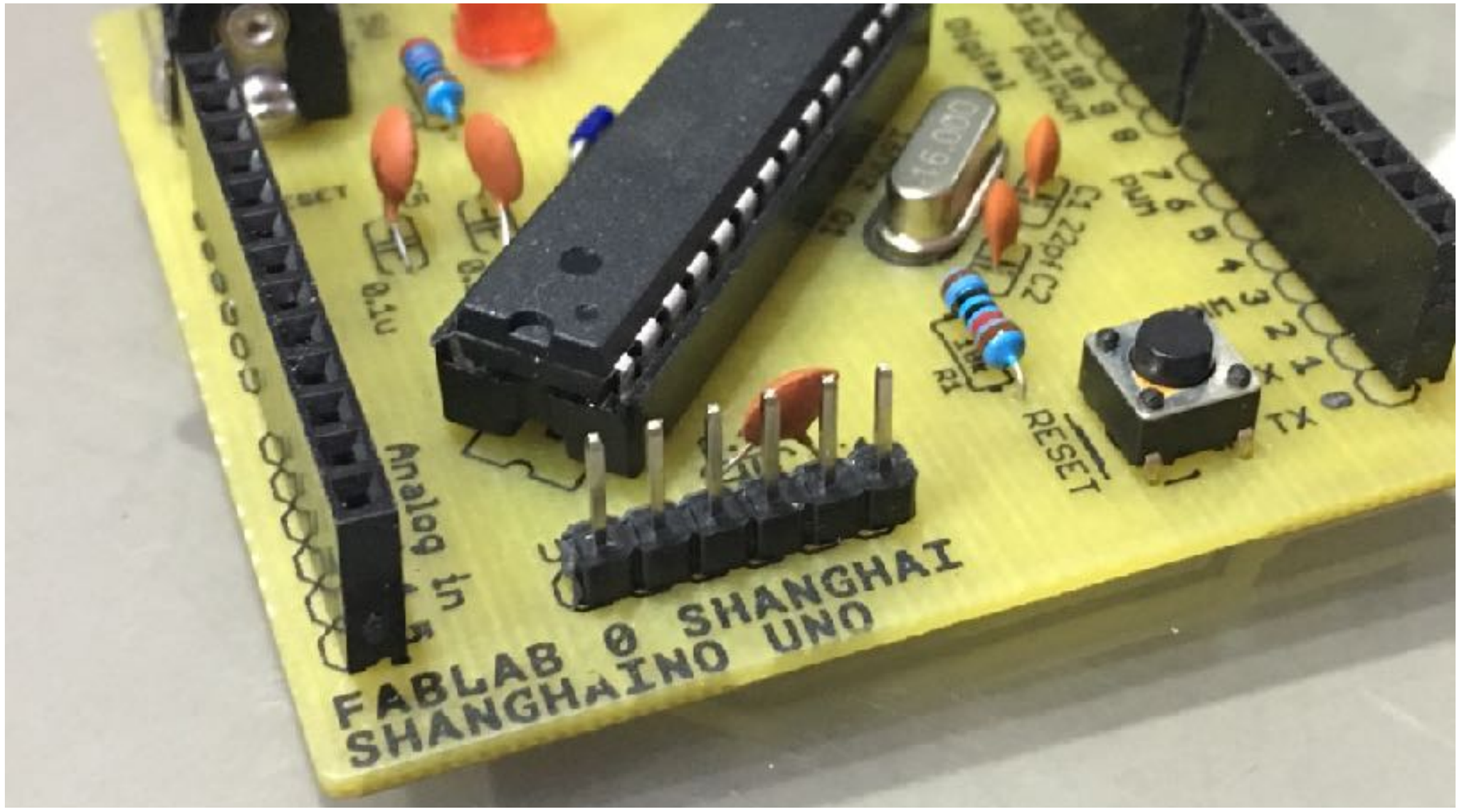
FABO ACADEMY X

ELECTRONIC PRODUCTION

FABO ACADEMY X 同济大学设计创意学院 Fabo | Shanghai

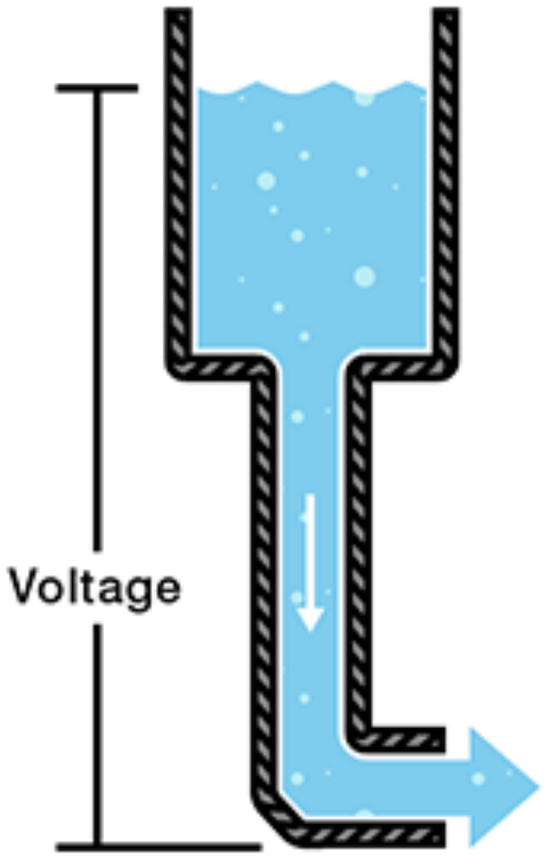


MAKING YOUR FIRST PCB

The Shanghaino is a simple but powerful PCB board. You will learn how it works, understand its components, solder it and upload the bootloader on it.

HOW DOES A CIRCUIT WORK?

The most important element is a source of electric charge (a power source) like a battery, providing an **electric potential** called **Voltage** , "**V**", measured in **Volts (V)**.

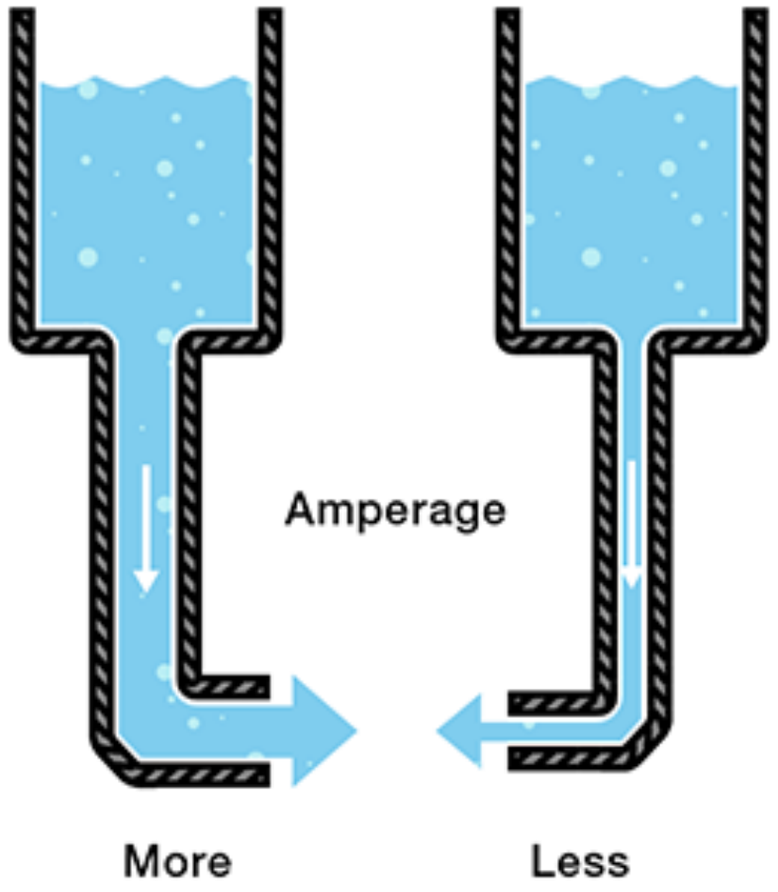


WATER ANALOGY

Electricity in a circuit is similar to water in a pipe: the voltage is like water stored in a tank

