Voltage Divider

Applied Mechatronics

First Grade Level

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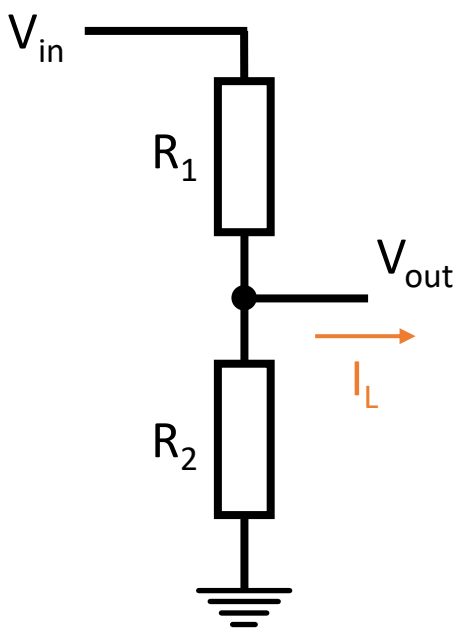
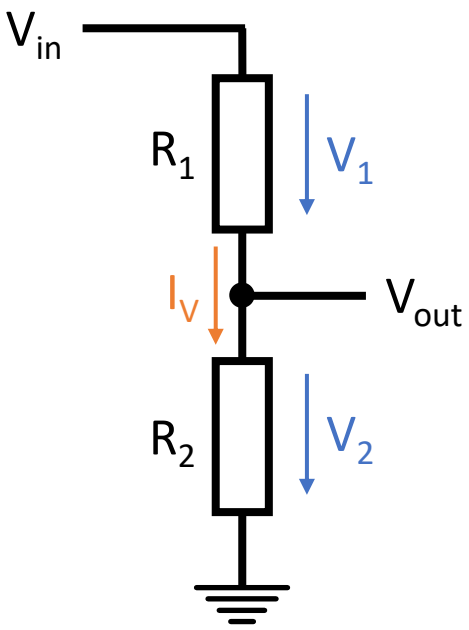
Voltage Divider (1)

- Mode of Operation
  - Reduce voltage with the aid of resistors
  - Two resistors in series
  - Two modes
    - Unloaded voltage divider
      - No current load on V_{out}
    - Loaded voltage divider
      - With current load on V_{out}



Voltage Divider (2)

- Unloaded voltage divider
  - Given values
    - R_1, R_2, V_{in}
  - Required values
    - V_{out}, I_V, P_{tot}
  - Relations
    - $R_{tot} = R_1 + R_2$
    - $V_{in} = V_1 + V_2$
    - $V_{out} = V_2$
    - $I_V = \frac{V_{in}}{R_{tot}} = \frac{V_1}{R_1} = \frac{V_2}{R_2}$
    - $P_{tot} = V_{in} \cdot I_V$



V_{in}: Input Voltage

V_{out}: Output Voltage

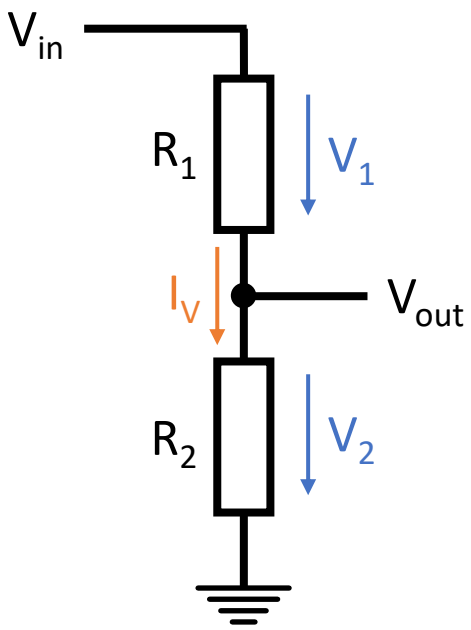
I_V: Vertical Current

R_{tot}: Total Resistance

P_{tot}: Total Power = Power Loss

Voltage Divider (3)

