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Ohms Law

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Ohms Law

The relationship between Voltage, Current and Resistance in any DC electrical circuit was firstly discovered by the German physicist **Georg Ohm**, (1787 - 1854). **Georg Ohm** found that, at a constant temperature, the electrical current flowing through a fixed linear resistance is directly proportional to the voltage applied across it, and also inversely proportional to the resistance. This relationship between the Voltage, Current and Resistance forms the bases of **Ohms Law** and is shown below.

Ohms Law Relationship

$$Current, (I) = \frac{Voltage, (V)}{Resistance, (R)} \text{ in Amperes, (A)}$$

By knowing any two values of the Voltage, Current or Resistance quantities we can use **Ohms Law** to find the third missing value. **Ohms Law** is used extensively in electronics formulas and calculations so it is "very important to understand and accurately remember these formulas".

To find Voltage (V)

[V = I x R] V (volts) = I (amps) x R (Ω)

To find Current (I)

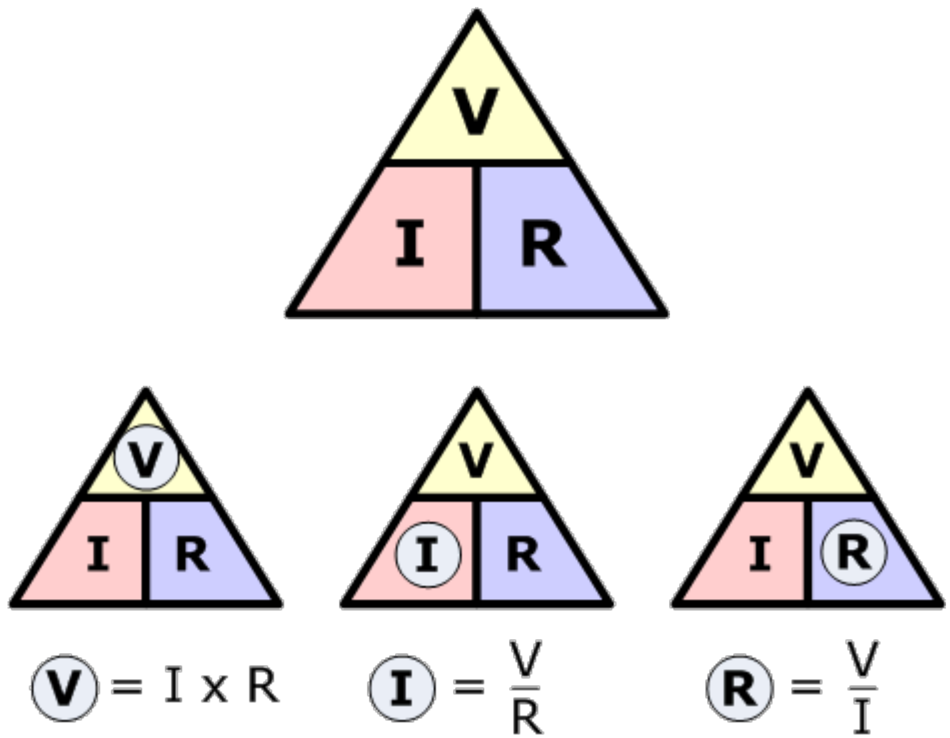
$$[I = V \div R] \qquad I\ (\text{amps}) = V\ (\text{volts}) \div R\ (\Omega)$$

To find Resistance (R)

$$[R = V \div I] \qquad R\ (\Omega) = V\ (\text{volts}) \div I\ (\text{amps})$$

It is sometimes easier to remember Ohms law relationship by using pictures. Here the three quantities of V, I and R have been superimposed into a triangle (affectionately called the **Ohms Law Triangle**) giving voltage at the top with current and resistance at the bottom. This arrangement represents the actual position of each quantity in the Ohms law formulas.