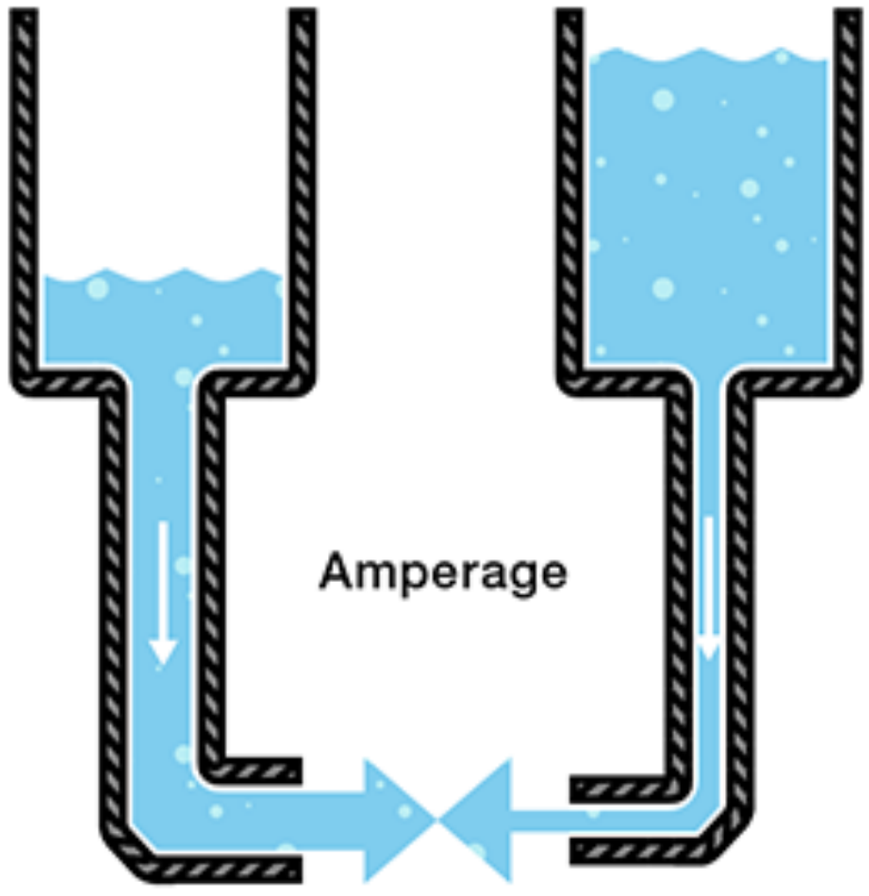
HOW DOES A CIRCUIT WORK?

If we have two water tanks with the same amount of water (same Voltage) but with pipes of two different size, the flow of water will be different. In the larger pipe there will be more water flowing. The flow of water is like the **flow** of electrons, called **Current**, "**I**", measured in **Amperes (A).**



HOW DOES A CIRCUIT WORK?

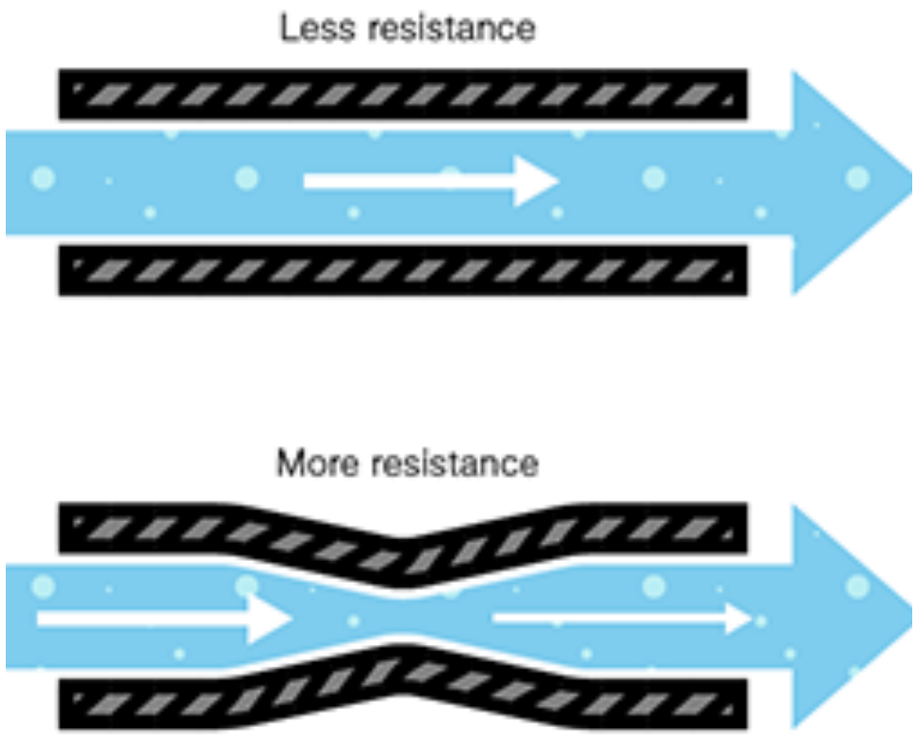
If the larger pipe is connected to a tank with less water (smaller Voltage) we can have the same amount of Current (Amperage) even if we have different Voltages.



