

Basic Electricity

<https://github.com/teaksoon/lmaewapm>

When we make PROGRAM for Regular Computers, we do not need to know much about electricity because we do not connect "raw" electrical components to the Regular Computers

When we work with micro-controllers, we will have many "raw" electrical components connected to the micro-controller. Many of those "raw" electrical components can only be manipulated with raw electrical properties. Because of that, we will need to know at least the basics of electricity. Otherwise, it will be very difficult for us to write our PROGRAM effectively for our micro-controller

For start, we only need to know a few basic properties of electricity

1. VOLTAGE (measured in Volt)
2. RESISTANCE (measured in Ohm)
3. CURRENT (measured in Ampere) - we often see mA, mA is milli-Ampere
4. CURRENT FLOW DIRECTION

Here are examples of a few "raw" electrical components,



LED bulb - The operation of this component depends on electrical properties "VOLTAGE", "CURRENT", and "CURRENT FLOW DIRECTION".



Tactile Switch - This is a mechanical device that can prevent or allow "VOLTAGE", "CURRENT" to parts of our system



RESISTOR - This device has a fixed "RESISTANCE" value. When we put it in series with another device, it gives additional resistance to reduce the intensity of "CURRENT" flow to the device preventing the device from damage. It can be paired with another Resistor to be used as "Voltage divider" so that we can have a different "VOLTAGE" at different parts of our circuit

BASIC ELECTRICAL FORMULA

Ohm's Law, VOLTAGE, RESISTANCE and CURRENT are related to each other, by changing any one of them will effect the others

$$\text{VOLTAGE (Volt)} = \text{CURRENT (Ampere)} \times \text{RESISTANCE (Ohm)}$$

This formula can be interchanged like mathematic equations (make sure the correct unit measurement is used)

Krichoff's Voltage Law, in a Closed Electrical Circuit,

$$\text{TOTAL SUPPLY VOLTAGE (Volt)} = \text{TOTAL VOLTAGE DROP (Volt)}$$

VOLTAGE DROP is specific to each individual Device on an electrical circuit

Power, In some product specifications, Power rating in "Watt" is sometimes mentioned

$$\text{POWER (Watt)} = \text{VOLTAGE (Volt)} \times \text{CURRENT (Ampere)}$$

As example: A "0.25W Resistor" means the VOLTAGE x CURRENT on the Resistor must not exceed 0.25W, otherwise the Resistor risk being damaged

There are other electrical formulas, the few formula above are the ones that we will be using the most when working with micro-controllers

How exactly does **VOLTAGE**, **RESISTANCE**, **CURRENT** and **CURRENT FLOW DIRECTION** come into existence ?

All physical thing in the world (including our physical body) is made from combination of the smallest unit called "Atom"

Atom is very small, each is measured in picometers. It will take more than "billions" of atoms combined, in order to become something visible



Each Atom is consist of 3 components, Neutron, Proton and Electron. The Neutron and Proton are bind together in the middle, while the smaller Electrons moves freely on the outside.

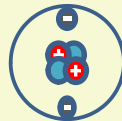
For the sake of simplicity in this tutorial, we use a "fictitious Atom" with 2 electrons (which happens to be a Helium in the real-world)

This is just an example for easy visualization

We are only interested in the **Electrons**



In normal situation



the **Number of Electrons** are **EQUAL** to the **Number of Protons**
The Atom is in **"NEUTRAL"** state (**Electrically Neutral**)

The Proton and Neutron are bind together in the middle of the Atom in a very strong binding

However, the Electrons on the outside in some material can be removed or added when external interference took place

An interference took place to the two Atoms below

Electron is taken away from Atom



Electron is added to Atom

the **Number of Electrons** are **NOT EQUAL** to the **Number of Protons**
These Atoms are now in **"CHARGED"** state

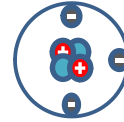
LESS Electron than Proton
POSITIVE CHARGED Atom

MORE Electron than Proton
NEGATIVE CHARGED Atom

LESS Electron than Proton
POSITIVE CHARGED Atom

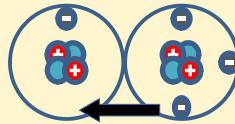
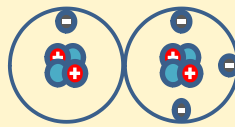


MORE Electron than Proton
NEGATIVE CHARGED Atom



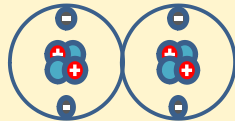
Atoms always want to return to their "NEUTRAL" State

What happen if we put POSITIVE and NEGATIVE CHARGED Atoms together ?



