Basic Electronic Series

Ohm's Law

Fundamentals

- "Electricity" is the movement or flow of free electrons from one atom to another.
- Electrons are negatively-charged sub-atomic particles, which orbit in rings around the nucleus of an atom.
- Atoms with tightly-bound outer ring electrons exhibit little movement of electrons from one atom to another – called *insulators.*
- Atoms with loosely-bound outer ring electrons exhibit ready movement of electrons from one atom to another – called *conductors.*

Fundamentals

- The flow of electrons is called *current.*
- The effect of a material opposing the flow of electrons is called *resistance.*
- The force that causes electrons to flow is called *electro-motive force (EMF),* or more commonly and simply, *voltage.* Voltage is akin to *electrical pressure.*
- There is a certain fixed relationship between these three factors – voltage, current, and resistance.

The Relationship

- The relationship between voltage, current, and resistance is summed up in a principle known as *Ohm's Law.*
  - Named for German physicist Georg Ohm
  - Published treatise in 1827 that laid the groundwork for the modern iteration of Ohm's Law
- The current through a conductor between two points in a circuit is directly proportional to the voltage across those two points.
  - The quality of that conductor that allows for the flow of a specific current through that conductor is its resistance.

Mathematically…

- Ohm's Law can be expressed using the equation

$$I = E/R$$

  - Where…
    - I represents the current in the circuit;
    - E represents the voltage applied to the circuit; and
    - R represents the resistance of the circuit.
- Ohm's Law can be expressed in other forms through mathematics

Mathematically…

- Other forms of Ohm's Law:

