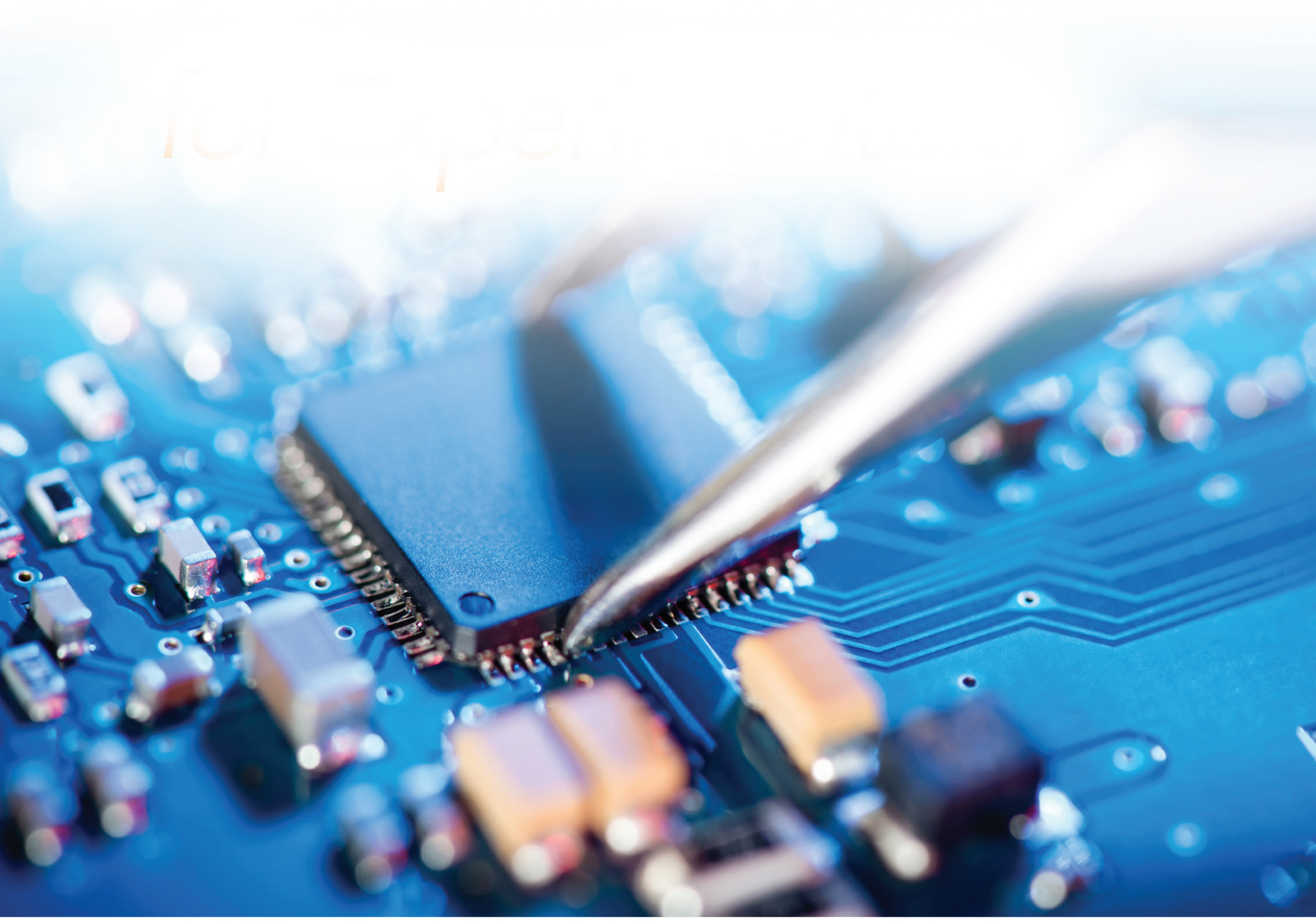
VOLUME - I

ELECTRONICS



ROBOTROD

by Olatus Systems Private Limited

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CHAPTER 1: INTRODUCTION TO BASIC ELECTRONICS

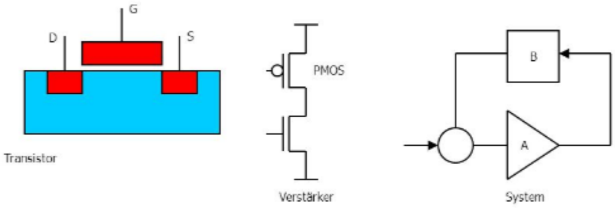
Electronics is the science of controlling electrical energy electrically, in which the electrons have a fundamental role. Electronics deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes, integrated circuits, associated passive electrical components, and interconnection technologies. Commonly, electronic devices contain circuitry consisting primarily or exclusively of active semiconductors supplemented with passive elements; such a circuit is described as an electronic circuit.

DIFFERENCE BETWEEN ELECTRICITY AND ELECTRONICS

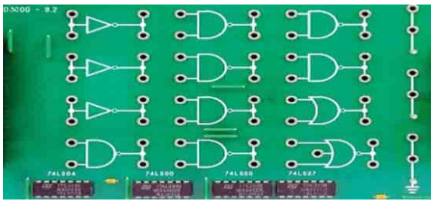
Electricity is all about making electromagnetic energy flow around a circuit so that it will drive something like an electric motor or a heating element, powering appliances such as electric cars, kettles, toasters, and lamps. Generally, electrical appliances need a great deal of energy to make them work so they use quite large (and often quite dangerous) electric currents.

Electronics is a much more subtle kind of electricity in which tiny electric currents (and, in theory, single electrons) are carefully directed around much more complex circuits to process signals (such as those that carry radio and television programs) or store and process information. Think of something like a microwave oven and it's easy to see the difference between ordinary electricity and electronics. In a microwave, electricity provides the power that generates high-energy waves that cook your food; electronics controls the electrical circuit that does the cooking.

ANALOG AND DIGITAL ELECTRONICS



Analog Electronics- Analogue electronics (also spelled analog electronics) are electronic systems with a continuously variable signal, in contrast to digital electronics where signals usually take only two levels. The term "analogue" describes the proportional relationship between a signal and a voltage or current that represents the signal. The word analogue is derived from the Greek word ανάλογος (analogos) meaning "proportional".



Digital Electronics- Digital electronics or digital (electronic) circuits are electronics that handle digital signals (discrete bands of analog levels) rather than by continuous ranges as used in analog electronics. All levels within a band of values represent the same information state.

SOURCES OF ENERGY

Sources of energy, origins of the power used for transportation, for heat and light in dwelling and working areas, and for the manufacture of goods of all kinds, among other applications. The development of science and civilization is closely linked to the availability of energy in useful forms. Modern society consumes vast amounts of energy in all forms: light, heat, electrical, mechanical, chemical, and nuclear. The rate at which energy is produced or consumed is called power, although this term is sometimes used in common speech synonymously with energy.

DC sources: Battery, Cells etc

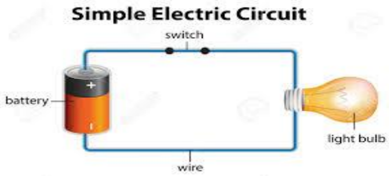
AC sources: Home wall socket

ELECTRONICS COMPONENTS

If you've ever looked down on a city from a skyscraper window, you'll have marveled at all the tiny little buildings beneath you and the streets linking them together in all sorts of intricate ways. Every building has a function and the streets, which allow people to travel from one part of a city to another or visit different buildings in turn, make all the buildings work together. The collection of buildings, the way they're arranged, and the many connections between them is what makes a vibrant city so much more than the sum of its individual parts.

