Circuit Laws

Michael Brodskiy
Professor: N. Sun

January 18, 2023

- Voltmeter — Measures voltage without drawing current
- Ammeter — Measures current without dropping voltage
- Resistance is a function of size, shape, and media properties:

$$\boxed{R = \frac{V}{I} = \frac{l}{\sigma A} = \rho\frac{l}{A}}$$

  - σ is the conductivity, ρ is the resistivity, l is the length of the wire, and A is the cross-sectional area

- Siemens (S), the unit for conductance, is the inverse of resistance, where: $\boxed{S = \frac{1}{\Omega}}$

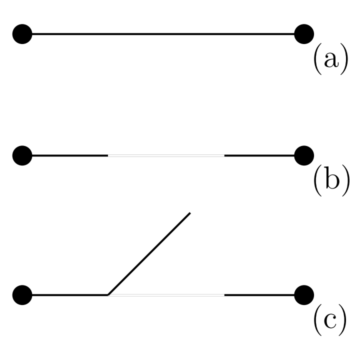

Figure 1: Different Circuit Types

  - (a) shows a short circuit
  - (b) shows an open circuit
  - (c) shows an open switch

- Kirchoff's Laws
  - A circuit is said to be solved when voltage and current across each circuit element has been determined
  - Consist of Kirchoff's current law (KCL) and Kirchoff's voltage law (KVL)
  - Node — A point where two or more circuit elements meet
  - Sum of currents entering a node is zero (also holds for closed boundary)

$$\boxed{\sum_{n=1}^{N} i_n = 0 \quad \text{(KCL)}}$$

  - For any node, a unique voltage can be assigned
  - Sum of voltages around a closed path is zero, or the sum of voltage drops is equal to the sum of voltage rises

$$\boxed{\sum_{n=1}^{N} v_n = 0 \quad \text{(KVL)}}$$

  - Add up the voltages in a systematic, clockwise movement around the loop
  - Assign a positive sign to the voltage across an element if the (+) side of that voltage is encountered first, and assign a negative sign if the (-) side is encountered first

- Equivalent Circuits
  - If the current and voltage characteristics at nodes are identical, the circuits are considered "equivalent"
  - Identifying equivalent circuits simplifies analysis
  - The following two equations may be used when working with resistors

$$\boxed{R_{eq} = \sum_{i=1}^{N} R_i \quad \text{(in series)}}$$

$$\boxed{v_i = \left(\frac{R_i}{R_{eq}}\right) v_s}$$

  - Variable resistors are useful in making an adjustable voltage divider circuit
  - Identifying equivalent circuits simplifies analysis

- Resistors in Parallel

- The equivalent resistance for resistors in parallel may be found as follows:

$$\boxed{R_{eq} = \left(\sum_{i=1}^{N} \frac{1}{R_i} \right)^{-1} \qquad \text{(in parallel)}}$$

- Voltage Sources
  - Voltage sources also add in series
- Current Sources
  - Current sources add in parallel

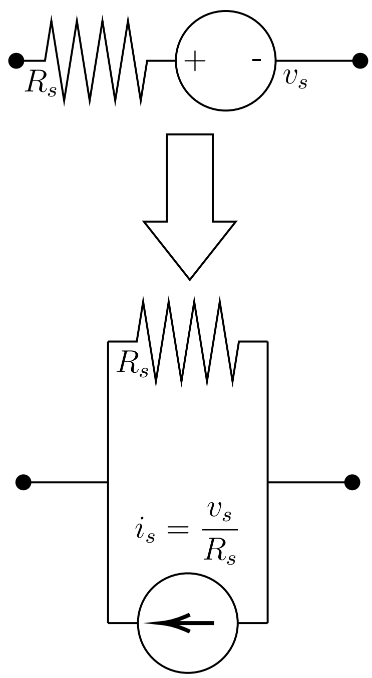

Figure 2: An Equivalent Circuit Example