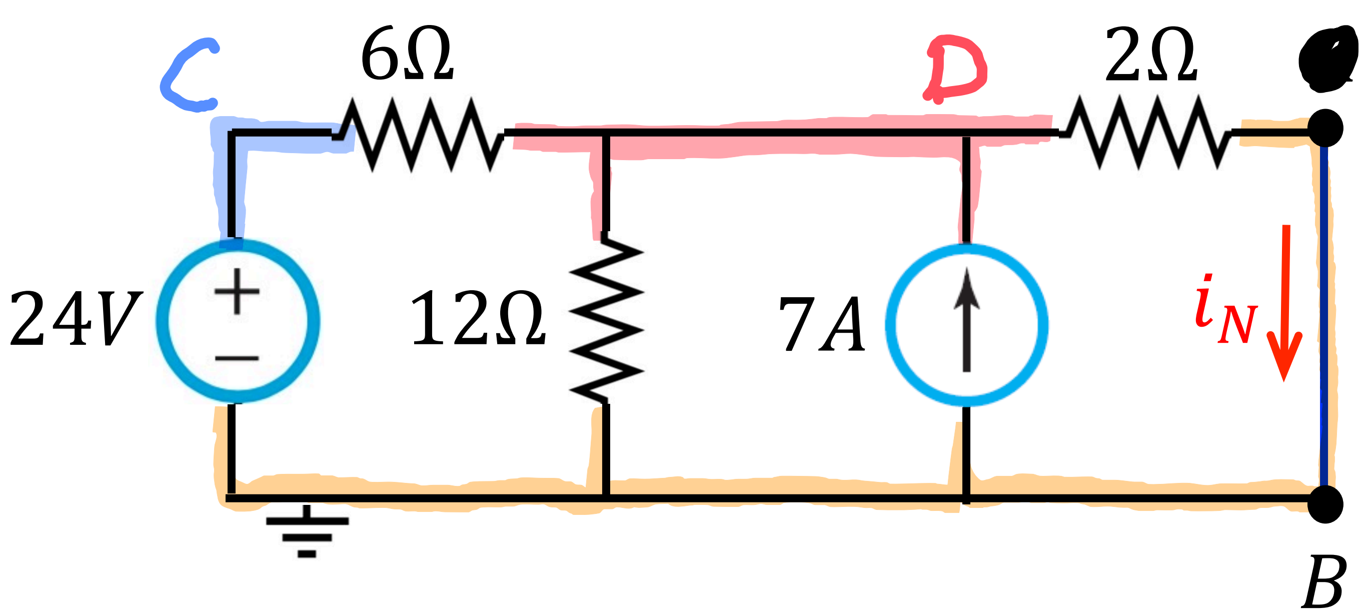
$7 + \frac{V_6}{6} = \frac{V_{12}}{12} + \frac{V_2}{2}$

$84 + 2V_6 = V_{12} + 6V_2$

$84 + 2(24 - V_D) = V_D + 6V_D$

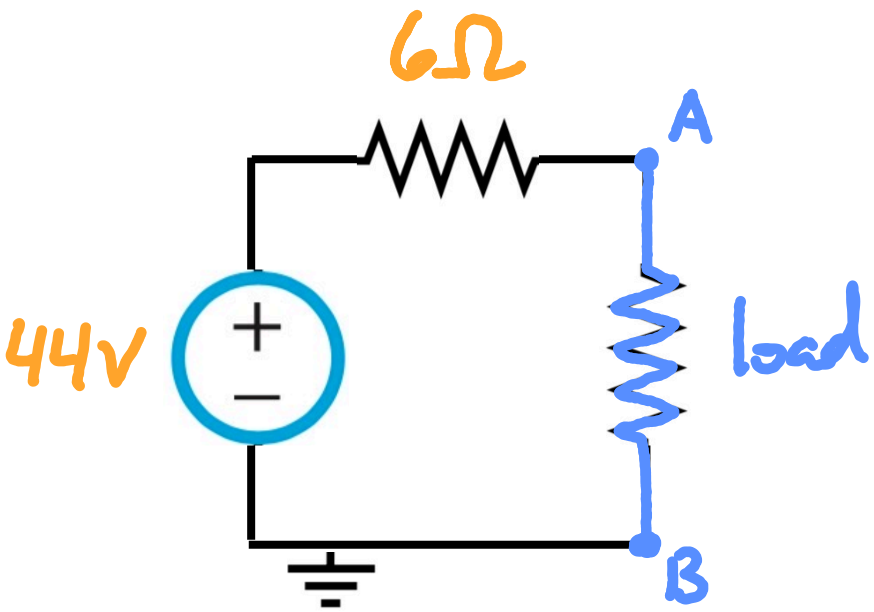
$84 + 48 = 9V_D$

$V_D = \frac{132}{9} = \frac{44}{3}V$



Equivalent Circuits

Thevenin Circuit



Norton Circuit