The circuits inside pieces of electronic equipment are a bit like cities too: they're packed with components (similar to buildings) that do different jobs and the components are linked together by cables or printed metal connections (similar to streets). Unlike in a city, where virtually every building is unique and even two supposedly identical homes or office blocks may be subtly different, electronic circuits are built up from a small number of standard components. But, just like LEGO®, you can put these components together in an infinite number of different places so they do an infinite number of different jobs. These are some of the most important components you'll encounter:

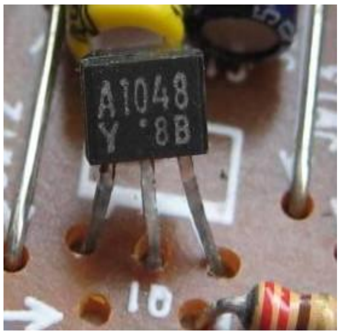
- RESISTORS - These are the simplest components in any circuit. Their job is to restrict the flow of electrons and reduce the current or voltage flowing by converting electrical energy into heat. Resistors come in many different shapes and sizes. Variable resistors (also known as potentiometers) have a dial control on them so they change the amount of resistance when you turn them. Volume controls in audio equipment use variable resistors like these.



- DIODES- The electronic equivalents of one-way streets, diodes allow an electric current to flow through them in only one direction. They are also known as rectifiers. Diodes can be used to change alternating currents (ones flowing back and forth round a circuit, constantly swapping direction) into direct currents (ones that always flow in the same direction).

- CAPACITORS- These relatively simple components consist of two pieces of conducting material (such as metal) separated by a non-conducting (insulating) material called a dielectric. They are often used as timing devices, but they can transform electrical currents in other ways too. In a radio, one of the most important jobs, tuning into the station you want to listen to, is done by a capacitor.

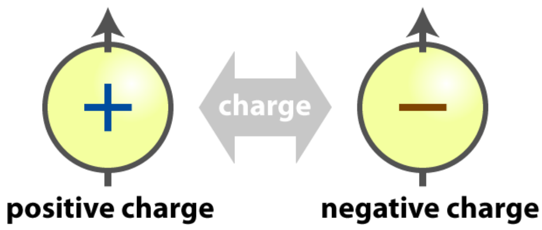
- TRANSISTORS-Easily the most important components in computers, transistors can switch tiny electric currents on and off or amplify them (transform small electric currents into much larger ones). Transistors that work as switches act as the memories in computers, while transistors working as amplifiers boost the volume of sounds in hearing aids. When transistors are connected together, they make devices called logic gates that can carry out very basic forms of decision making. (Thyristors are a little bit like transistors, but work in a different way.)



- ELECTRIC CIRCUITS- The key to an electronic device is not just the components it contains, but the way they are arranged in circuits. The simplest possible circuit is a continuous loop connecting two components, like two beads fastened on the same necklace. Analog electronic appliances tend to have far simpler circuits than digital ones.Generally speaking, the more complex the circuit, the more intricate the operations it can perform.

If you've experimented with simple electronics, you'll know that the easiest way to build a circuit is simply to connect components together with short lengths of copper cable. But the more components you have to connect, the harder this becomes. That's why electronics designers usually opt for a more systematic way of arranging components on what's called a circuit board. A basic circuit board is simply a rectangle of plastic with copper connecting tracks on one side and lots of holes drilled through it. You can easily connect components together by poking them through the holes and using the copper to link them together, removing bits of copper as necessary, and adding extra wires to make additional connections. This type of circuit board is often called "breadboard".

CHARGE



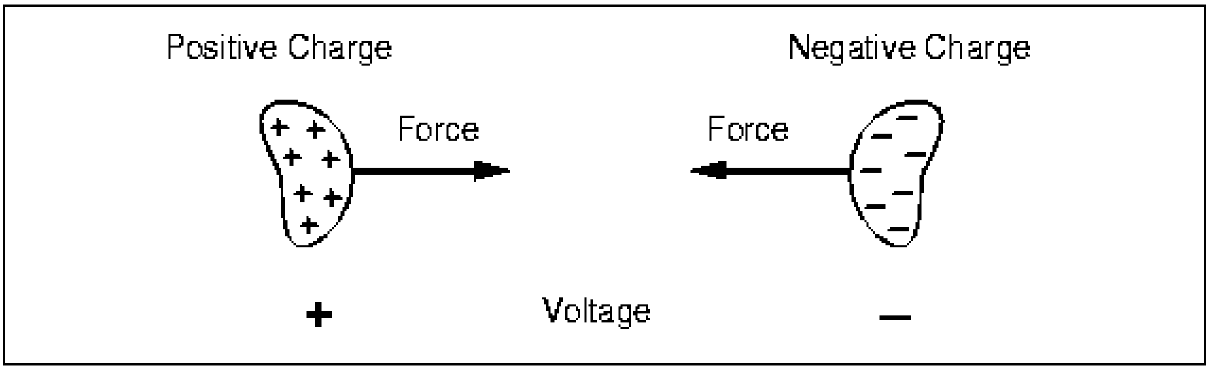
No one knows what charge really is anymore than anyone knows what gravity is. Both are models, constructions, fabrications if you like, to describe and represent something that can be measured in the real world, specifically a force. Gravity is the name for a force between masses that we can feel and measure. Early workers observed that bodies in "certain electrical condition" also exerted forces on one another that they could measure, and they invented charge to explain their observations. Amazingly, only three simple postulates or assumptions, plus some experimental observations, are necessary to explain all electrical phenomena. Everything: currents, electronics, radio waves, and light. Not many things are so simple, so it is worth stating the three postulates clearly.

CHARGE EXIST

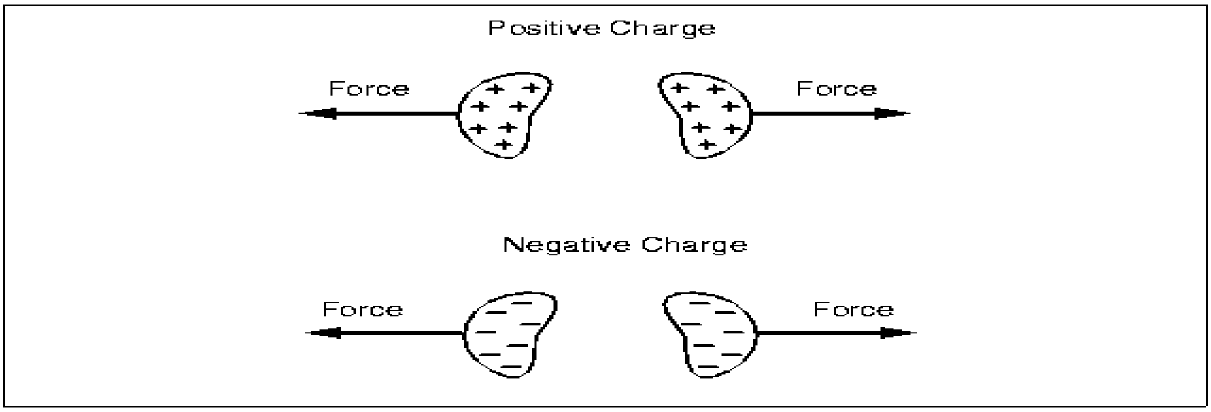
We just invent the name to represent the source of the physical force that can be observed. The assumption is that the more charge something has, the more force will be exerted. Charge is measured in units of Coulombs, abbreviated C. The unit was named to honor Charles Augustin Coulomb (1736-1806) the French aristocrat and engineer who first measured the force between charged objects using a sensitive torsion balance he invented. Coulomb lived in a time of political unrest and new ideas, the age of Voltaire and Rousseau. Fortunately, Coulomb completed most of his work before the revolution and prudently left Paris with the storming of the Bastille.