The extra Electron from NEGATIVE CHARGED Atom will move over to the POSITIVE CHARGED Atom

both CHARGED Atoms now becomes NEUTRAL ("DISCHARGED")



Movement of Electrons across the Atoms generates "Energy"
and this "Energy" can be used to do work for us

We make alot of POSITIVE and NEGATIVE CHARGED Atoms
Keep them separated

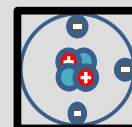
When we need the Electron to move, we just connect them together

This become our "POWER SOURCE"

+Ve



POWER SOURCE

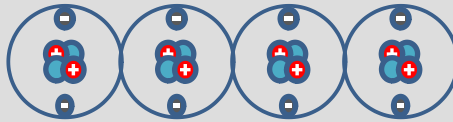


-Ve



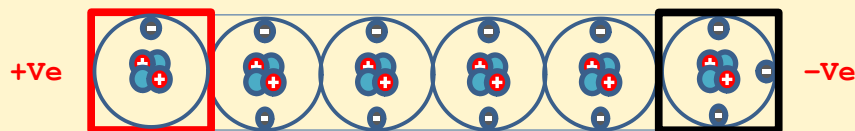
ELECTRIC CONDUCTOR

ELECTRIC CONDUCTOR is made from material where its Electrons can be easily removed its Atom
(they are mostly metals. example: copper wires)



Not all ELECTRIC CONDUCTOR are the same, in some material the Electrons are easily removed from its atom (**Low RESISTANCE**), in some material the Electrons are harder to be removed from its atom (**High RESISTANCE**).

What will happen when we place the ELECTRIC CONDUCTOR between the POWER SOURCE connecting the **POSITIVE** and the **NEGATIVE** ?



A **"PATH"** is created between the +ve and -ve of the Power Source

VOLTAGE in CLOSED CIRCUIT

1. From the picture above, we can see a **"PATH"** where Electron can move to make CHARGED Atoms neutral, this is called a **"CLOSED CIRCUIT"**

2. From the picture above, we can also see **"imbalance"** at the both ends of this **"CLOSED CIRCUIT"**

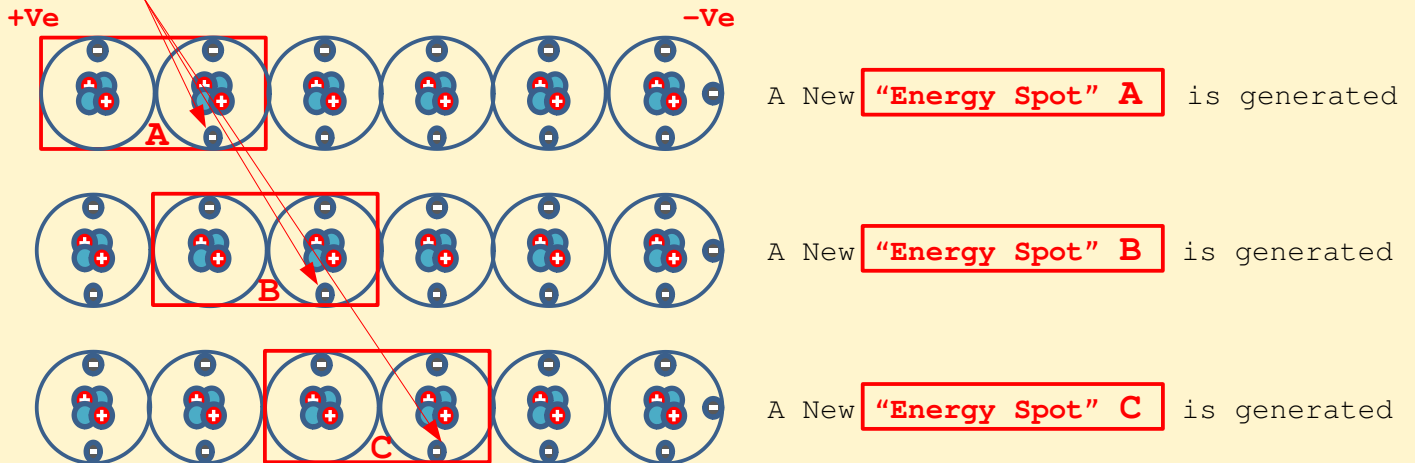
- The Atoms at **one end** is charged and have **MORE Electron(-ve)**
- The Atoms at **the other end** is also charged but with **LESS Electron(+ve)**