Ohms Law Triangle



Then by using Ohms Law we can see that a voltage of 1V applied to a resistor of 1Ω will cause a current of 1A to flow and the greater the resistance, the less current will flow for any applied voltage. Any Electrical device or component that obeys "Ohms Law" that is, the current flowing through it is proportional to the voltage across it ($I \propto V$), such as resistors or cables, are said to be **"Ohmic"** in nature, and devices that do not, such as transistors or diodes, are said to be **"Non-ohmic"** devices.

Power in Electrical Circuits

Electrical Power, (**P**) in a circuit is the amount of energy that is absorbed or produced within the circuit. A source of energy such as a voltage will produce or deliver power while the connected load absorbs it. The quantity symbol for power is P and is the product of voltage multiplied by the current with the unit of measurement being the **Watt** (**W**) with prefixes used to denote **milliwatts** ($mW = 10^{-3}W$) or **kilowatts** ($kW = 10^{3}W$). By using Ohm's law and substituting for V, I and R the formula for electrical power can be found as:

To find Power (P)

$$[P = V \times I] \qquad P \text{ (watts)} = V \text{ (volts)} \times I \text{ (amps)}$$

Also,

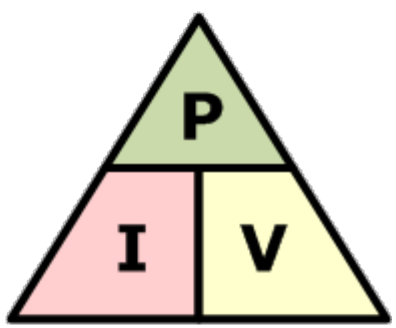
$$[P = V^2 \div R] \qquad P \text{ (watts)} = V^2 \text{ (volts)} \div R\ (\Omega)$$

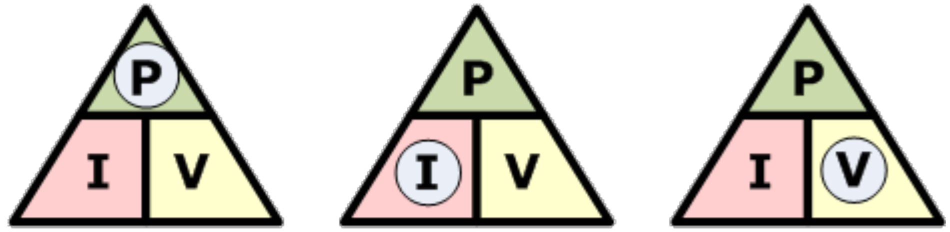
Also,

$$[P = I^2 \times R] \qquad P \text{ (watts)} = I^2 \text{ (amps)} \times R\ (\Omega)$$

Again, the three quantities have been superimposed into a triangle this time called the **Power Triangle** with power at the top and current and voltage at the bottom. Again, this arrangement represents the actual position of each quantity in the Ohms law power formulas.

The Power Triangle





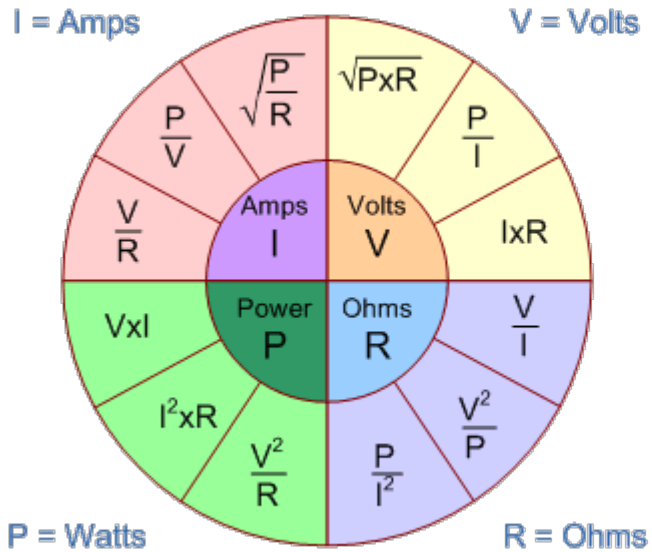
$$P = I \times V \qquad I = \frac{P}{V} \qquad V = \frac{P}{I}$$

One other point about Power, if the calculated power is positive in value for any formula the component absorbs the power, but if the calculated power is negative in value the component produces power, in other words it is a source of electrical energy. Also, we now know that the unit of power is the *WATT* but some electrical devices such as electric motors have a power rating in **Horsepower** or **hp**. The relationship between horsepower and watts is given as: 1hp = 746W.