same

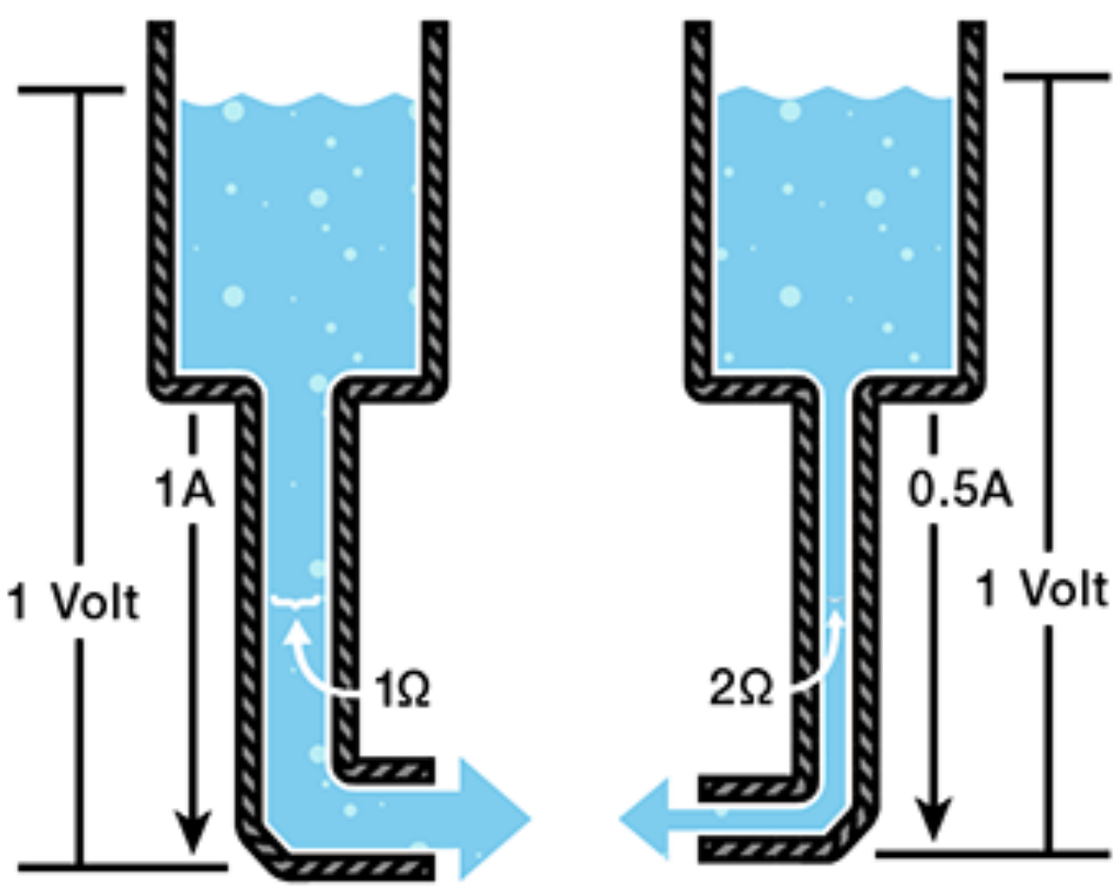
HOW DOES A CIRCUIT WORK?

We need to define the last variable: the **width** of the pipes is called **Resistance**, "**R**", measured in **Ohms (Ω)**. The resistance allows more or less current to pass in the circuit. So with the same Voltage, different Resistance values will give different values of Current.



HOW DOES A CIRCUIT WORK?

The relation between Voltage, Current and Resistance is the fundamental law for electric circuits and it is called **Ohm's Law**, by the name of the scientist who formulated it. Knowing two of the variables, you can always find the third one.

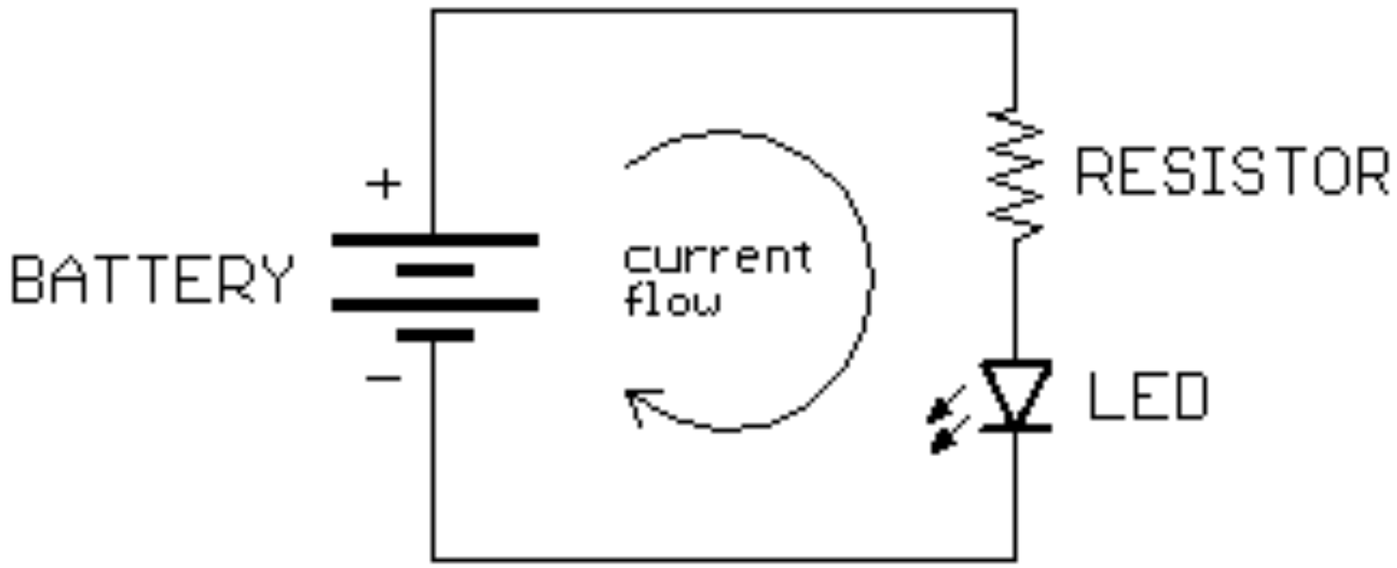


$$V = I \cdot R$$

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

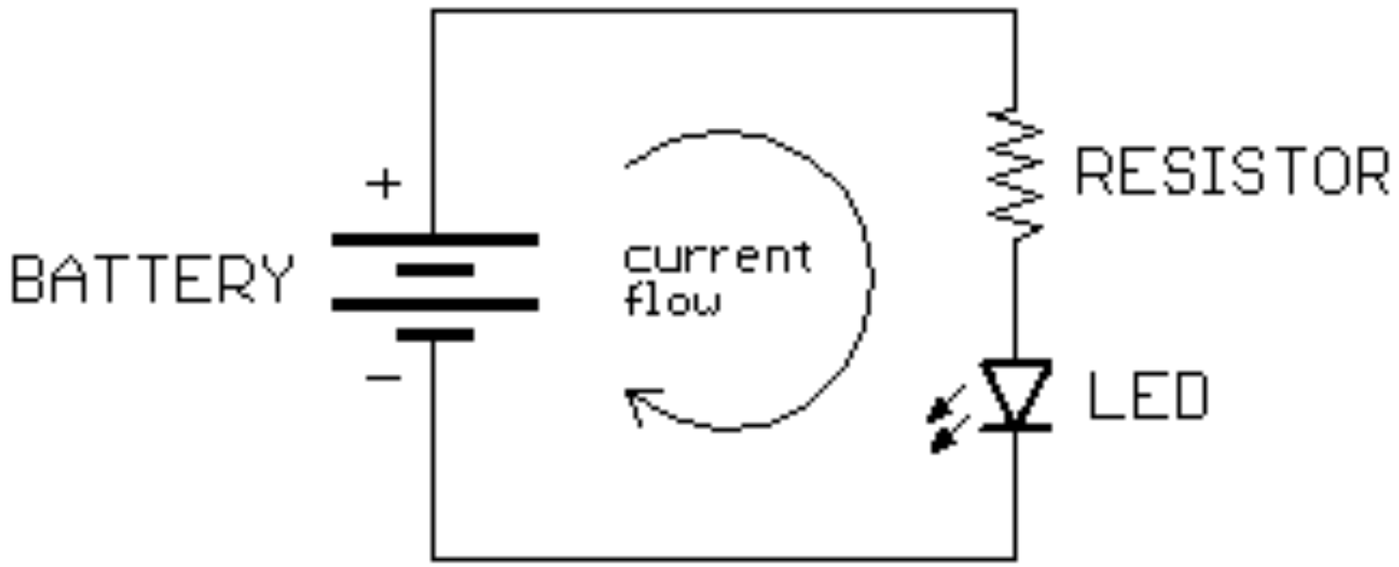
$$R = \frac{V}{I}$$

HOW DOES A CIRCUIT WORK?



