Circuit Basics and Components

Circuit Basics

Electric circuits are arrangements of conductors and components that permit electrical current to flow. A circuit can be as simple as a battery and lamp or as sophisticated as a computer.

Big ideas:

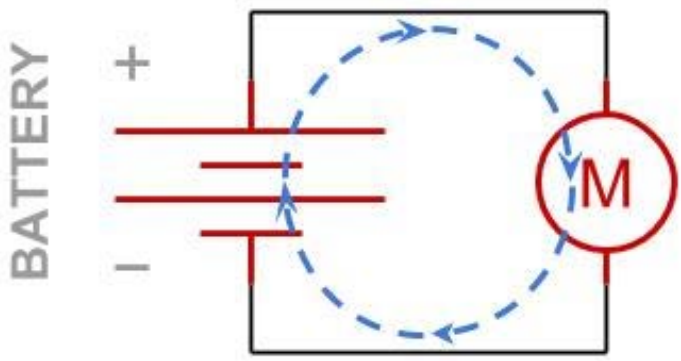
- Electrical **power** is defined by a **voltage** and a **current**.
- Electric current needs to flow in a **circuit**. The terms **open**, **closed**, and **short** circuit are used to describe special circuit conditions.
- Circuit components that are being powered make up the electric "**load**".
- Circuit elements can be arranged in a **series** or **parallel** fashion.

Voltage is a measurement of the electrical potential produced by a power source such as a battery or the utility grid connected to the wall outlet. It can be thought of as the amount of energy in the electrons. Voltage is measured in volts (V). Household batteries typically range from 1.5 V to 9 V. Electric grid power is typically at 110 V.

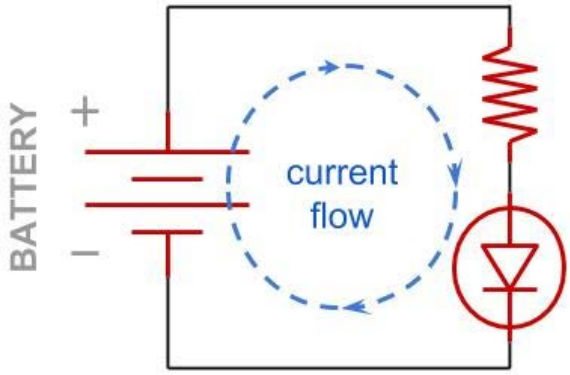
Current is the flow of electrons in a circuit, and can be thought of as the rate of electrons moving through the circuit. Current is defined as the flow of electricity from the positive (+) end of the power source to the negative (-) end. It is measured in amperes (A). Some approximate current measures are: small lamp with a 3V battery: 0.1 A, laptop computer: 2 A, vacuum cleaner: 10 A.

Electric Power can be calculated as Voltage x Current. Combining the mental models of voltage and current we see that power can be thought of as the rate of energy moving through the circuit. The units are watts (W). Electrical devices often have the power requirements written on them. Incandescent lightbulbs are often 60 W. New LED lightbulbs are typically 13 W.

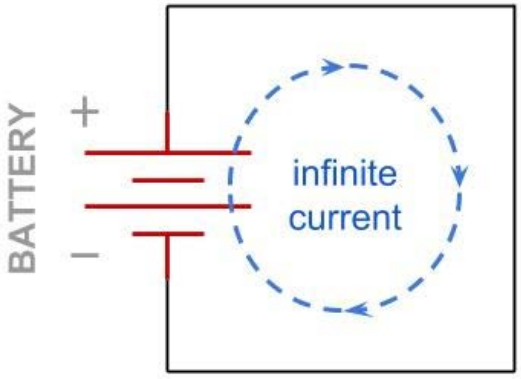
Electricity can only flow in a **circuit**. A circuit is a conductive path that starts at the positive (+) end of the power source and ends at the negative (-) end. Electronic components, like lamps and motors, can be inserted into that path and the electricity will do some work, like lighting up the lamp or spinning the motor. The **Load** in a circuit consists of the electric components that we want to power such as lights, motors, and speakers. Switches are often used to stop and start the current to the components.