Ohms Law Pie Chart

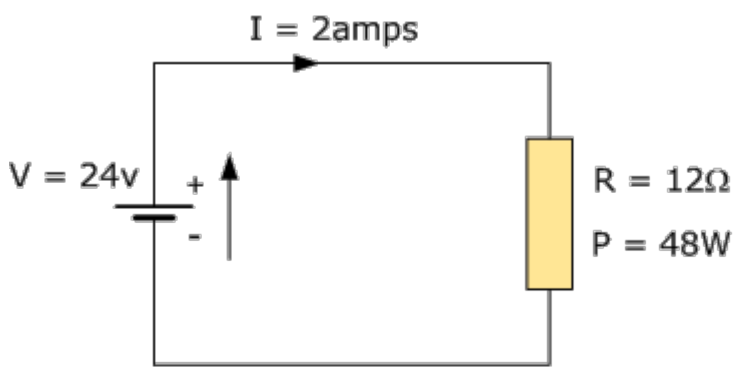
We can now take all the equations from above for finding Voltage, Current, Resistance and Power and condense them into a simple **Ohms Law pie chart** for use in DC circuits and calculations.

Ohms Law Pie Chart



Example No1

For the circuit shown below find the Voltage (V), the Current (I), the Resistance (R) and the Power (P).



Voltage [V = I x R] = 2 x 12Ω = 24V

Current [I = V ÷ R] = 24 ÷ 12Ω = 2A

Resistance [R = V ÷ I] = 24 ÷ 2 = 12 Ω

Power [P = V x I] = 24 x 2 = 48W

Power within an electrical circuit is only present when **BOTH** voltage and current are present for example, In an Open-circuit condition, Voltage is present but there is no current flow $I = 0$ (zero), therefore $V \times 0$ is 0 so the power dissipated within the circuit must also be 0. Likewise, if we have a Short-circuit condition, current flow is present but there is no voltage $V = 0$, therefore $0 \times I = 0$ so again the power dissipated within the circuit is 0.

As electrical power is the product of $V \times I$, the power dissipated in a circuit is the same whether the circuit contains high voltage and low current or low voltage and high current flow. Generally, power is dissipated in the form of **Heat** (heaters), **Mechanical Work** such as motors, etc **Energy** in the form of radiated (Lamps) or as stored energy (Batteries).

Energy in Electrical Circuits

Electrical Energy that is either absorbed or produced is the product of the electrical power measured in Watts and the time in Seconds with the unit of energy given as **Watt-seconds** or **Joules**.

$$\text{Electrical Energy} = \text{Power (W)} \times \text{Time (s)}$$

Although electrical energy is measured in Joules it can become a very large value when used to calculate the energy consumed by a component. For example, a single 100 W light bulb connected for one hour will consume a total of 100 watts x 3600 sec = 360,000 Joules. So prefixes such as **kilojoules** ($kJ = 10^3 J$) or **megajoules** ($MJ = 10^6 J$) are used instead. If the electrical power is measured in "kilowatts" and the time is given in hours then the unit of energy is in kilowatt-hours or kWh which is commonly called a "Unit of Electricity" and is what consumers purchase from their electricity suppliers.

Now that we know what is the relationship between voltage, current and resistance in a circuit, in the next tutorial about DC Theory we will look at the **Standard Electrical Units** used in electrical and electronic engineering to enable us to calculate these values and see that each value can be represented by either multiples or sub-multiples of the unit.

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