VOLTAGE

First we return to the basic assumption that forces are the result of charges. Specifically, bodies with opposite charges attract, they exert a force on each other pulling them together. The magnitude of the force is proportional to the product of the charge on each mass. This is just like gravity, where we use the term "mass" to represent the quality of bodies that results in the attractive force that pulls them together.

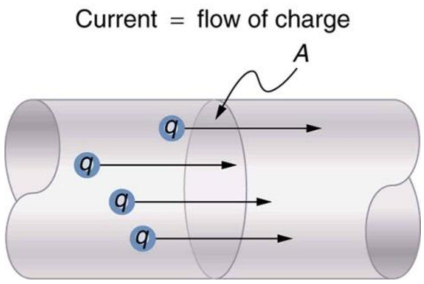


Electrical force, like gravity, also depends inversely on the distance squared between the two bodies; short separation means big forces. Thus it takes an opposing force to keep two charges of opposite sign apart, just like it takes force to keep an apple from falling to earth. It also takes work and the expenditure of energy to pull positive and negative charges apart, just like it takes work to raise a big mass against gravity, or to stretch a spring. This stored or potential energy can be recovered and put to work to do some useful task. A falling mass can raise a bucket of water; a retracting spring can pull a door shut or run a clock. It requires some imagination to devise ways one might hook on to charges of opposite sign to get some useful work done, but it should be possible.



The potential that separated opposite charges have for doing work if they are released to fly together is called voltage, measured in units of volts (V). (Sadly, the unit volt is not named for Voltaire, but rather for Volta, an Italian scientist.) The greater the amount of charge and the greater the physical separation, the greater the voltage or stored energy. The greater the voltage, the greater the force that is driving the charges together. Voltage is always measured between two points, in this case, the positive and negative charges. If you want to compare the voltage of several charged bodies, the relative force driving the various charges, it makes sense to keep one point constant for the measurements. Traditionally, that common point is called "ground."

CURRENT



The flow of charge is called current.

S.I Unit of current is Ampere (A).

There are 2 types of current:

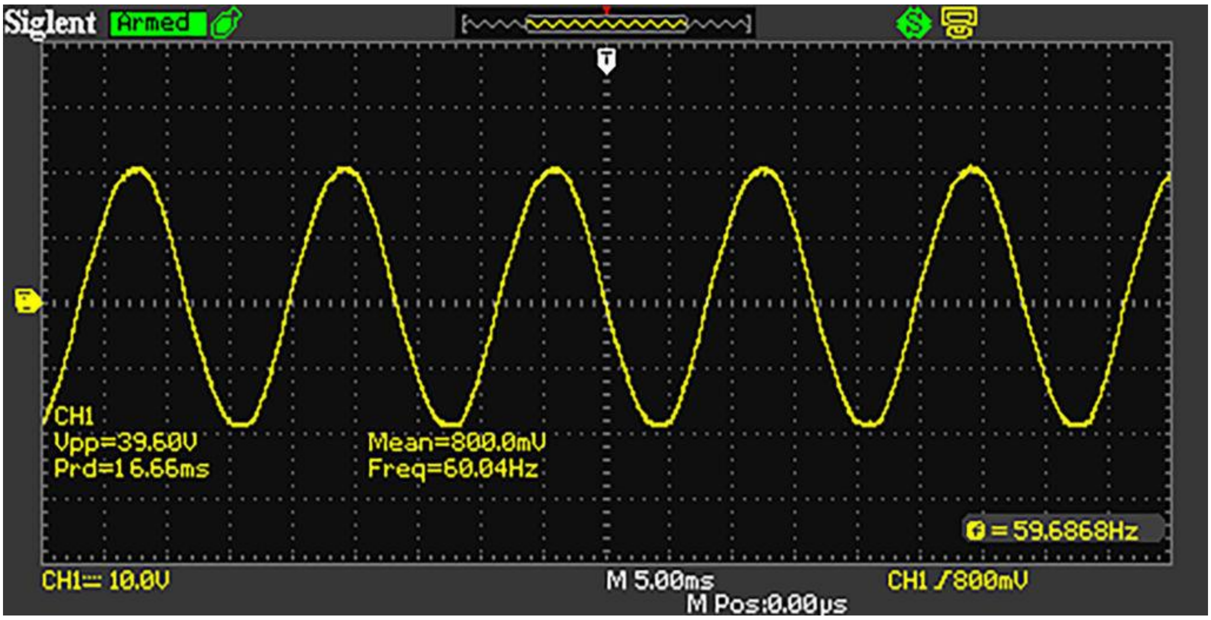
- Alternating Current
- Direct Current

ALTERNATING CURRENT

When we are talking about AC/DC, we are talking about the two different types of electrical current.

- AC (Alternating Current)

  In electricity, alternating current (AC) occurs when charge carriers in a conductor or semiconductor periodically reverse their direction of movement. Household utility current in most countries is AC with a frequency of 60 hertz (60 complete cycles per second), although in some countries it is 50 Hz. The radio-frequency (RF) current in antennas and transmission lines is another example of AC.

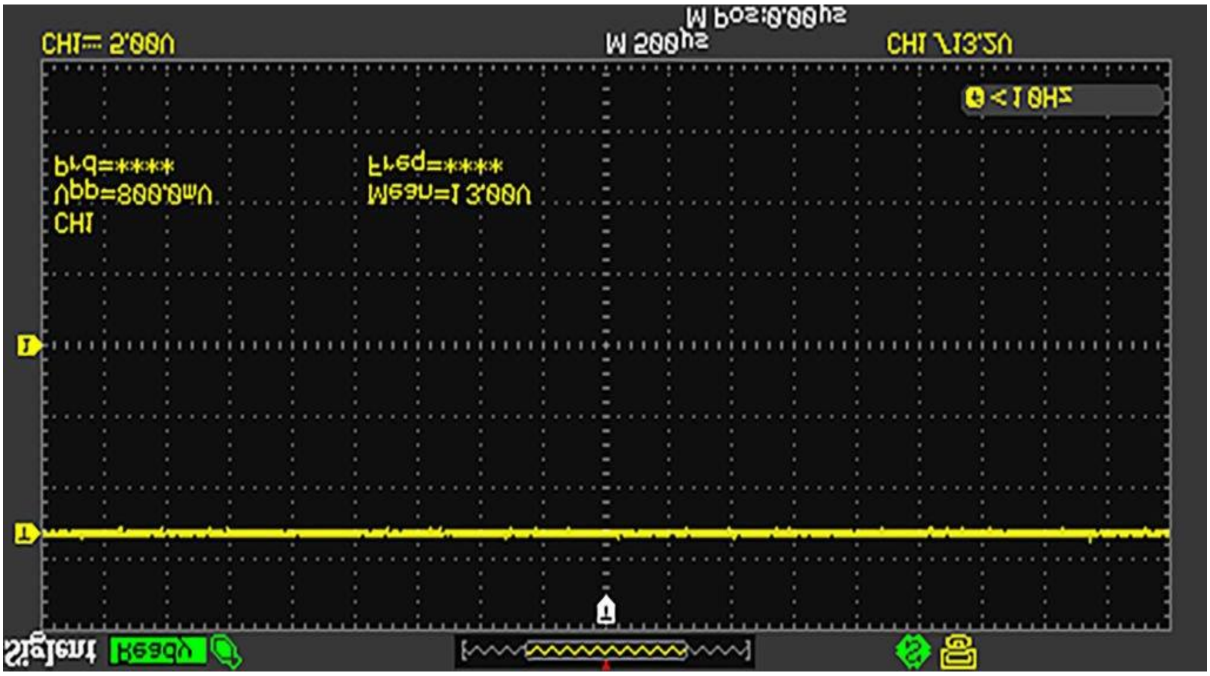


So, if you were to look at the picture of the 12V AC waveform above, you will notice that it alternates above and below the electrical ground (indicated by the little yellow marker on the left). This type of waveform consists of a current that is constantly fluctuating between a positive and a negative voltage. AC electricity is easier to transmit over long distances than other types.