- Unloaded voltage divider
  - Derivation
    - $\frac{V_{in}}{R_{tot}} = \frac{V_2}{R_2}$
    - $V_2 = \frac{R_2}{R_{tot}} \cdot V_{in}$
  - Formulas
    - $V_{out} = \frac{R_2}{R_1+R_2} \cdot V_{in}$
    - $I_V = \frac{V_{out}}{R_2}$
    - $P_{tot} = \frac{V_{out}}{R_2} \cdot V_{in}$



$$I_V = \frac{V_{in}}{R_{tot}}$$

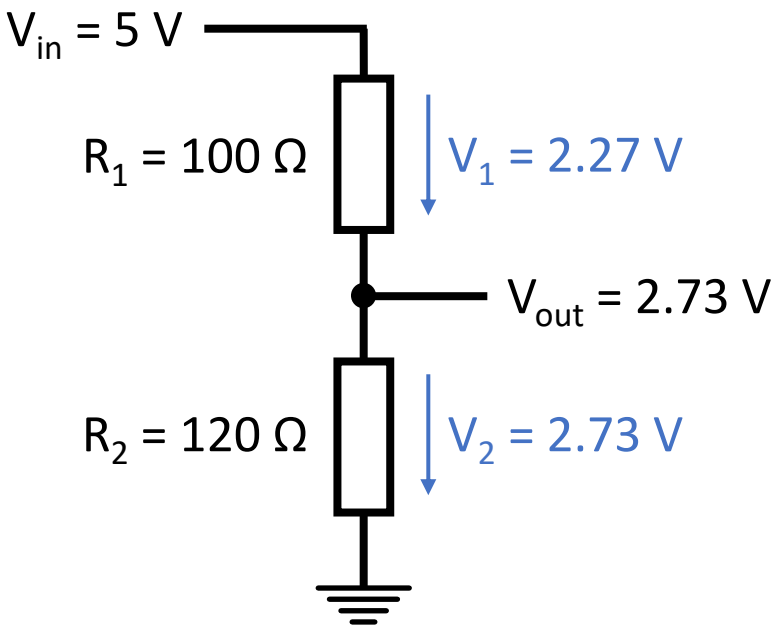
$$I_V = \frac{V_2}{R_2}$$

Voltage Divider (4)

- Unloaded voltage divider
  - Example
    - Given values
      - V_{in} = 5 V
      - R_1 = 100 Ω
      - R_2 = 120 Ω
  - Calculation
    - $V_{out} = \frac{R_2}{R_1+R_2} \cdot V_{in}$

$$= \frac{120\ \Omega}{100\ \Omega+120\ \Omega} \cdot 5\ \text{V}$$

$$= 2.73\ V$$



Voltage Divider (5)

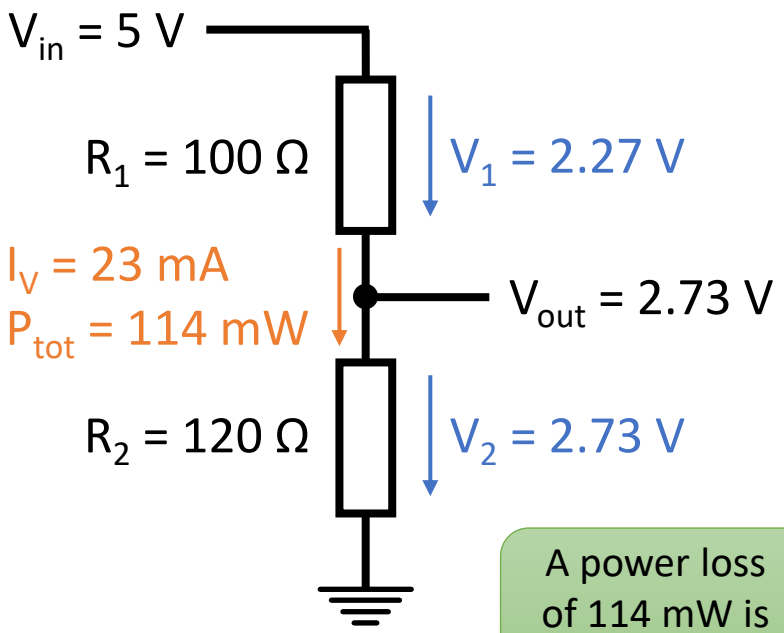
- Unloaded voltage divider
  - Calculation
    - $I_V = \frac{V_{out}}{R_2}$

      $= \frac{2.73\ V}{120\ \Omega}$

      $= 23\ mA$
    - $P_{tot} = \frac{V_{out}}{R_2} \cdot V_{in}$

      $= \frac{2.73\ V}{120\ \Omega} \cdot 5\ V$

      $= 114\ mW$



A power loss of 114 mW is relatively high.

Voltage Divider (6)

- Voltage Divider with Amplifier
  - Loaded voltage divider are difficult to handle
    - Current load may be unknown
    - Current load may vary
  - An amplifier can eliminate the load