The **"imbalance"** of electrons between the both ends of the POWER SOURCE is also known as called **"VOLTAGE"**. More **"imbalance"** also means more **"VOLTAGE"**, more strength to move the Electrons and it will also influence the direction of the Electron Movement

Electron will move from the side with more electrons to the side with less electrons

Starting from position **A**

This Electron starts moving, to the POSITIVE CHARGED Atom on the left



CURRENT

Movement starts from **position A**. When done, it does the same at **position B**, and then **position C**, and so on, ... **Each Electron Movement creates an "Energy Spot"**

When there is a continued movement of a large number of electrons for a long period of time at high speed, the entire Closed Circuit will be filled with this moving **"Energy Spot"**, also known as the **"ELECTRIC CURRENT"**

CURRENT FLOW DIRECTION

The **SEQUENCE** of **"Energy Spot"** appearing at **position A**, then at **position B**, then at **position C**, and so on, ... is the **"CURRENT FLOW DIRECTION"**.

From the picture above, we can visually see the **"Energy Spot"** moving from the **+ve side to -ve side**.

- **CURRENT FLOW** from from Positive towards Negative
- **PHYSICAL ELECTRON** movement is the opposite, from Negative to Positive

RESISTANCE

While moving across atoms, the Electrons will also face movement **RESISTANCE** in present in our Electric Conductor Material

The **more RESISTANCE**, the **less intense CURRENT** will be.
The **less RESISTANCE**, the **more intense CURRENT** will be.

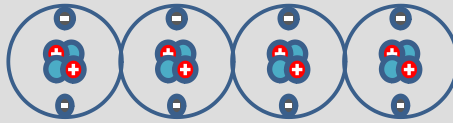
By having different resistance, we can control the intensity of **CURRENT** at a device which will change the behaviour of the device or prevent the device from damage. The amount of **RESISTANCE** can be "artificially introduced" into a closed circuit, by using a specialized conductor material (often in the form or component known as "Resistors")

Electric Conductor/Electric Components

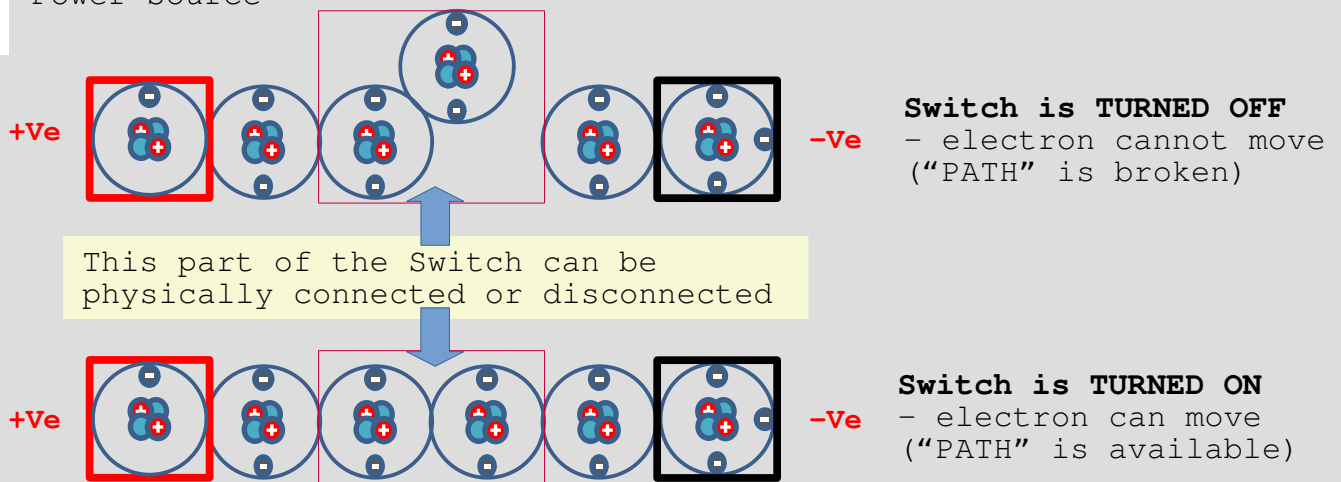
Often we associate Electric Conductors with wires

Electric Components are also a type of Electric Conductor

Unlike the wires, the Electric Components usually have some parts that will behave differently when CURRENT flow through it