A very simple circuit has a source of Voltage (a battery) with a positive side (cathode) and a negative one (anode). When the two sides are connected with a wire, the Current of electrons start flowing from “+” to “-”. In between this two sides there are all the components of the circuit, like a resistor that limits the current in the circuit and an LED that uses the energy to emit light.

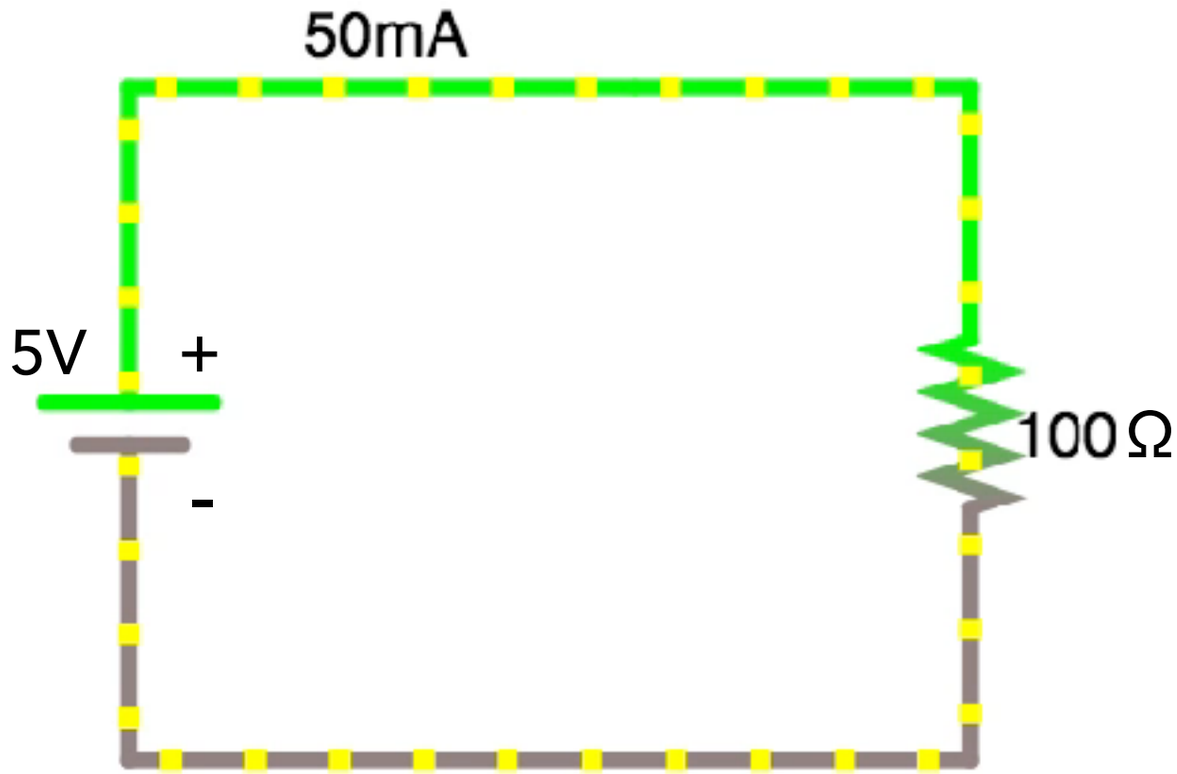
HOW DOES A CIRCUIT WORK?



Some important notes:

We say that the electrons flow from the positive to the negative side of the power source, but this convention, for historical reasons, is wrong. Infact they move the opposite way. As long as we all use the same convention, nothing changes.

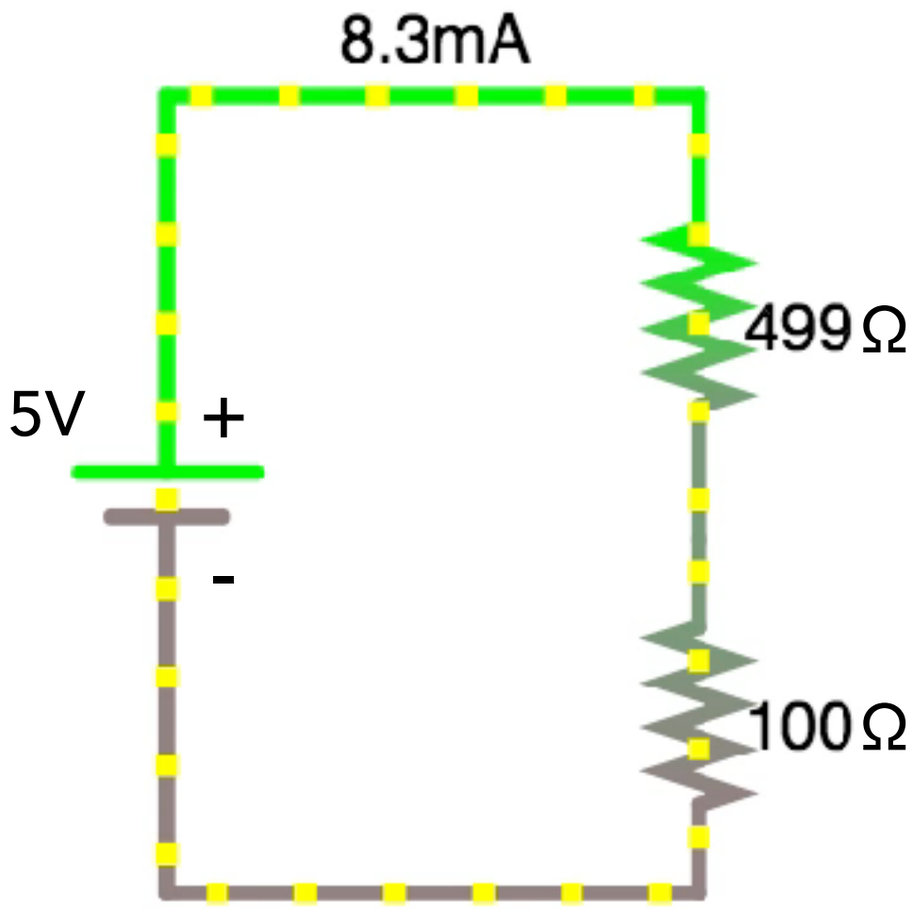
HOW DOES A CIRCUIT WORK?