- ## DC (Direct Current)

  Direct current (DC) is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, power supplies, thermocouples, solar cells, or dynamos. DC may flow in a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as in electron or ion beams. The electric current flows in a constant direction, distinguishing it from alternating current (AC). A term formerly used for this type of current was galvanic current.

- DC electricity is the type of current that comes from batteries, which are basically special containers that store a predetermined amount of voltage.
- It is so named because it travels in a direct line above ground. If you look at the waveform of a 12V DC voltage supply, you will notice that it's basically a solid yellow line running parallel above the ground. This type of electricity consists of a steady positive voltage, set apart from a ground plane.



POTENTIAL DIFFERENCE

The difference in electric potential between two points, especially two points in an electric circuit.

To understand what an electric potential is, let us consider an example. If we take a horizontal tube water does not flow in it. Now, if we connect one end of tube to a tank of water kept at higher level. Due to pressure difference between two ends of tube the tube, water starts flowing.

Similarly, the electrons move for flow of charges in a conductor if there is a difference of electric pressure called potential difference. This difference of potential is produced by a battery or cell. The chemical action within a cell produces potential difference across the terminals of cell. When a cell in connected to a conducting circuit the potential difference set the charges in motion in conductor and produces an electric current

$$Potential\ Difference = \frac{work\ done}{charge}$$

$$V = \frac{W}{Q}$$

S.I. unit of electric potential difference is Volts (V).

It is also called Voltage.

BATTERIES

Charges can be separated by several means to produce a voltage. A battery uses a chemical reaction to produce energy and separate opposite sign charges onto its two terminals. As the charge is drawn off by an external circuit, doing work and finally returning to the opposite terminal, more chemicals in the battery react to restore the charge difference and the voltage. The particular type of chemical reaction used determines the voltage of the battery, but for most commercial batteries the voltage is about 1.5 V per chemical section or cell. Batteries with higher voltages really contain multiple cells inside connected together in series. Now you know why there are 3 V, 6 V, 9 V, and 12 V batteries, but no 4 or 7 V batteries. The current a battery can supply depends on the speed of the chemical reaction supplying charge, which in turn often depends on the physical size of the cell and the surface area of the electrodes. The size of a battery also limits the amount of chemical reactants stored. During use, the chemical reactants are depleted and eventually the voltage drops and the current stops. Even with no current flow, the chemical reaction proceeds at a very slow rate (and there is some internal current flow), so a battery has a finite storage or shelf life, about a year or two in most cases. In some types of batteries, like the ones we use for the robot, the chemical reaction is reversible: applying an external voltage and forcing a current through the battery, which requires work, reverses the chemical reaction and restores most, but not all, the chemical reactants. This cycle can be repeated many times. Batteries are specified in terms of their terminal voltage, the maximum current they can deliver, and the total current capacity in ampere-hours.

Introduction to Basic Electronics

Worksheet

- Identify the sources of energy as DC or AC

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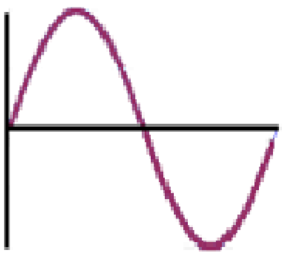
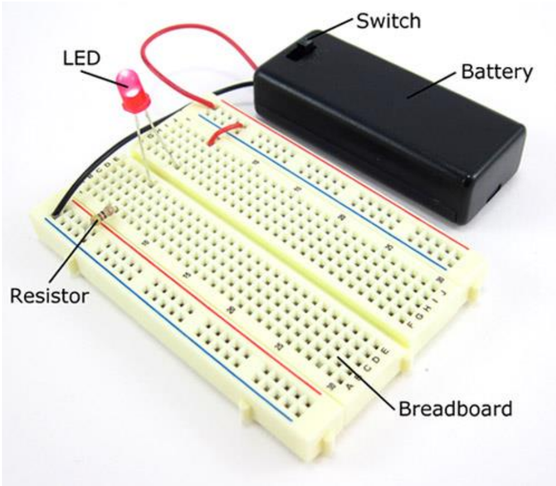
- Identify the waveform



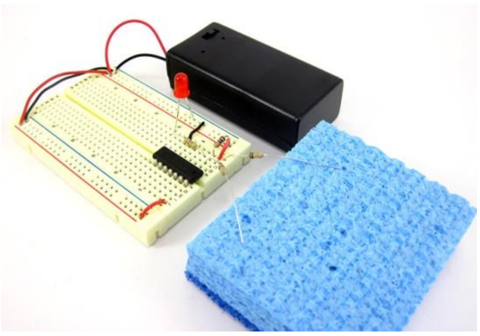
CHAPTER 2: BREADBOARD

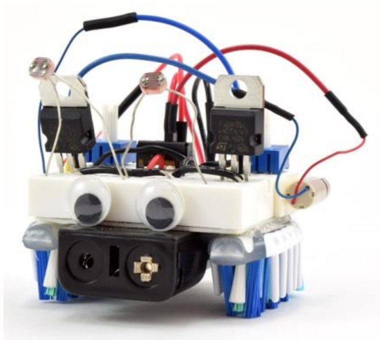
INTRODUCTION

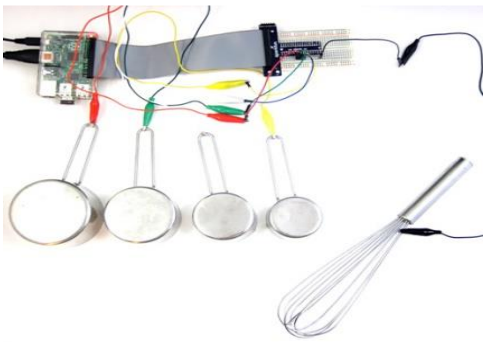
A breadboard is a rectangular plastic board with a bunch of tiny holes in it. These holes let you easily insert electronic components to prototype (meaning to build and test an early version of) an electronic circuit, like this one with a battery, switch, resistor, and an LED (light-emitting diode). To learn more about individual electronic components, see our Electronics Primer.



The connections are not permanent, so it is easy to remove a component if you make a mistake, or just start over and do a new project. This makes breadboards great for beginners who are new to electronics. You can use breadboards to make all sorts of fun electronics projects, from different types of robots or an electronic drum set, to an electronic rain detector to help conserve water in a garden, just to name a few.