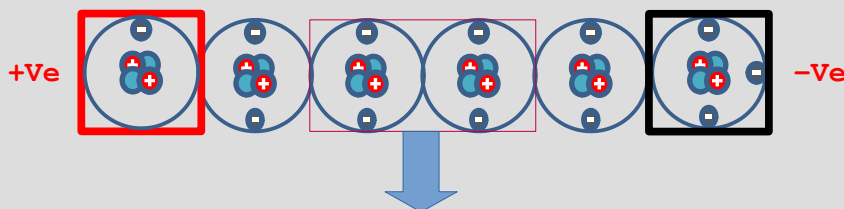
Electric Component Example: **ON/OFF Switch** when placed between the Power Source



This "Electric Conductor" has the ability to be connect and disconnect the "PATH" between the atoms by mechanical means



Electric Component Example: A tungsten **Light Bulb** when placed between the Power Source



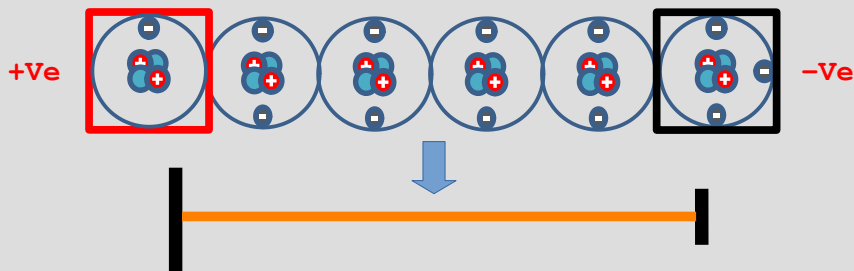
This part of the Light Bulb "Conductor" is made from thin tungsten wire

When a lot of CURRENT flow past the thin tungsten wire, it becomes very hot until it burns, fortunately tungsten wire will not melt, it just glow in burning hot, emitting lights

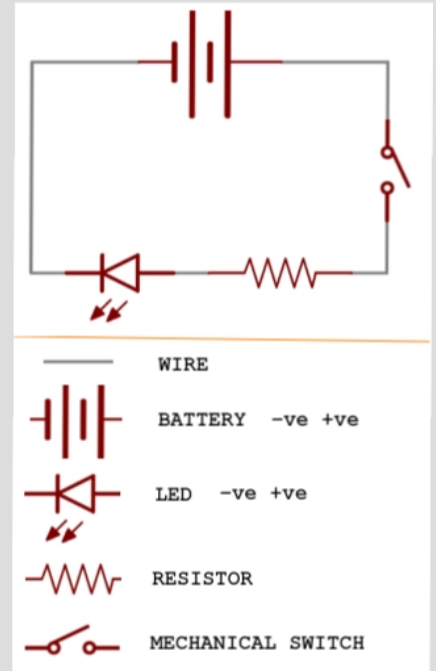
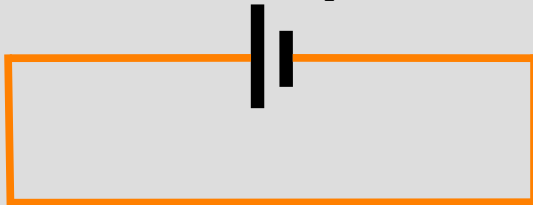
The other parts of this Light Bulb is made from different material, so they behave differently from the thin tungsten wire part

Basic Electric Circuit Diagram

Electrical Circuit is a situation where Electric Conductors are placed between the Power Source. We can place many devices on the Electrical Circuit, for the sake of keeping records or sharing the design with others. We need to draw them in a standard form, so that everyone can understand



Although the above is what really happening. Electric Circuit diagram are not drawn that way. It is normally in a "loop shape", like the one below. Both are actually the same, if we stretch out the one below, it will look exactly like the one on top.



Everyone will draw things differently, that is why an universal standard symbols are used in circuit diagrams, the picture on the right is what we normally see on circuit diagrams. (Different symbols are used for different devices)

DANGER IN A CLOSED CIRCUIT



In a Closed Circuit
Electric Current will flow for a long period of time

It is our duty to make sure that all the components in the circuit can cope with the amount CURRENT/ENERGY flowing in it, otherwise those parts that are unable to cope may end up burnt

Every Electrical Component, even a single wire has a manufacturer specification, telling us how much CURRENT that it can cope

Do not exceed the specified limits

ALSO

DO NOT CONNECT +ve and -ve Terminal of a POWER SOURCE directly without any device or "LOAD" in-between (like the picture above with just wire and POWER SOURCE). CURRENT FLOW will be too intense, something will most likely burn