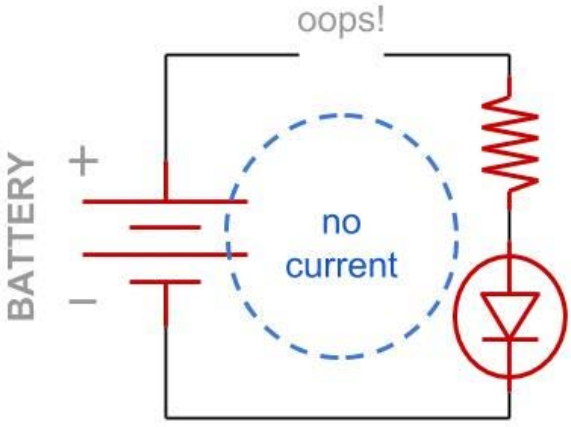
Closed Circuits are proper circuits including a power source and a set of appropriate components. In a useful circuit the load is matched to the power source. That means the power source provides the appropriate amount of voltage and current to run the desired electrical devices.



Short Circuits happen when the positive and negative ends of the battery are connected together. Sometimes this happens when the wire ends of a battery holder touch each other. In this case the batteries heat up quickly, melt the holder, and can burn a person holding it. Sometimes the short circuit is not obvious and is detected by a burning smell or components not functioning as expected. In that case, remove the power source and check the circuit.

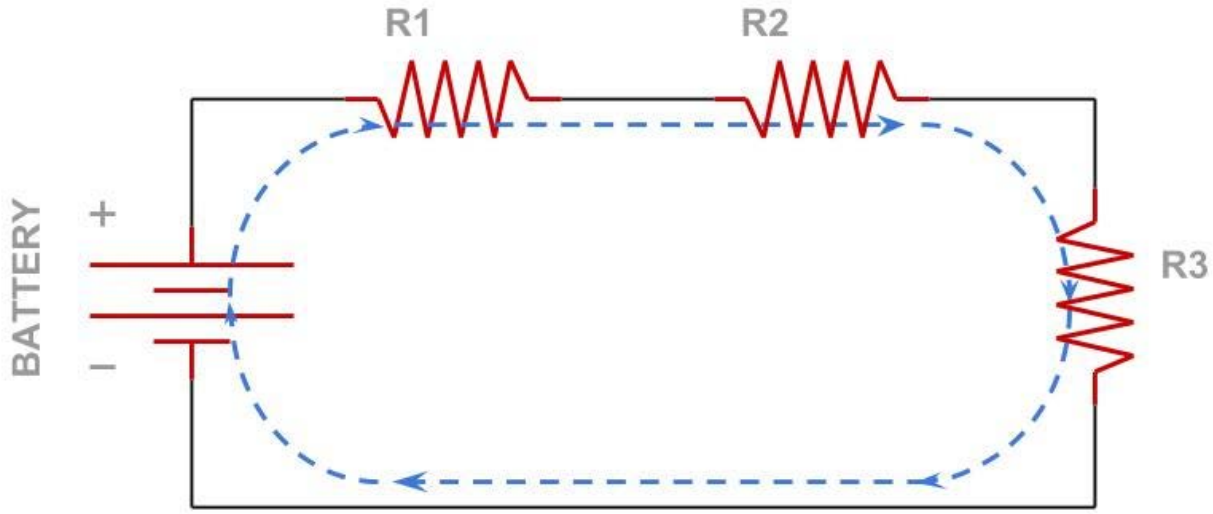


An **Open Circuit** is the opposite of a short circuit**.** This is a circuit where the loop isn't fully connected – and therefore it isn't really a circuit at all.