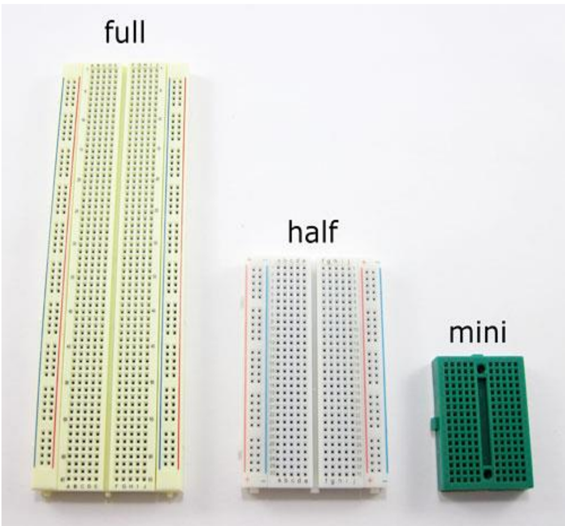


WHERE DOES THE NAME BREADBOARD COME FROM ?

You might be wondering what any of this has to do with bread. The term breadboard comes from the early days of electronics, when people would literally drive nails or screws into wooden boards on which they cut bread in order to connect their circuits. Luckily, since you probably do not want to ruin all your cutting boards for the sake of an electronics project, today there are better options.

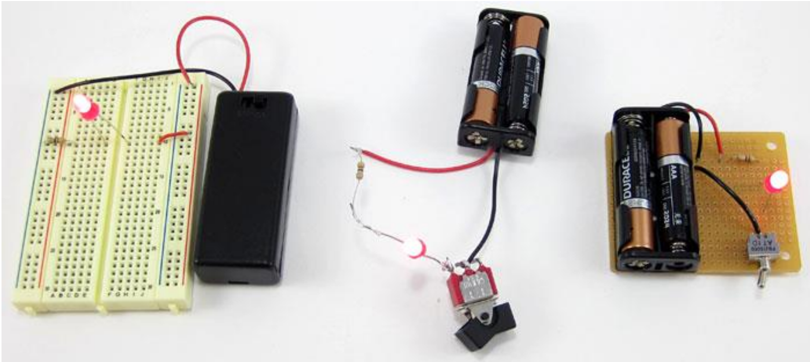
ARE THERE DIFFERENT KINDS OF BREADBOARDS?

Modern breadboards are made from plastic, and come in all shapes, sizes, and even different colours. While larger and smaller sizes are available, the most common sizes you will probably see are "full-size," "half-size," and "mini" breadboards. Most breadboards also come with tabs and notches on the sides that allow you to snap multiple boards together. However, a single half-sized breadboard is sufficient for many beginner-level projects.



SOLDER LESS BREADBOARD

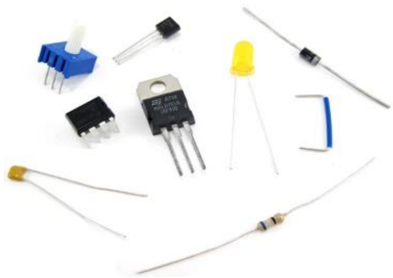
Technically, these breadboards are called solderless breadboards because they do not require soldering to make connections. Soldering (pronounced SAW-der-ing) is a method where electronic components are joined together by melting a special type of metal called solder. Electronic components can be soldered directly together, but more commonly they are soldered onto printed circuit boards (PCBs). PCBs are what you will see if you take the cover off many electronic devices, like a computer or cell phone. Frequently, engineers will use solderless breadboards to prototype and test a circuit before building the final, permanent design on a PCB. This image shows the same circuit (battery, switch, resistor, and LED) built three different ways: on a solderless breadboard (left), with the components soldered directly together (middle), and on a printed circuit board (right):



Soldering is a great technique to learn if you are interested in electronics, but the connections are much more permanent and it requires purchasing some tools to get started. The rest of this tutorial will focus on solderless breadboards, but you can read our soldering tutorial to learn more about soldering.

WHICH ELECTRONIC PARTS ARE COMPATIBLE WITH BREADBOARDS

So, how do electronic components fit into a breadboard? Many electronic components have long metal legs called leads (pronounced "leeds"). Sometimes, shorter metal legs are referred to as pins instead. Almost all components with leads will work with a breadboard (to learn more about these components and which types work with a breadboard, see the advanced section).



Breadboards are designed so you can push these leads into the holes. They will be held in place snugly enough that they will not fall out (even if you turn the breadboard upside-down), but lightly enough that you can easily pull on them to remove them.

INSIDE A BREADBOARD

The leads can fit into the breadboard because the inside of a breadboard is made up of rows of tiny metal clips. This is what the clips look like when they are removed from a breadboard.

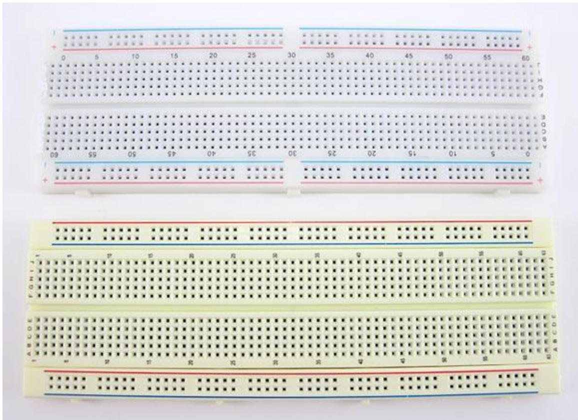
When you press a component's lead into a breadboard hole, one of these clips grabs onto it. Some breadboards are actually made of transparent plastic, so you can see the clips inside.

Most breadboards have a backing layer that prevents the metal clips from falling out. The backing is typically a layer of sticky, double-sided tape covered by a protective layer of paper.

If you want to permanently "stick" the breadboard to something (for example, a robot), you just need to peel off the paper layer to expose the sticky tape underneath. In this picture, the breadboard on the right has had its backing removed completely (so you can see all the metal clips). The breadboard on the left still has its sticky backing, with one corner of the paper layer peeled up.

ARE ALL BREADBOARDS LABELLED THE SAME WAY

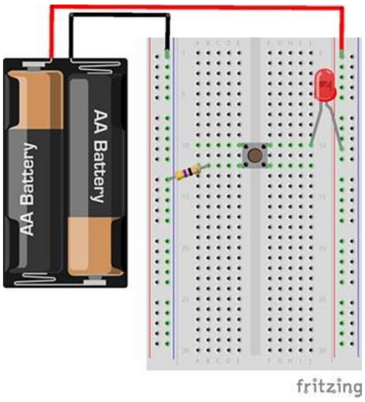
Note that exact configurations might vary from breadboard to breadboard. For example, some breadboards have the labels printed in "landscape" orientation instead of "portrait" orientation. Some breadboards have the buses broken in half along the length of the breadboard (useful if you need to supply your circuit with two different voltage levels). Most "mini" breadboards do not have buses or labels printed on them at all.

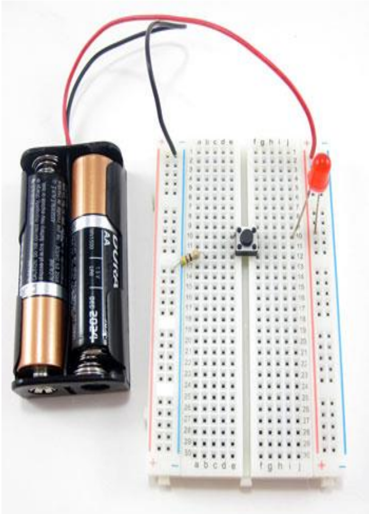


There may be small differences in how the buses are labeled from breadboard to breadboard. Some breadboards only have the colored lines and no plus (+) or minus (-) signs. Some breadboards have the positive buses on the left and the negative buses on the right, and on other breadboards, this is reversed. Regardless of how they are labeled and the left/right positions, the function of the buses remains the same.

