Lesson 2

Electric Power

The rate of doing work in an electrical circuit is termed *electrical power* and is measured in watts. A common misconception is that electric power is supplied to your house. In reality "electrical energy" is traded and delivered to your house. Electrical energy will be addressed later.

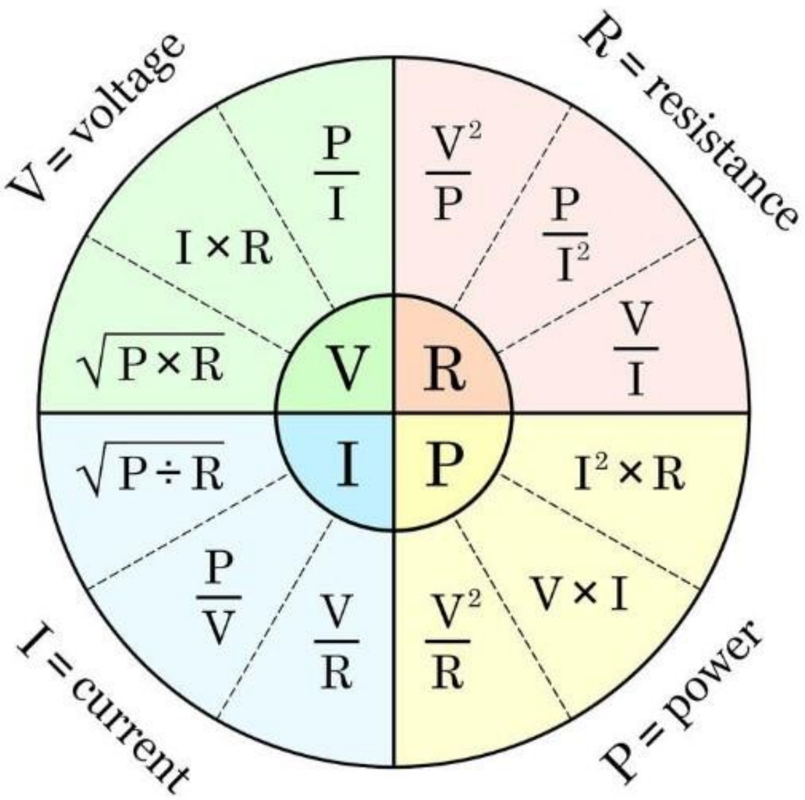
The first place you probably encountered watts is in light bulbs. Brake lights in cars are around 20 watts and taillights are around 10 watts. From this we now know that the higher the wattage of the bulb, the brighter it is.

The formula for electrical power in a resistive circuit is shown below.

$$P = I \; x \; E \qquad P = I^2 x \; R \qquad P = \frac{E^2}{R}$$

P = electrical power in watts
I = current in amperes
E = electromotive force in volts
R = resistance in ohms

Ohm's law tied I, E and R together. So now if we know two of the quantities, we can calculate the other two. This relationship is depicted in the formula circle below.



Examples: What power is dissipated when 12 V is applied across a load with 0.5 A flowing?

$P = I \times E = 0.5 \times 12 = 6$ W

What power is dissipated when 2 A flows through a 10 Ω load?

$P = I^2 \times R = 2^2 \times 10 = 4 \times 10 = 40$ W

What power is dissipated when 12 V is applied to a 10 Ω load?

$P = E^2 \div R = 12^2 \div 10 = 144 \div 10 = 14.4$ W

Electric Energy

Electrical energy for public consumption is generated by central power stations and is usually provided through a grid system.

Electrical energy is measured in the unit kilowatt-hour (kWh). One kilowatt of power for one hour and this is the common billing unit for electrical energy.

Understanding the units

We have used the units of volt, ampere, resistance and watt but what is the basis of these units? How are these units the same here in Australia as they are anywhere else in the world? These units are defined as SI (Système International) units or International Standard units.

Volt

Voltage is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conductor.

1 volt = energy ÷ charge = 1 Joule (J) ÷ 1 Coulomb (Q) = J ÷ Q

*A **joule (J)** is the work unit of energy in the International System of Units. A joule is the heat dissipated when an electric current of one ampere passes through a resistance of one ohm for one second.*

*A **coulomb** (**Q** as C is used for capacitance) is the unit of electric charge in the International System of Units equal to the electric charge delivered by a 1 ampere at a constant current in 1 second.*

Example: What voltage is required to push 10 Q while dissipating 7 joules?

$V = J \div Q = 7 \div 10 = 0.7$ V

Ampere

Ampere relates to the intensity or quantity of electrons flowing.

1 Ampere = 1 coulomb (Q) ÷ 1 second (t) = Q ÷ t

Example: What current is flowing in a circuit if 10 Q passes a point in 5 seconds?

A = Q ÷ t = 10 ÷ 5 = 2 A

Watt

The watt relates to power.

1 watt = 1 joule per second (J/s) = J ÷ t

Example: What power is dissipated in a circuit if 20 joules are expended in 5 seconds?