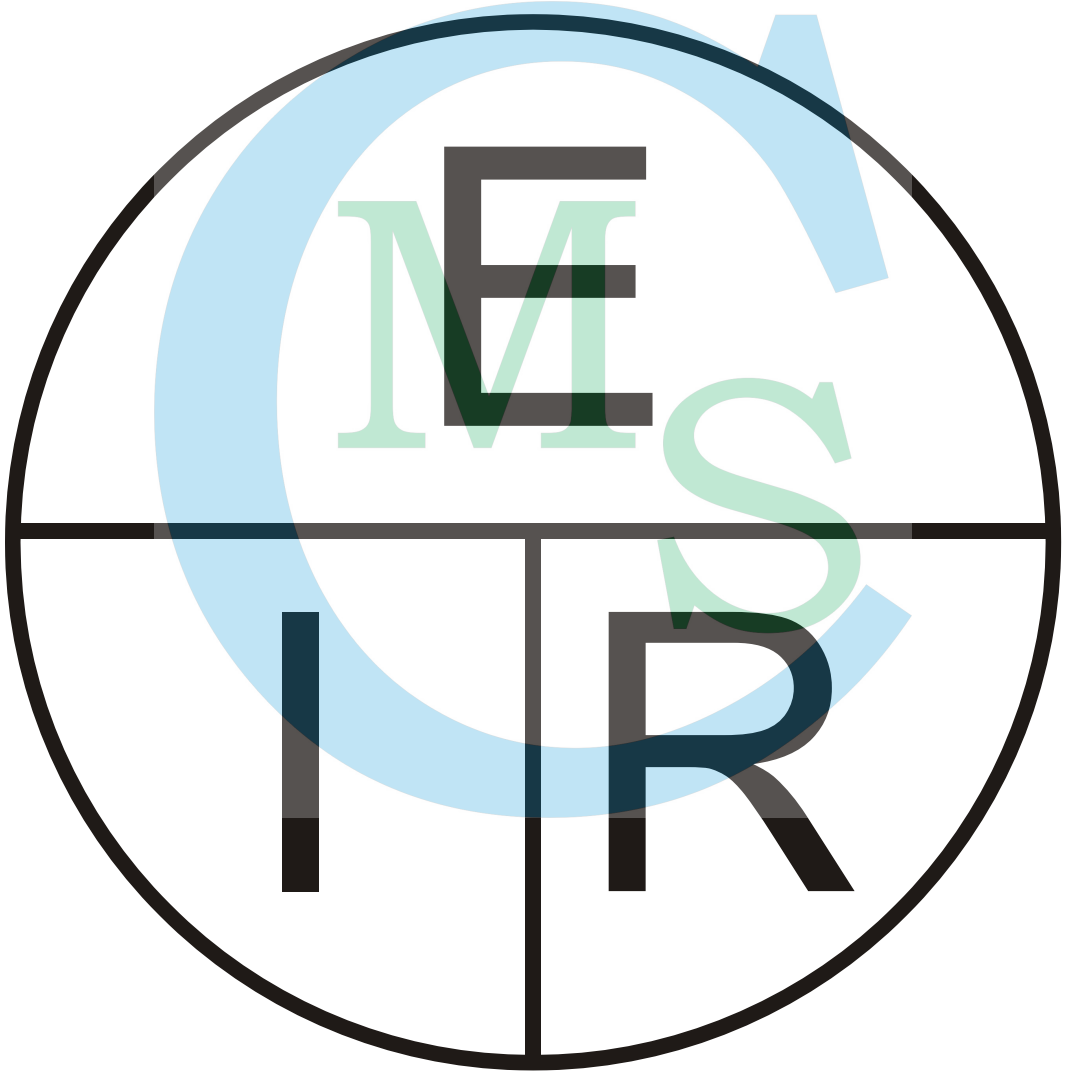
$$E = I \times R$$

or

$$R = E / I$$

- Used to solve for the unknown value

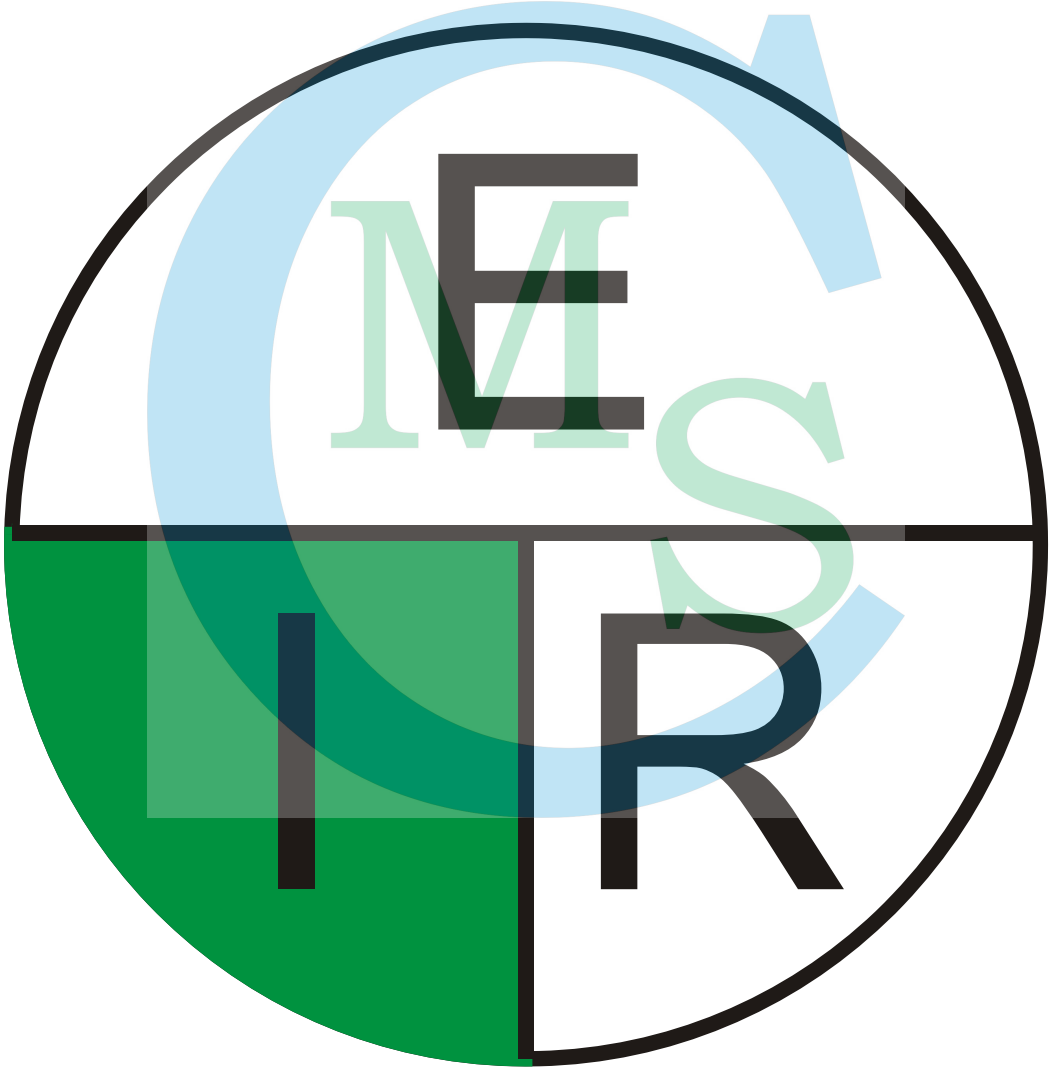
Ohm's Law Wheel



Ohm's Law Circle

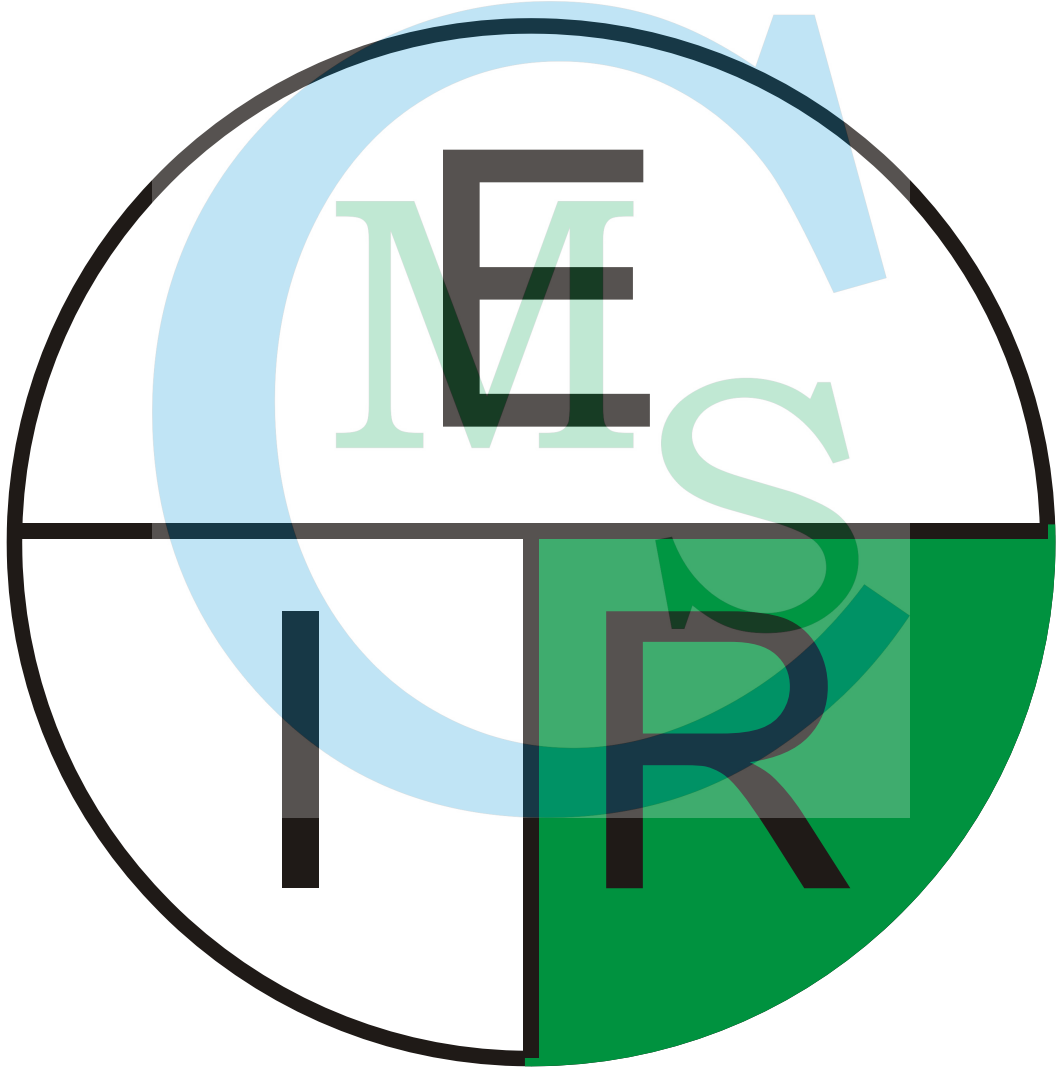
- The Ohm's Law Circle is a handy tool for remembering the various forms of Ohm's Law, and it aids in working out the math.
  - When working Ohm's Law problems, we are given two of the three factors and have to solve for the third or missing element.
  - Cover the element you are solving for, and the formula will be shown by the remaining two factors – multiplication or division.