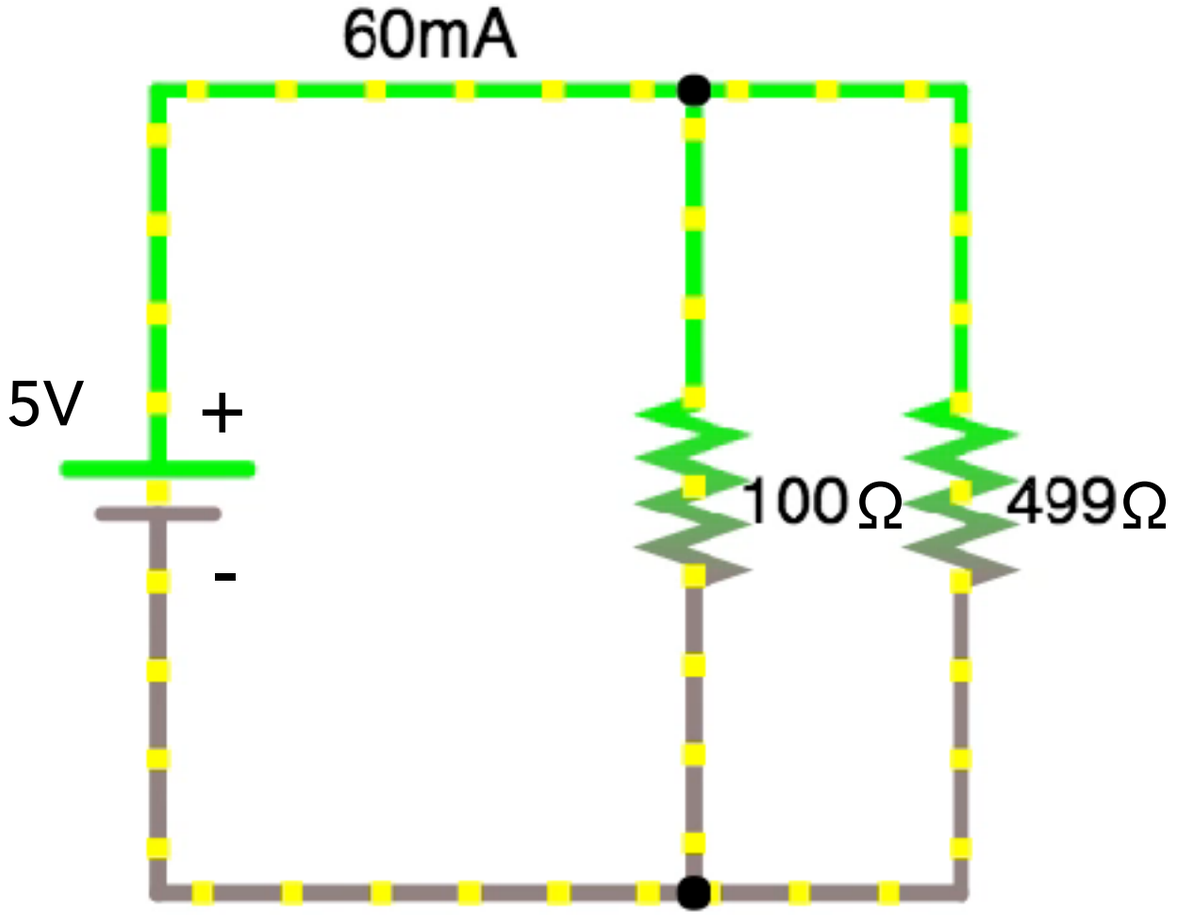
Some important notes:

Take a look at this example. There is a 5Volts power source, a 100Ohm Resistor and the yellow dots represent the flow of electrons, the Current. It is important to understand that the value of the current is the same both before and after a resistor. This is a semplification of Kirchoff's Law, but it's a key concept.