WHAT IS BREAD BOARD DIAGRAM

A breadboard diagram is a computer-generated drawing of a circuit on a breadboard. Unlike a circuit diagram or a schematic (which use symbols to represent electronic components; see the Advanced section to learn more), breadboard diagrams make it easy for beginners to follow instructions to build a circuit because they are designed to look like the "real thing." For example, this diagram (made with a free program called Fritzing) shows a basic circuit with a battery pack, an LED, a resistor, and a pushbutton, which looks very similar to the physical circuit:





Sometimes, breadboard diagrams might be accompanied by (or replaced with) written directions that tell you where to put each component on the breadboard. For example, the directions for this circuit might say:

- Connect the battery pack's red lead to the power bus.
- Connect the battery pack's black lead to the ground bus.
- Connect the resistor from hole B12 to the ground bus.
- Insert the pushbutton's four pins into holes E10, F10, E12, and F12.
- Insert the LED's long lead into the power bus, and the short lead into hole J10.

Component	Picture	Symbol	Location
Battery pack			Red lead to (+) bus Black lead to (-) bus
LED			Long lead to (+) bus Short lead to J10
Pushbutton			Holes E10, F10, E12, F12
Resistor			Hole B12 to (-) bus

HOW DO I BUILD A CIRCUIT?

To build a circuit:

- Follow the breadboard diagram for the circuit, connecting one component at a time.
- Always connect the batteries or power supply to your circuit last. This will give you a chance to double-check all your connections before you turn your circuit on for the first time.
- Keep an eye out for common mistakes that many beginners make when using a breadboard.

PUTTING COMPONENTS IN BACKWARDS

For some electronic components, direction matters. Some components have polarity, meaning they have a positive side and a negative side that must be connected correctly. Other components have multiple pins that all serve different functions. Putting these components into your circuit backwards or facing the wrong way will prevent your circuit from functioning properly. If your circuit is not working and it involves any of these components, check to make sure they are inserted the right way

BATTERIES- Batteries have a positive terminal and a negative terminal. There are many different types of batteries, but the positive terminal is almost always marked with a "+" symbol. Typically, battery holders will have "+" and "-" symbols printed inside them; make sure the "+" symbols on your batteries line up with the "+" symbols in the battery holder.

LEDs- LEDs have a positive side (called the anode) and a negative side (called the cathode). The metal lead for the anode is longer than the lead for the cathode. The cathode side also usually has a flat edge on the plastic part of the LED.

DIODES- Diodes are like one-way valves that only let electricity flow in one direction. They are usually small cylinders marked with a band or stripe on one end (this is the direction electricity can flow toward).

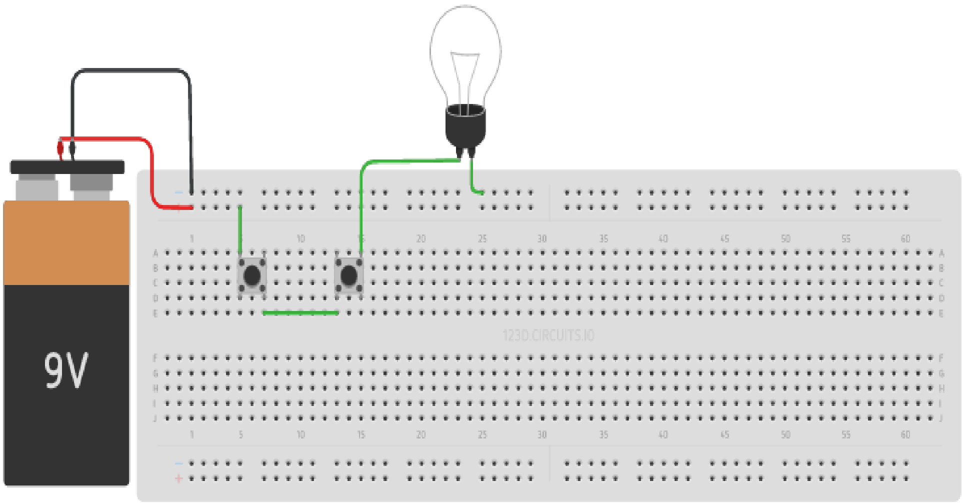
INTERGRATED CIRCUITS- Integrated circuits or ICs for short (sometimes also called “chips” are black rectangular pieces with two rows of pins. They typically have a notch or hole at one end that tells you which way is "up," so you do not put the IC in the breadboard upside-down.

Many electronic components are available in both through-hole and surface mount packages. For example, the LM3914 is an integrated circuit that is designed to drive 10 LEDs as a "bar graph" display. If you search Jameco Electronics for "LM3914", several different results come up. You can tell from looking at the thumbnails that this part is through hole and this part is surface mount. While most Science Buddies projects will link to exactly what parts you need to buy for a project, be careful if you are buying parts for your own project. If you are using a breadboard, make sure you buy through-hole parts and not surface mount.

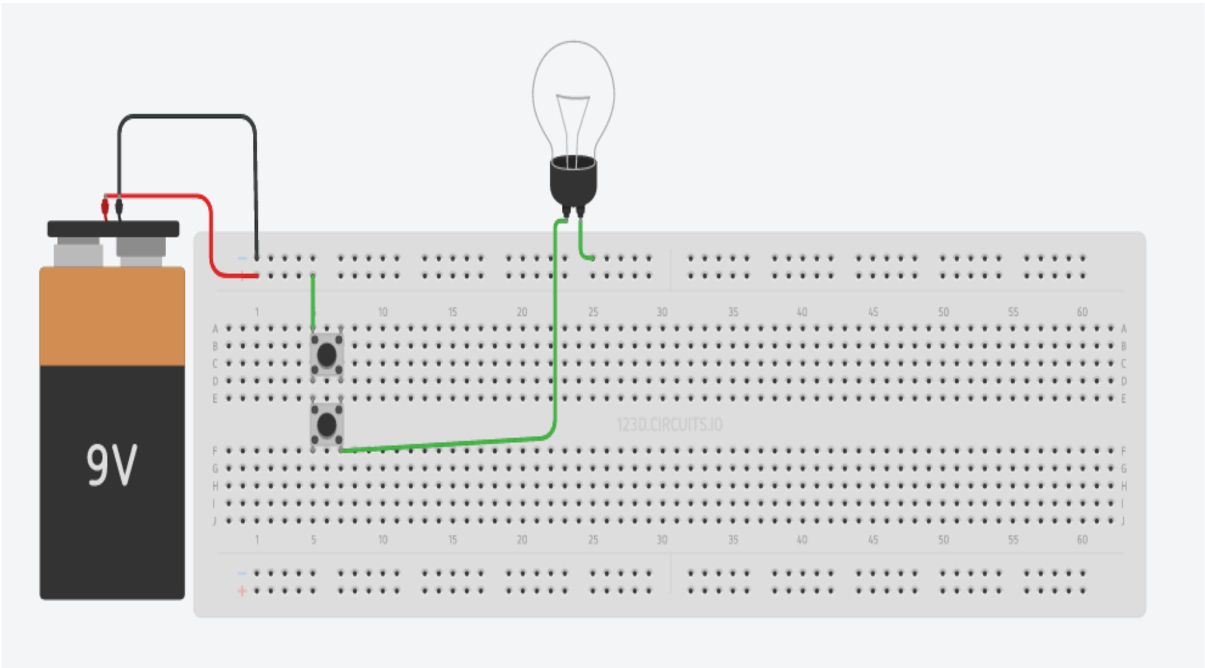
Activity

Make a Series and parallel circuit

Circuit Diagram (Series)



Circuit Diagram (Parallel)



Material Required

Name	Quantity
9V Battery	1
Pushbutton	2
Bulb	1
Breadboard	1

Instructions

For Series circuit

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now press the buttons and record your observations in the table below.

