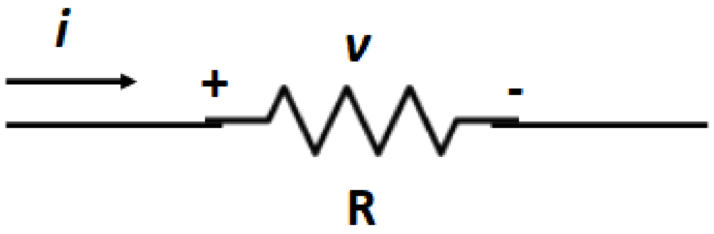
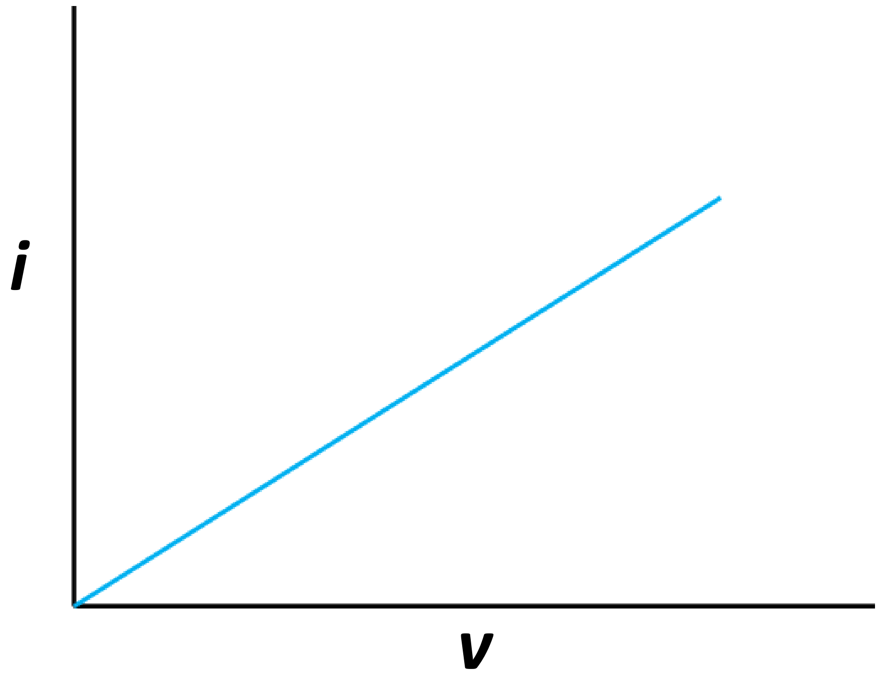
Ohm's Law

- **Ohm's law** states that the potential difference (or voltage) across any two ends of a conductor is directly proportional to the current flowing between the two ends provided that the temperature of the conductor remains constant.

$$v \propto i$$

$$v = iR$$





i-v characteristic of a linear resistor

Resistance and Conductance

- **Resistance** *R* of an element denotes its ability to resist the flow of electric current; it is measured in ohms (Ω).

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

- Careful attention must be considered to the current direction and voltage polarity. The direction of current i and the polarity of voltage v must conform with the passive sign convention.

- If current flows from a **higher potential to a lower potential**, **v = iR**.
- If current flows from a **lower potential to a higher potential**, **v = −iR**.

- A **short circuit** is a circuit element with resistance approaching zero.
- An **open circuit** is a circuit element with resistance approaching infinity.

Resistance and Conductance…Continued

- **Conductance** is the ability of an element to conduct electric current; it is measured in siemens (S).

$$i = Gv$$

- The same resistance can be expressed in ohms or siemens. For example, 10 Ω is the same as 0.1 S.

$$G = \frac{1}{R} = \frac{i}{v}$$

Power

- Power is the time rate of expending or absorbing energy, measured in watts (W).

$$p = \frac{dw}{dt} = \frac{dw}{dq}\frac{dq}{dt} = vi$$

$$p = \frac{v^2}{R} = i^2 R$$

- The power dissipated in a resistor is a nonlinear function of either current or voltage.
- The power dissipated in a resistor is always positive. Thus, a resistor always absorbs power from the circuit.