SERIES AND PARALLEL CIRCUITS

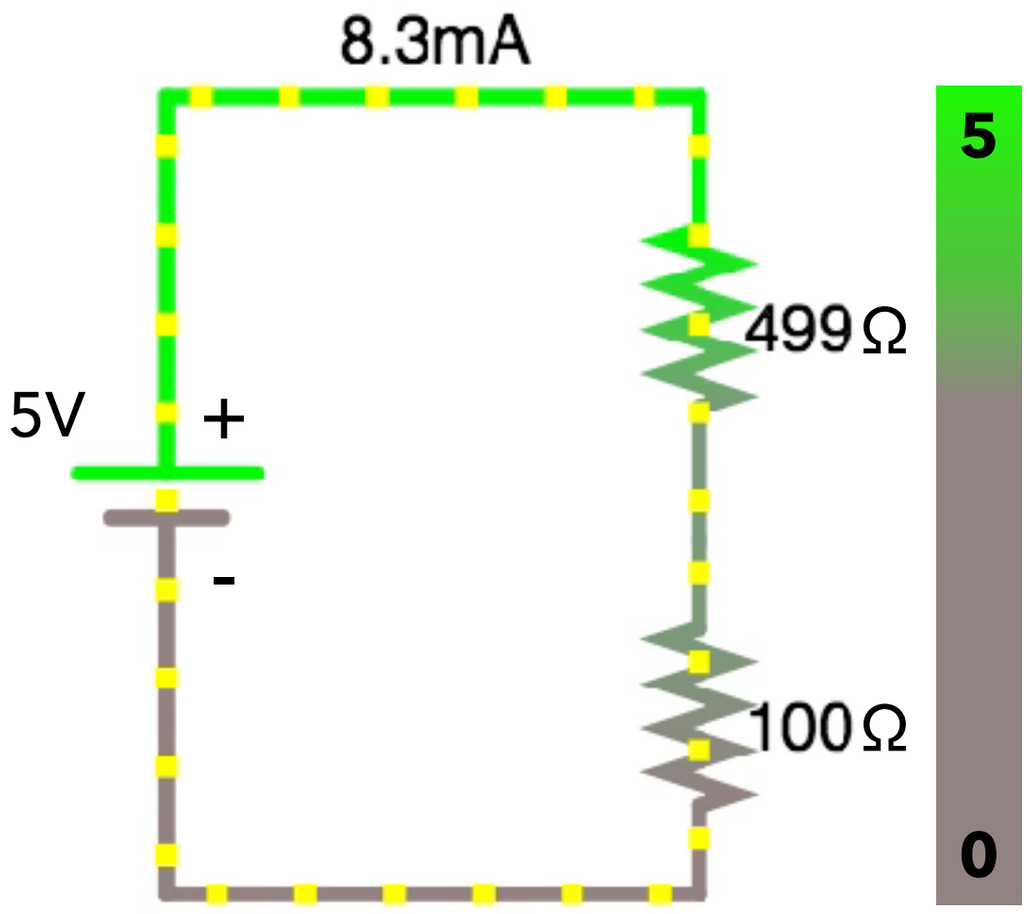


Series Circuit



Parallel Circuit

SERIES AND PARALLEL CIRCUITS



Series Circuit

Voltage Drop

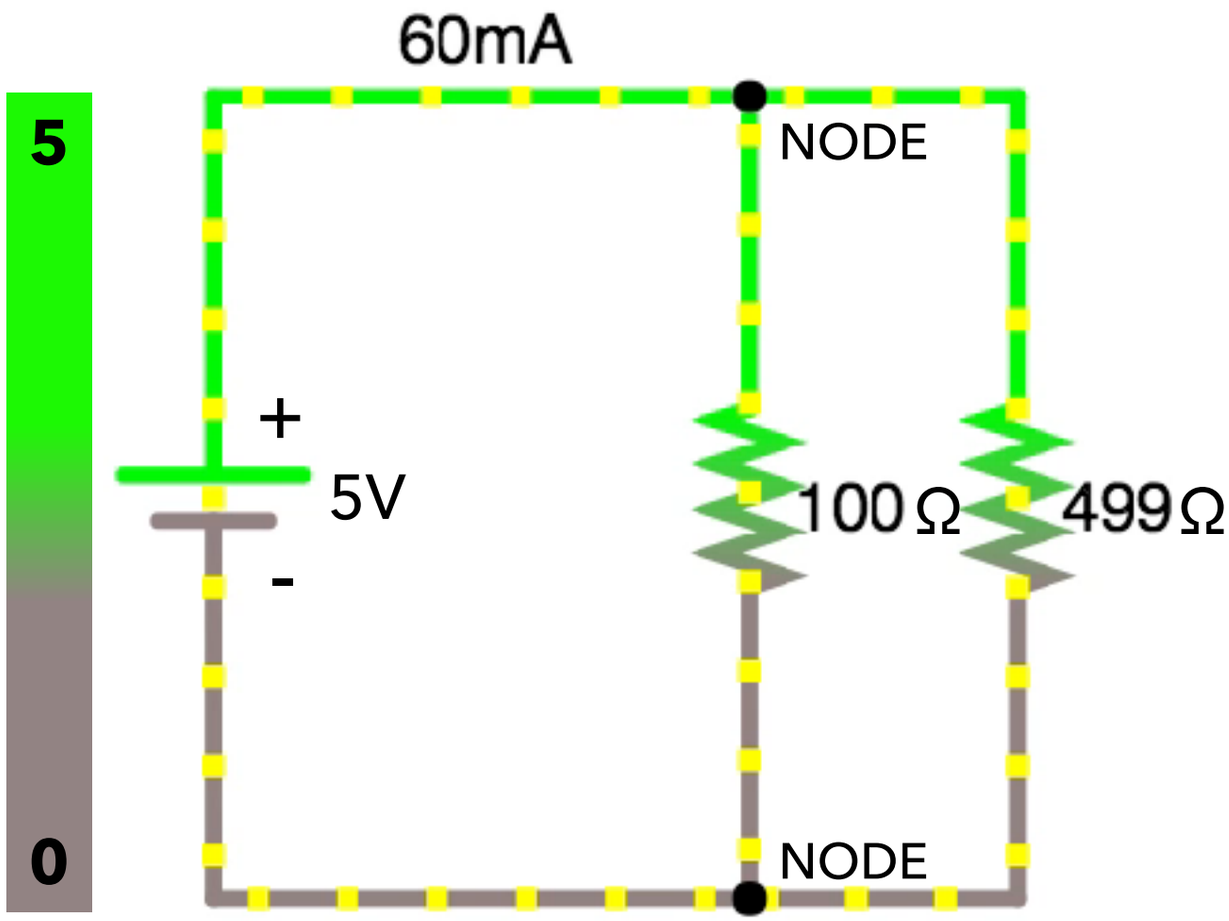
In a series circuit:

- The **voltage** has a first drop in the first component and keeps dropping in the next ones.
- The Resistor value sums up as in the following formula:

$$R_{tot} = R_1 + R_2 + ... + R_{N-1} + R_N$$

- The Current is the same all around the circuit.

SERIES AND PARALLEL CIRCUITS



Parallel Circuit

In a parallel circuit:

- The **voltage** drops in all the components with the same value.
- The Resistor value is not a simple addition:

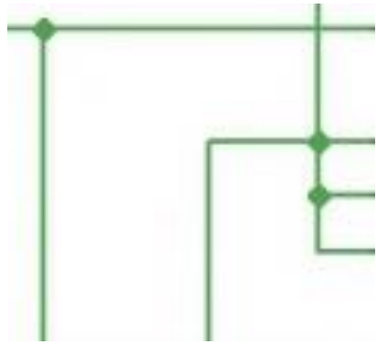
$$R_{tot} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

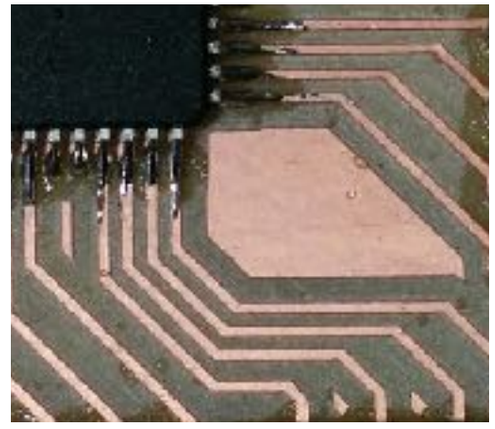
- The Current value will be different inside the node of the parallel circuit (a node is when you have three wires connected)

ELECTRONIC COMPONENTS & SYMBOLS

WIRE

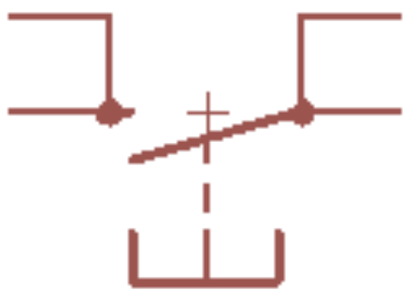
Any conductive material used to transport electrons accross a distance. The traces of a PCB are wires.





SWITCH (BUTTON)

A device that is used to interrupt a wire, opening or closing the circuit when pressed or switched.



RESISTOR

A resistor is a component with a specific electrical resistance value, expressed in Ohms. The resistor's resistance limits the flow of electrons (Current) through a circuit.

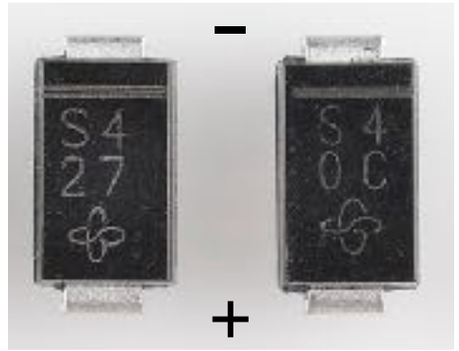
ELECTRONIC COMPONENTS & SYMBOLS

CAPACITOR

The main function of a capacitor is storing energy up to a certain value expressed in Farads (F). The capacitor can later release the energy stored if needed. It is used in an electronic circuit to suppress voltage spikes, clean a signal and as local energy storage.