Solve for Current



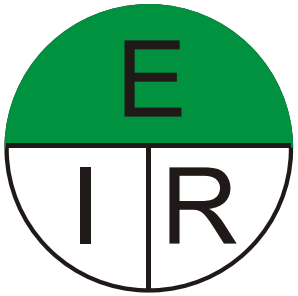
Solve for Voltage

Solve for Resistance



Ohm's Law Circle

Cover the "I" and you are left with E / R



Cover the "E" and you are left with I x R

Cover the "R" and you are left with E / I

Example 1

- 12VDC applied through a resistance of 100Ω – solve for current
  - $I = E / R$
  - $I = 12 / 100$
  - $I = 0.12A$

Example 2

- 500mA flowing through 1KΩ – solve for voltage
  - $E = I \times R$
  - $E = 0.5 \times 1000$
  - $E = 500V$

Example 3

- 1500mA flowing in a circuit with 13.8V supply – solve for resistance
  - $R = E / I$
  - $R = 13.8 / 1.5$
  - $R = 9.2\Omega$

Power Calculations

- Power is a measure of the electrical energy consumed, measured in ***watts***.
- The standard power formula is:

$$P = I \times E$$

  - Where…
    - P = power in Watts
    - I = current in Amperes
    - E = EMF in Volts

Power Calculations

- Power is also sometimes expressed as the formula

$$P = E^2 / R$$

  - Where…
    - P = power in Watts
    - E = EMF in Volts
    - R = resistance in Ohms
- Formula comes directly from Ohm's Law in that the "I" is substituted by its formulaic E/R equivalent, thus power in watts is equal to the formulaic $E \times E/R$, or E^2/R.

Power Calculations

- The same could be done if the voltage was the unknown factor, but current and resistance are provided. Now, the formula becomes:

$$P = I^2 \times R \text{ or } P = I^2R$$

  - Where…
    - P is power in Watts
    - I is current in Amperes
    - R is resistance in Ohms
- This again is a formulaic substitution of $I \times R$ for voltage, giving us $P = I \times I \times R$ or $P = I^2R$

Example 1

- How much power is consumed in a circuit where 21.5 amps is being drawn by a radio operating on 13.8 volts?
- $P = I \times E$
- $P = 21.5 \times 13.8$
- $P = 296.7W$

Example 2

- How much power is being consumed in a circuit wherein 13.8V is applied through a resistance of 2.2KΩ?
- $P = E^2 / R$
- $P = 13.8 \text{ x } 13.8 / 2200$
- $P = 190.44 / 2200$
- $P = 0.086563636W$ or $86.563636mW$

Example 3

- How much power is being consumed in a circuit in which 3575mA is flowing through a resistance of 330KΩ?
- $P = I^2R$
- $P = 3.575 \text{ x } 3.575 \text{ x } 330000$
- $P = 12.780625 \text{ x } 330000$
- $P = 4217.60625\text{W or } 4.21760625\text{kW}$

Any Questions?