Active and Passive Components

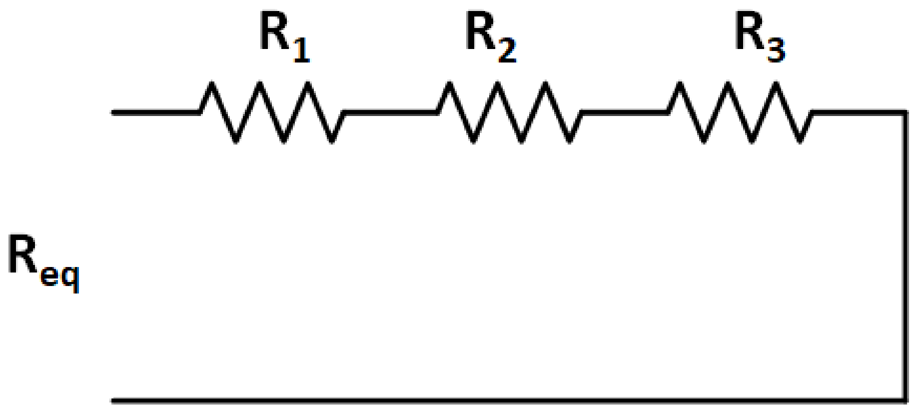
- An **active element** is capable of generating energy.
- Typical active elements include generators, batteries, and operational amplifiers.
- **Passive components** don’t need an external power source to function. They only require the current traveling through the connected circuit.
- Passive components like resistors, capacitors, inductors, diodes etc. impede the flow of electrons without introducing more electricity into the system.

Resistors Connected in Series

$$R_{eq} = R_1 + R_2 + R_3$$

- The total resistance of a series configuration is the sum of the individual resistances.

- More resistors in series combination, the greater the resistance, no matter what the value of the resistor is.

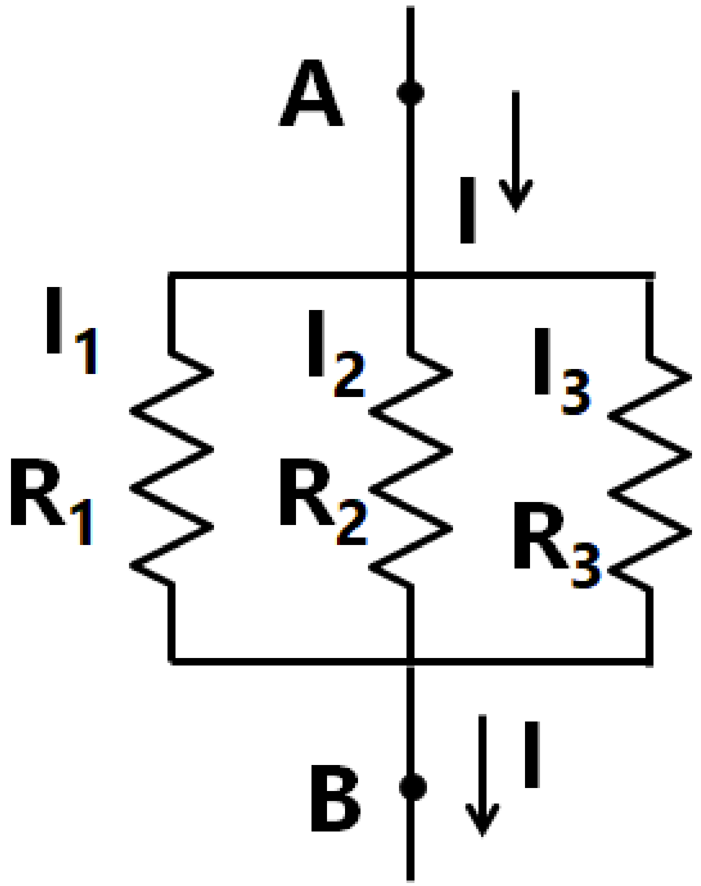


Resistors Connected in Parallel

- Two or more resistors are in parallel if they have two points in common.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

