DC Circuit Analysis

HRW P639>
Circuit Symbols

- Resistor
- Voltage source (battery)
- Switch (open)
- Wire (Conductor)
What is a circuit?

A basic circuit comprises:

- **Voltage** source (ex. battery)
- **Load** (ex. Resistors)
- **Conductor** (ex. Wires)
- **Control** (ex. Switch)
DC Circuit Analysis

- DC Circuits are analyzed in 3 models
  - **Series** resistors
  - **Parallel** resistors
  - **Combination** resistors
- Circuit Analysis investigates:
  - Equivalent **resistance**
  - Circuit **current** in/out battery
  - **Voltage drop across** components
  - **Current through** components
DC Circuit Analysis - Series

- Components are connected “nose-tail” or inline
- There is only one path for the circuit current (I) to flow.
Examples of series circuits
Circuit Analysis - Series

![Circuit Diagram]

- **SW1**
- **V1**: 12 V
- **R1**: 10 Ω
- **R2**: 20 Ω
- **R_{tot}**: 30 Ω
DC Circuit Analysis – Series

- **Equivalent** (or total) resistance
  - \( R_T = R_1 + R_2 + R_3 \)
- **Current** is the same through all components = circuit current (I)
- **Voltage** drop across each resistor (n)
  - \( V_n = I \times R_n \)
  - Sum of voltage drops = battery voltage
DC Circuit Analysis – Series Practice

- Analyze the series circuit by calculating:
  - Equivalent resistance $R_T$
  - Circuit current (I) flowing into/out of the battery
  - Voltage drop across the 3, 4 and 5 ohm resistor
DC Circuit Analysis - Parallel

- Components are connected "side by side"
- There are multiple paths for the current to flow, splitting into branch currents through R1, R2 and R3, according to their resistive values.
- The circuit current (I) flows into/out of the battery.
Examples of parallel circuits

Ladder analogy
Circuit Analysis - Parallel

![Diagram of a parallel circuit with resistors and a voltage source.]

- **SW1**: Switch
- **V1**: 12 V voltage source
- **R18, R19, R20**: Resistors with values 100 Ω each
- **Ammeter**: Measures current through the circuit

- **R22**: 100 Ω resistor in another branch of the circuit.
DC Circuit Analysis – Parallel

- Equivalent resistance
  - \( \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \)
- Voltage is the same across all \( n \) resistors (V)
- Current in each resistor (\( I_n \))
  - \( I_n = \frac{V}{R_n} \)
DC Circuit Analysis – Parallel Practice

- Analyze a parallel circuit by finding:
  - Equivalent resistance \( R_T \)
  - Circuit current \( I \)
  - Current \( I_n \) through each of the resistors \( R_n \)
    - \( I_1 \) through \( R_1 \)
    - \( I_2 \) through \( R_2 \)
    - \( I_3 \) through \( R_3 \)
Circuit Analysis - Combo
DC Circuit Analysis – Combo

- Resistors are connected in both series (R3) and parallel (R1, R2) methods.

- Analyze by starting to simplify from the inside-out:
  - Simplify R1 and R2 \( > R_{12} \)
  - Add result \( (R_{12}) \) to R3 for total circuit resistance \( (R_{\text{tot}}) \)

- Calculate circuit current
  - \( I = \frac{V}{R_{\text{tot}}} \)

- Calculate currents through selected resistances

Shortcut: \( R_{\text{tot}} = R_3 + \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)} \)
Parallel part of combo

- Consider current (I)
  - Passes through R3 in series with battery
  - Splits so that larger part goes through the low value resistor ($R_{low}$), and smaller part goes through high value ($R_{high}$) resistor
Given $V = 12V$, $R_1$, $R_2$ and $R_3 = 1, 2, 3$ ohm respectively, calculate:

- Equiv resistance ($R_T$)
- Circuit current ($I$)
- Current through $R_2$ ($I_2$)

See next slide
Combo Shortcut for current

- R₁ and R₂ are in parallel, so the voltage drop across each resistor is the same.
- Shortcut for calculating \( I_n \) when there are 2 resistors (\( R_{\text{low}} \) and \( R_{\text{high}} \)) in parallel:
  - \( I_{\text{low}} = \frac{R_{\text{high}}}{R_{\text{low}} + R_{\text{high}}} \times \text{circuit current (I)} \)
  - \( I_{\text{high}} = \frac{R_{\text{low}}}{R_{\text{low}} + R_{\text{high}}} \times \text{circuit current (I)} \)
- We are simply apportioning the current according to the resistance
  - Higher resistance = lower current (and v.v)

\( I_{\text{low}} = \text{current through } R_{\text{low}} \) & \( I_{\text{high}} = \text{current through } R_{\text{high}} \)