W = J ÷ t = 20 ÷ 5 = 10 W

kWh

Electrical energy is measured in kWh.

1000 w = joules ÷ (60 x 60 hour to seconds)

1000 w = joules ÷ 3600 seconds

3600 x 1000 =joules

= 3,600,000

3.6 MJ

One kilowatt-hour (kWh) can be defined as 3.6 megajoules (MJ).

Resistance

Resistance is defined as the resistance equals one ohm when one amp of current flows and the electromotive force is one volt. (Ohm's Law)

1 ohm = 1 volt ÷ 1 ampere

Example: What is the resistance of a circuit with 2 A flowing and an EMF of 16 V?

Ω = V ÷ A = 16 ÷ 2 = 8 Ω

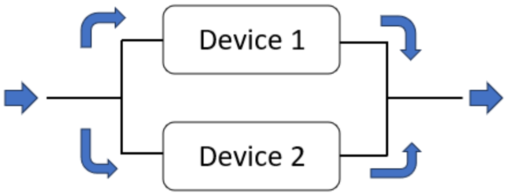
Series and Parallel Voltage Sources

Voltage sources, e.g. batteries, can be connected in series or parallel depending on the system requirements.

Series is defined as the configuration where current flows through one device then the then the second device.

Parallel is defined as the configuration where current splits and goes through two devices at the same time.

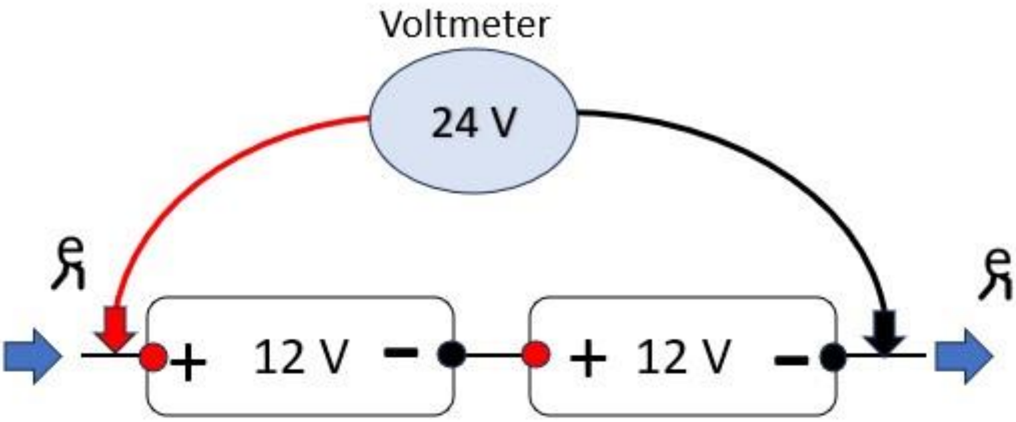
Series Connection



Parallel Connection

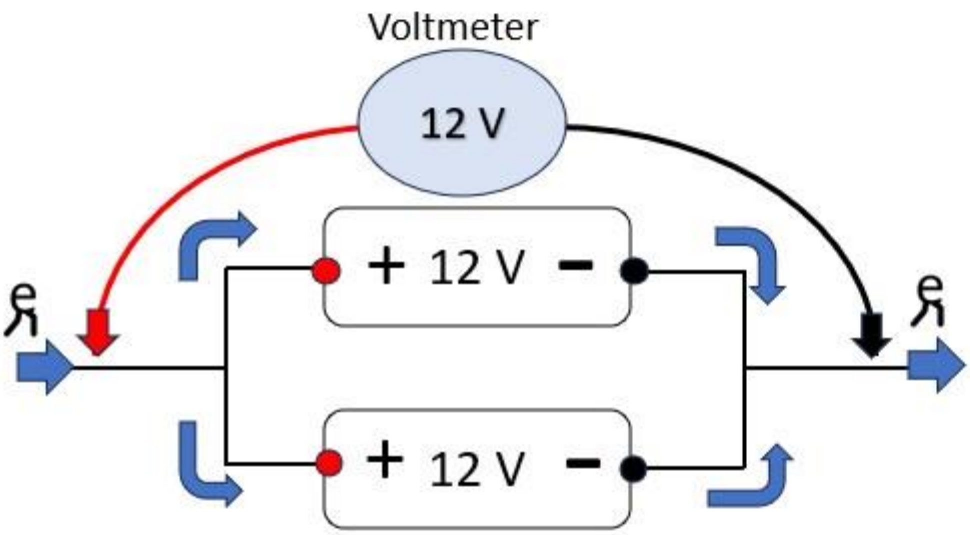
Connecting two or more voltage sources in series will increase the voltage or EMF across the devices.

In the case of a series connection, the voltage potential across the devices is the sum of the voltage sources. See Fig 2-2.



Series Connection
Voltage doubles but current same as one device

For a parallel connection the voltage potential across the devices does not change but the current can increase. See figure 2-3



Parallel Connection

Voltage remains the same, but this combination can deliver double the current.

Go to Lesson 2 questions.

Have fun and stay safe.