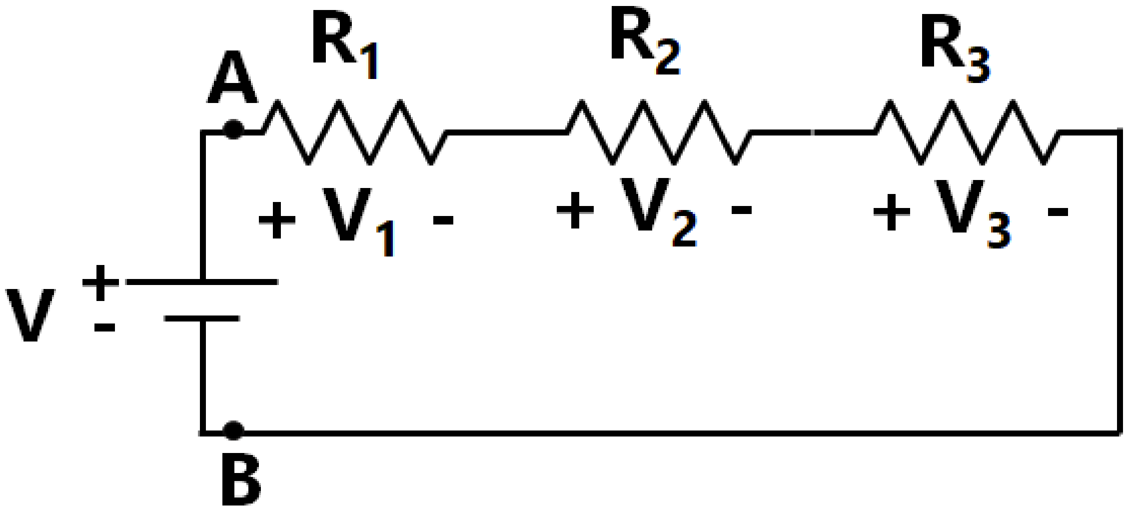
- Req is always smaller than the resistance of the smallest resistor in the parallel combination



Voltage Division Rule

- Current through the circuit I is given by

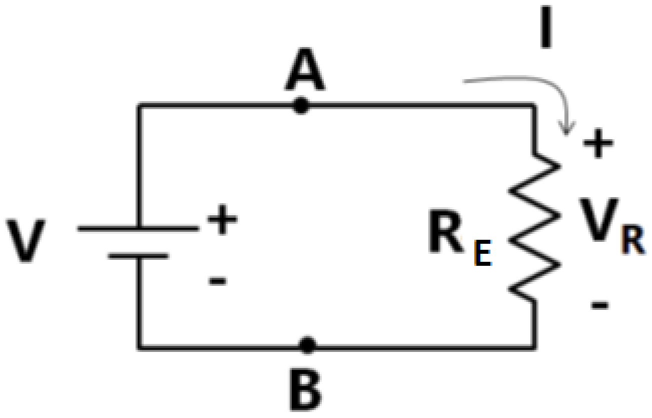
$$I = \frac{V}{R_E}$$



- Voltage drop across resistors R_1, R_2, R_3:

$V_1 = I.R_1$ $V_2 = I.R_2$
$V_3 = I.R_3$

- $V = V_1 + V_2 + V_3$

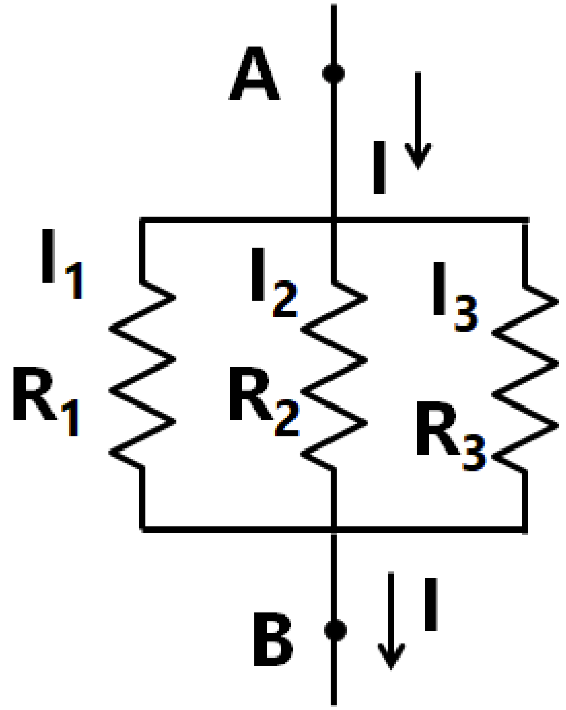


$$V_1 = \frac{R_1}{R_E} V \qquad V_2 = \frac{R_2}{R_E} V \qquad V_3 = \frac{R_3}{R_E} V$$

$$V = IR_1 + IR_2 + IR_3 = \left(\frac{R_1}{R_E} + \frac{R_2}{R_E} + \frac{R_3}{R_E} \right)$$

Current Division Rule

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \mathrm{R}_{eq} = \frac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$



- Total Current flowing through the circuit:

$$I = \frac{V_{AB}}{R_E}$$

- Current I_1 through R_1 is:
- $I_1 = \dfrac{V_{AB}}{R_1}$ i.e., $I_1 = \dfrac{R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1} I$
- Similarly, $I_2 = \dfrac{R_1R_3}{R_1R_2 + R_2R_3 + R_3R_1} I$

$$I_3 = \frac{R_1R_2}{R_1R_2 + R_2R_3 + R_3R_1} I$$