Series Circuits

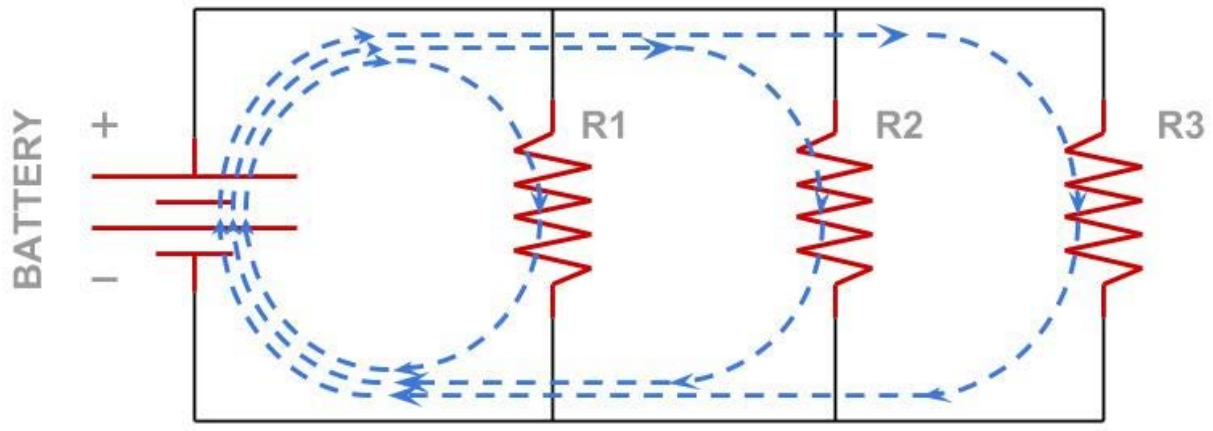
Two components are **in series** if the same current flows through them. Here's an example circuit with three series resistors:



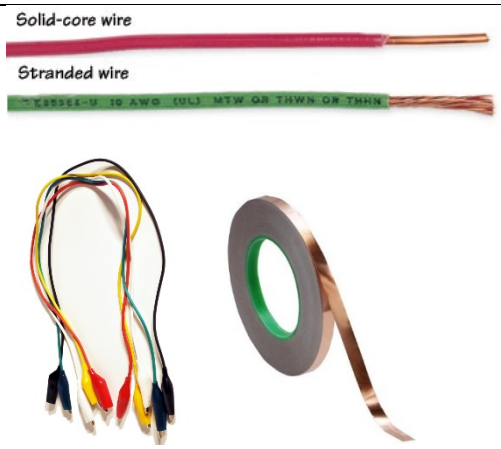
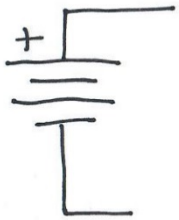
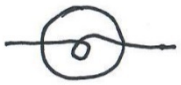
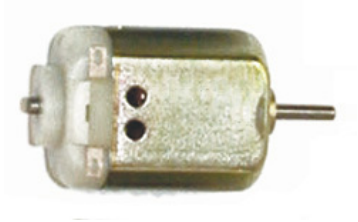
There's only one way for the current to flow in the series circuit. Current starts at the (+) end of the battery and flows through components before returning to the (-) end of the battery. Note that the current is constant through each component and the battery.

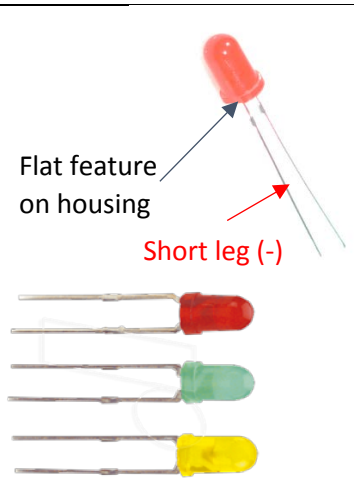
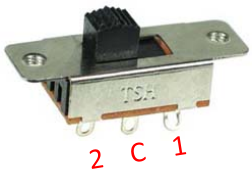
Parallel Circuits

Components are in parallel when they create separate paths for current to flow through. In parallel circuits all components in parallel all have the same voltage dropping across them, but are likely to have different currents. This example shows 3 parallel resistors. Note that the currents that go through each component sum up at the battery.