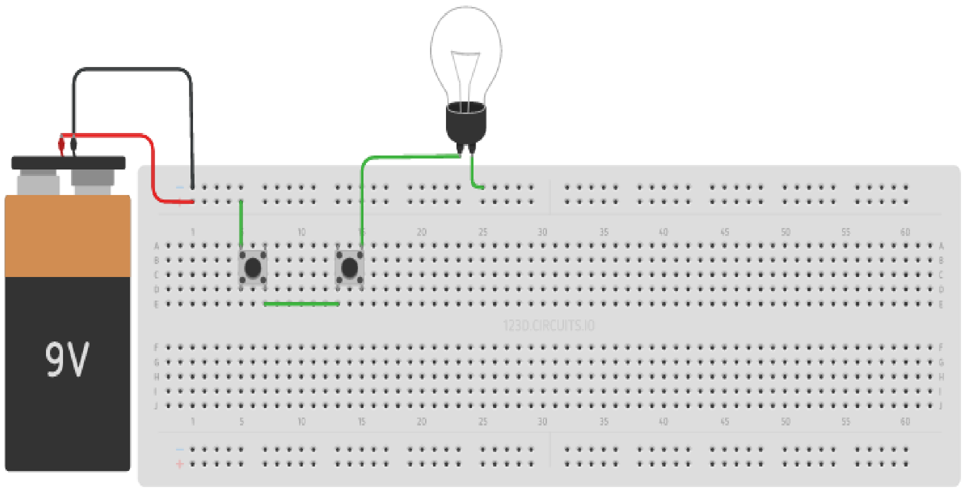
For Parallel circuit

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now press the buttons and record your observations in the table below.

ACTIVITY

Based on your Observations now answer the following Questions:

Identify the components in the circuit-



LED will light up when:

	Series	Parallel
One Button Pressed		
Both Button Pressed		

CHAPTER 3: SWITCH

INTRODUCTION TO SWITCHES

A switch is the simplest device you can imagine. It is basically a mechanical device which makes or breaks a circuit. In other words, a switch consists of two (or more) conductive terminals that can be connected or disconnected with a mechanism (such as a lever or button). Almost all electrical devices have at least one switch and they play a vital role in all electronics.

DESCRIPTION

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is nonconducting. The mechanism actuating the transition between these two states (open or closed) can be either a "toggle" (flip switch for continuous "on" or "off") or "momentary" (push-for "on" or push-for "off") type.

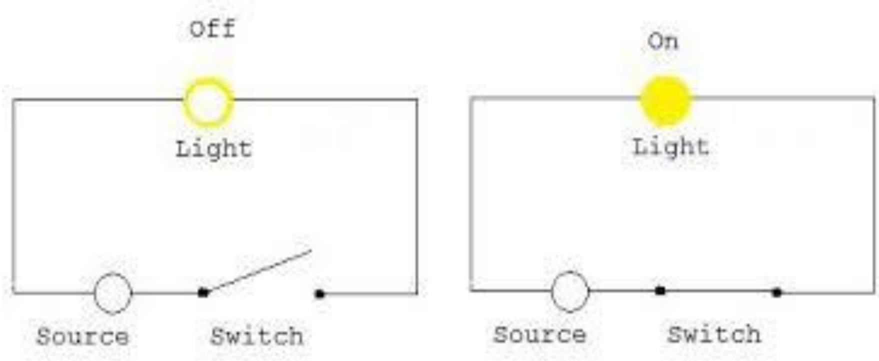
A switch may be directly manipulated by a human as a control signal to a system, such as a computer keyboard button, or to control power flow in a circuit, such as a light switch. Automatically operated switches can be used to control the motions of machines, for example, to indicate that a garage door has reached its full open position or that a machine tool is in a position to accept another workpiece. Switches may be operated by process variables such as pressure, temperature, flow, current, voltage, and force, acting as sensors in a process and used to automatically control a system. For example, a thermostat is a temperature-operated switch used to control a heating process. A switch that is operated by another electrical circuit is called a relay. Large switches may be remotely operated by a motor drive mechanism. Some switches are used to isolate electric power from a system, providing a visible point of isolation that can be padlocked if necessary to prevent accidental operation of a machine during maintenance, or to prevent electric shock.

An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating. It would have zero rise time and fall time during state changes, and would change state without "bouncing" between on and off positions.

Practical switches fall short of this ideal; they have resistance, limits on the current and voltage they can handle, finite switching time, etc. The ideal switch is often used in circuit analysis as it greatly simplifies the system of equations to be solved, but this can lead to a less accurate solution. Theoretical treatment of the effects of non-ideal properties is required in the design of large networks of switches, as for example used in telephone exchanges.

WORKING

A switch works by interrupting current flow around an electrical circuit. A basic switch is a binary device: it is either opens (off) or closed (on). The simplest type of switch is one that comprises two metal strips that are brought into contact by a spring or some other form of actuating mechanism.



As shown in the picture when the two contacts are not connected in a switch the current will not flow in the circuit and light is OFF.

When the two contacts of the switch are connected, it completes the circuit and current will flow in it and the light will be ON.

TYPES OF SWITCHES

There are 7 types of switches:

- Knife Switch
- Toggle Switch
- Light Switch
- Rocker Switch
- Slider Switch
- Push button Switch
- Tactile Switch

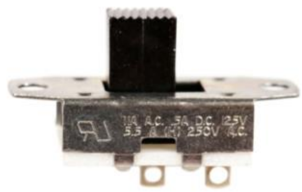
KNIFE SWITCH – Knife Switch is one of the oldest forms of switch, and likely familiar to you if you are a fan of old monster movies. It's about as simple as switches come, consisting of a metal bar with an insulated handle that bridges two (or more electrical contacts). In the switch pictures, when you lower the lever onto the terminal, it makes a connection and completes the circuit. Otherwise, no circuit is made.

TOGGLE SWITCH - Getting a bit more advanced, we have a toggle switch. This type of switch has a little lever that is toggled back and forth to activate the switch. By flicking the lever back and forth, you can make or break one or more connections.

LIGHT SWITCH - The standard light switch is basically little more than just a specialized toggle switch meant to handle a fair bit of electricity.

ROCKER SWITCH - Very similarly to the toggle switch, the rocker switch moves back and forth. Instead of being pushed back and forth, it "rocks" or pivots along its center axis. They are commonly used as power switches and are sometimes illuminated (i.e. internally light up).

SLIDER SWITCH - Just like toggle and rocker switches, the slider switch toggles back and forth. Unlike a toggle switch, the lever switch can have multiple positions to toggle between.



PUSH BUTTON SWITCH - A pushbutton switch is activated when you push down on it. These are found everywhere from elevators, to arcade machines, to game shows, to consumer products. They share the ease of mounting that we have come to know and love from the toggle switch.

TACTILE SWITCH - The tactile switch is basically just a small pushbutton switch that gets soldered directly to a circuit board. Most small electronics devices with a pushbutton interface are actually using one of these with a custom molded plastic cab on top of it.

ELECTRONIC SWITCHES

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching—often a silicon-controlled rectifier or triac.

The analogue switch uses two MOSFET transistors in a transmission gate arrangement as a switch that works much like a relay, with some advantages and several limitations compared to an electromechanical relay.