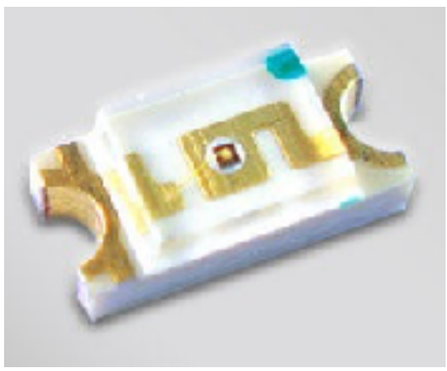
DIODE

It's function is to control the direction of current-flow. Current passing through a diode can only go in one direction. Current trying to flow the reverse direction is blocked. It has an orientation.



LED (LIGHT EMITTING DIODE)

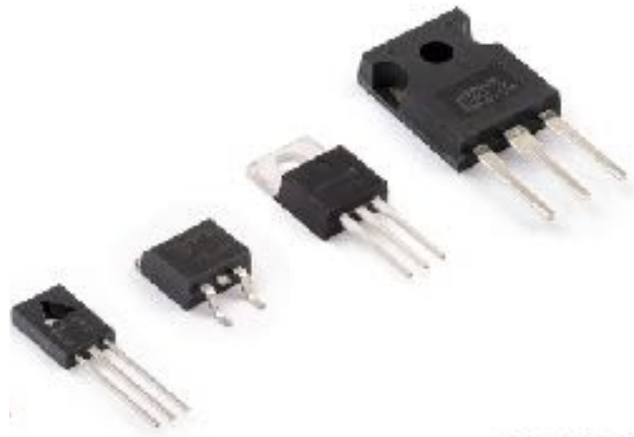
LEDs are a particular type of diode that convert electrical energy into light.



ELECTRONIC COMPONENTS & SYMBOLS

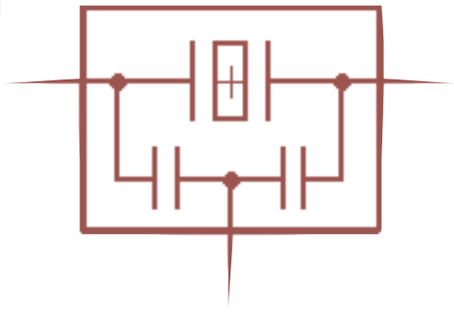
TRANSISTOR

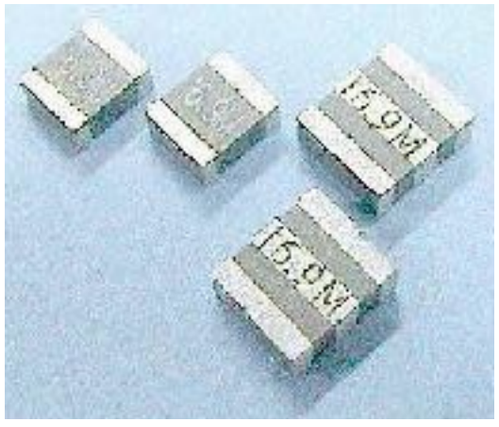
Transistors is the most important component of modern electronics. They are used as a digital switch in a variety of function.



CRYSTAL/RESONATOR

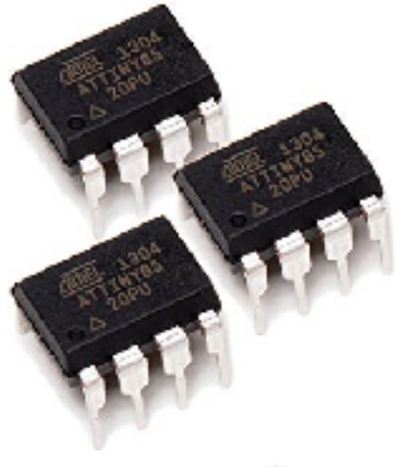
These components are also called clocks and they are like the Orchestra Director of the circuit: they emit a frequency that is used by the other components to align to the same timing.