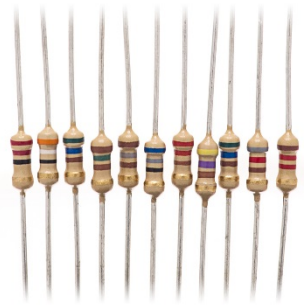


Circuit Basics and Components

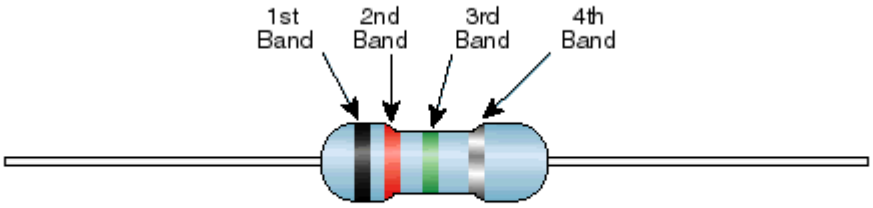
Name and Definition	Physical appearance	Schematic Symbol
Conductor: Any material, usually metal, that carries an electrical current, such as wire, alligator clips, or copper tape.		 It's really just a line!
Battery: A device that converts chemical energy into electrical energy and provides direct current (DC) power. The common household batteries (sizes AAA, AA, C, D) provide 1.5 Volts. Battery holders are often used to connect batteries in series and create higher voltages. A 9 Volt battery actually has 6 small 1.5 Volt batteries inside the case.		
Lamp: This traditional device converts electrical energy into light (and lots of heat) using a resistive filament. Increasing the voltage will increase the brightness.		
Motor: There are many types of electric motors, but all convert electrical energy into rotary motion of an output shaft. Small DC motors are usually appropriate for low-voltage electronics. These motors have output shafts that spin very fast with low torque (turning force). Gears are often used to achieve greater torque and lower rotation speeds.		

LED: Light Emitting Diodes are components that give off light when current goes through in the correct direction, as indicated by the "arrow" in the symbol. LEDs usually come with 1 leg longer than the other. Connect the higher voltage to the longer end for proper current flow. The negative end is also indicated a by a small flat on the bottom of the plastic housing. In circuits with 9 Volt batteries, LEDs are wired in series with a resistor to prevent them from burning out.		
Piezo Buzzer: Piezoelectric materials are special semiconductors that can be used to convert electrical energy to motion, and can also convert mechanical motion to electrical energy. The piezos used for electronics are often packaged with a small circuit board that creates an oscillating electrical signal that is then used to drive the piezo material. The frequency of the signal determines the pitch of the tone created by the device. Piezo components only work when current flows from the positive side (red wire) to the negative side (black wire).		
Switch SPST (Single Pole Single Throw): This switch serves as an On/Off switch in a circuit. The handle moves side to side to open or close the circuit. It is connected to a small conductive piece that makes contact between the Center tab "C" and tab 1 when it is over at side 1.		
Switch SPDT (Single Pole Double Throw): This switch is often used to switch power between 2 circuit paths. As the handle on this switch is moved side to side it opens one circuit and closes the other. It either closes the circuit between the Center tab C and tab 1, or C and tab 2.		

Resistor: Electronic component that slows the flow of electricity. Resistors are used in a circuit to set the electric current to a desired level. This is similar to the way that a valve is used to control the flow of water from a hose. Resistors have a color code that specifies the amount of resistance they provide.

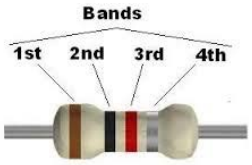


Standard EIA Color Code Table 4 Band: ±2%, ±5%, and ±10%



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Chart Provided By XICON



A 1,000 ohm resistor

Potentiometer: This device works as a variable resistor. It has 3 contact points. A resistive element goes from one outer contact, A, to the other, B. The middle contact is connected to a sliding center tap that moves along the resistive element. When the resistance between C and A decreases, the resistance between C and B increases. The total resistance between A and B remains constant.

Potentiometers are often used to control volume or brightness.