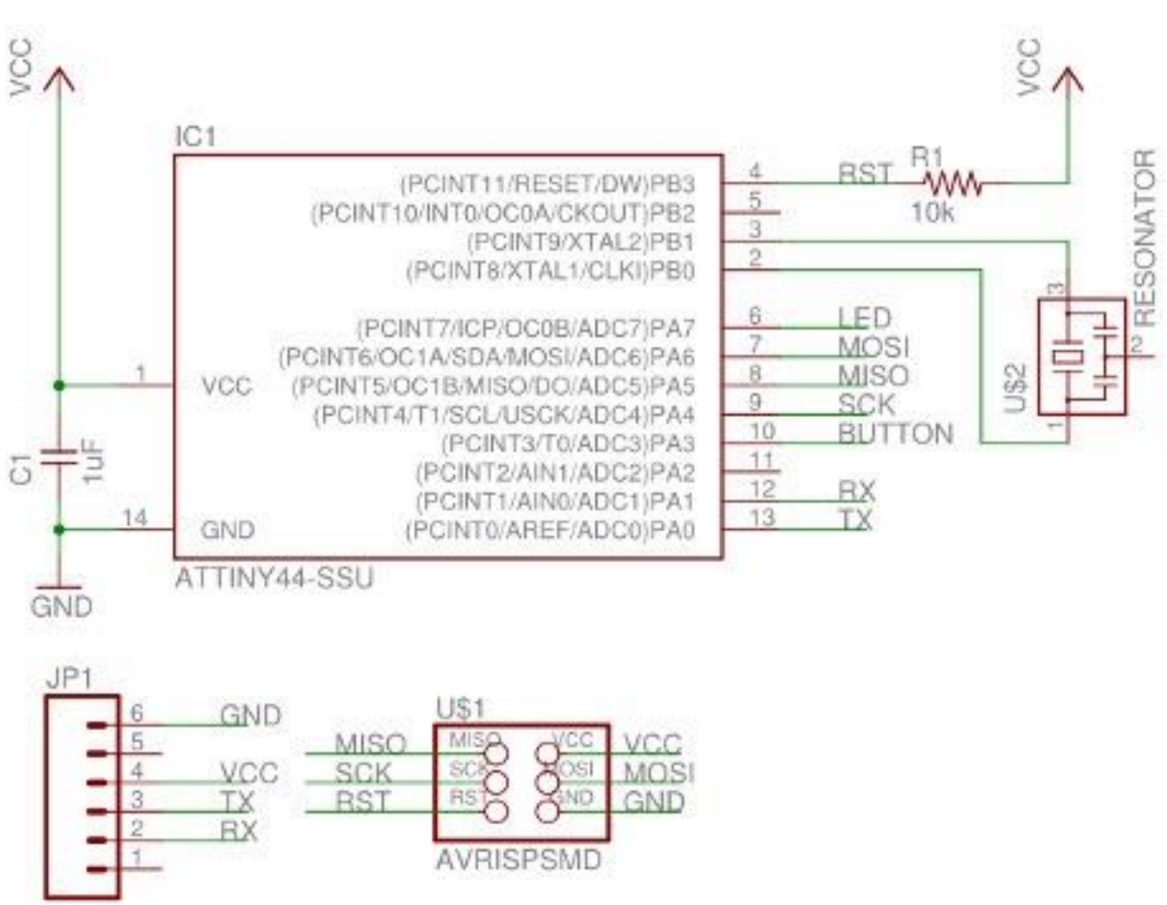
MICROCONTROLLER

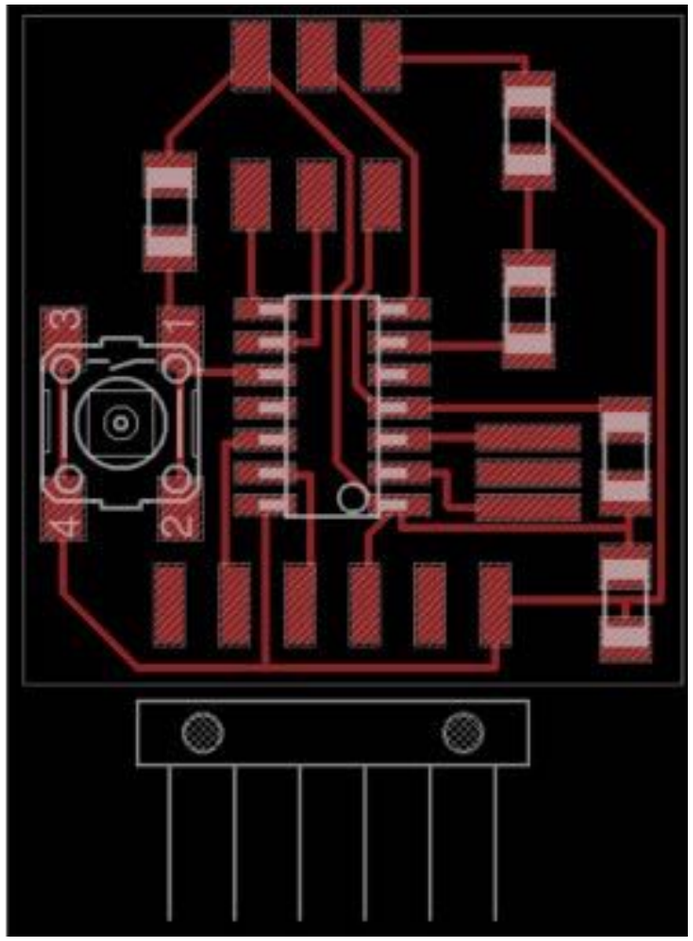
The brain of the circuit. It can be programmed to make something using its input and output pins.



PCB CAD SOFTWARE: EAGLE

Eagle is a computer aided design software for PCB. It has two workspace, the first is the **Schematic**, containing the abstract instructions on what components you need and how they are connected.
The second workspace is the **Board**, a graphic representation of the actual size, shape and disposition of the components on the board.

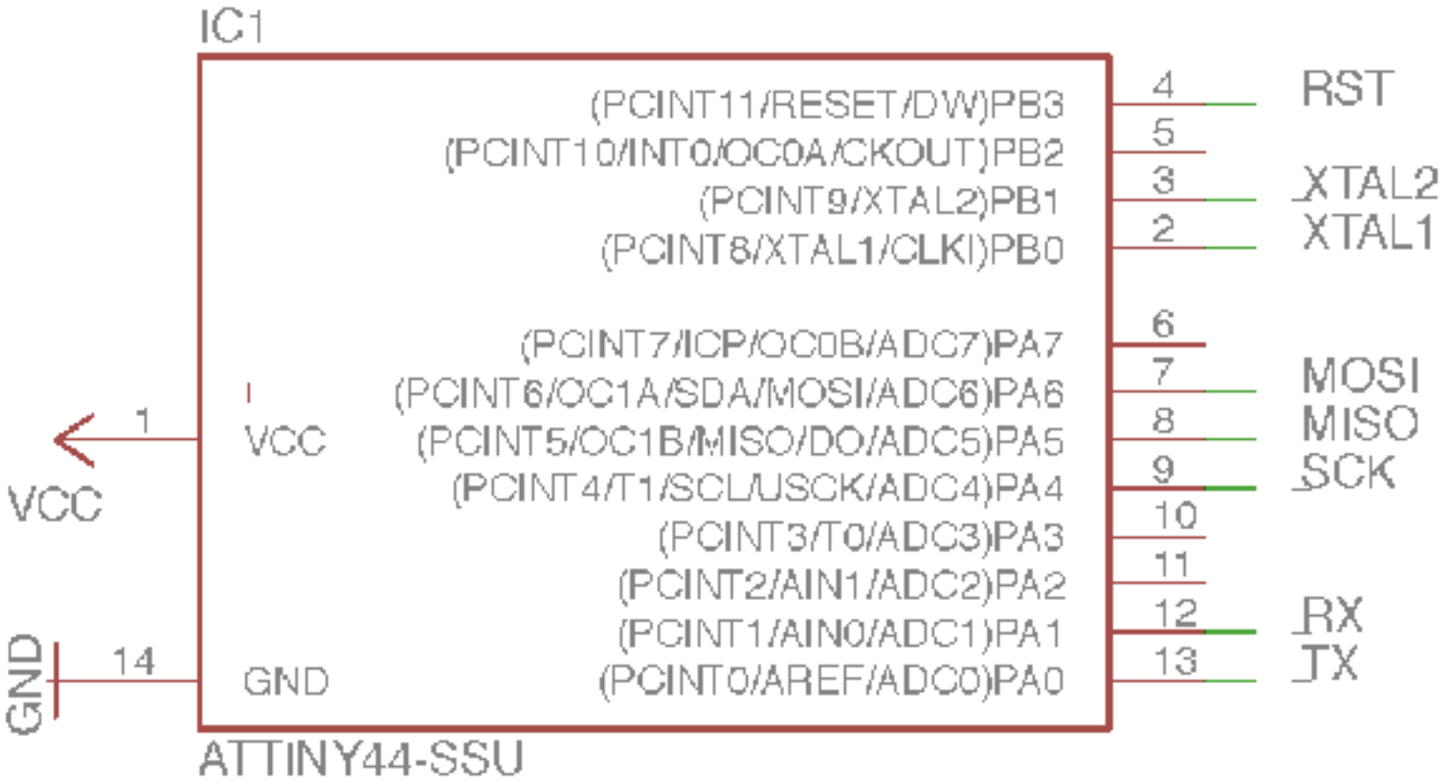




Schematic **Board**

PCB CAD: SCHEMATIC

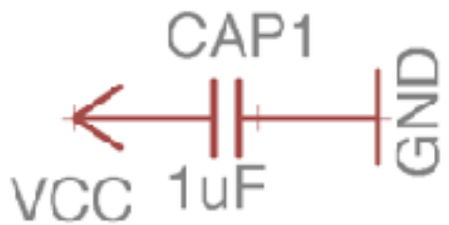
The schematic is the ingredient list of your board: all components are represented with symbols, names and values.



Microcontroller (IC, integrated circuit)
An IC is represented as a box containing the list of functions assigned to each pin of the component: you will find the description of the functions inside the datasheet of the component

10 kΩ Resistor connected to Reset pin and 5V (VCC)

1uF Capacitor connected to 5V and Ground (GND)



EXERCISE

Make a list of the Shanghaino's components and specify what they are used for. Solder all the components on the PCB. Connect it to the computer and upload a test program with Arduino IDE.