The power transistor(s) in a switching voltage regulator, such as a power supply unit, are used like a switch to alternately let power flow and block power from flowing.

Many people use metonymy to call a variety of devices "switches" that conceptually connect or disconnect signals and communication paths between electrical devices, analogous to the way mechanical switches connect and disconnect paths for electrons to flow between two conductors. Early telephone systems used an automatically operated Strowger switch to connect telephone callers; telephone exchanges contain one or more crossbar switches today.

Since the advent of digital logic in the 1950s, the term switch has spread to a variety of digital active devices such as transistors and logic gates whose function is to change their output state between two logic levels or connect different signal lines, and even computers, network switches, whose function is to provide connections between different ports in a computer network. The term 'switched' is also applied to telecommunications networks, and signifies a network that is circuit switched, providing dedicated circuits for communication between end nodes, such as the public switched telephone network. The common feature of all these usages is they refer to devices that control a binary state: they are either on or off, closed or open, connected or not connected.

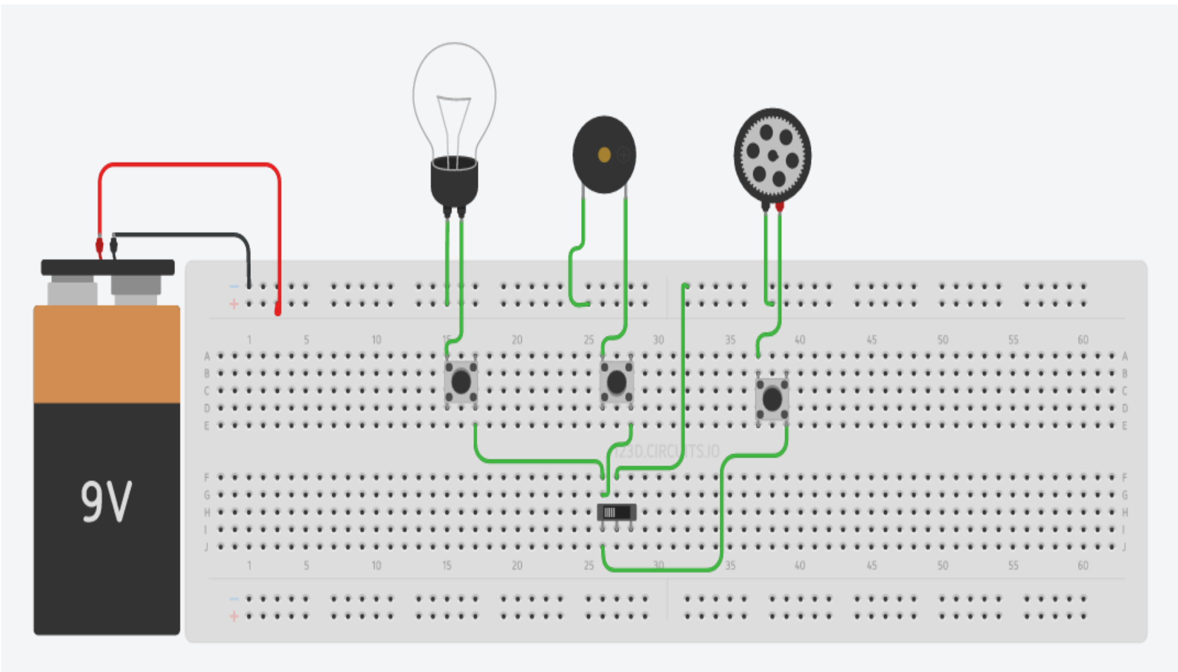
HOW DOES A SWITCH WORK ON A CIRCUIT?

The spring or actuating mechanism inside the switch pushes the metal strips together so that they touch. The switch is then said to be on, and electric current flows around the circuit. When the spring is released so that it does not push against the metal strips, the switch is open and the current flow is cut off. Switches come in many types. Toggle switches are designed to be operated by people and are some of the most common switches. A typical example of a toggle switch is a household light switch. Push-button switches are also relatively common; this type of switch uses a push-button and some type of momentary configuration to actuate the circuit. Selector switches use a rotary knob or some form of lever to actuate, and they may be built with a spring mechanism for momentary operation. Other types of switches include the joystick switch, proximity switch, speed switch and pressure switch.

Activity

Make a Power Supply Circuit using Switches

Circuit Diagram



Material Required

Name	Quantity
9V Battery	1
Pushbutton	3
Bulb	1
Breadboard	1

Motor	1
Buzzer	1
Slider switch	1

Instructions

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now press the buttons and record your observations in the table below.

Based on your Observations now answer the following Questions.

When Slider switch is on postion1.

	ON	**OFF**
Motor		
Bulb		
Buzzer		

When Slider switch is on postion2.

	ON	**OFF**
Motor		

Bulb		
Buzzer		

Explain the reason of Observations

CHAPTER 4: RESISTORS

INTRODUCTION TO RESISTOR

A resistor is an electronic component that limits the flow of electrons. In doing so, it works up a lot of energy and converts this into heat. It's a little bit like how your body heats up when you do vigorous exercise.

It provides a known amount of resistance to a circuit, and the electricity always has to do the same amount of work to get through it. The amount of resistance that a resistor offers is measured in Ohms. The symbol for ohms is the Omega symbol from the Greek Alphabet.

Ω

In terms of electronics, the resistor reduces electrical current by a precise amount. If you consider that in a circuit you typically have a fixed input voltage, and resistors offer a fixed amount of resistance, you can then use Ohm's Law to determine how much a resistor will limit current.

The resistance of any material is dictated by four factors:

1. Material property—each material will oppose the flow of current differently. 2. Length—the longer the length, the more is the probability of collisions and, hence, the larger the resistance. 3. Cross-sectional area—the larger the area A, the easier it becomes for electrons to flow and, hence, the lower the resistance. 4. Temperature—typically, for metals, as temperature increases, the resistance increases.
2. Thus, the resistance R of any material with a uniform cross-sectional area A and length is directly proportional to the length and inversely proportional to its cross-sectional area.In mathematical form,

OHM'S LAW

Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. The relation is

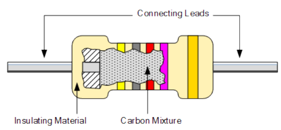
$$V = RI$$

Where, I = Current, V = Voltage, R = Resistance

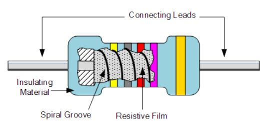
In a circuit, a resistor's symbol looks like a zigzag line.

TYPES OF RESISTORS

- Carbon Composition Resistor – Made of carbon dust or graphite paste, low wattage values



- Film or Cermets Resistor – Made from conductive metal oxide paste, very low wattage value.



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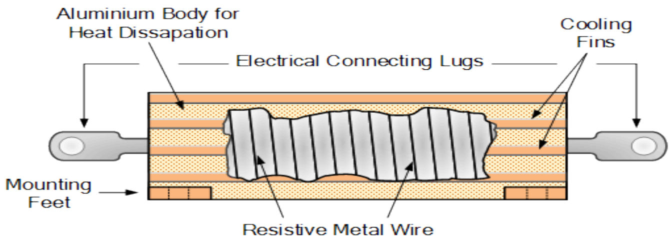
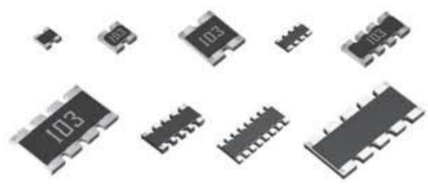
- Wire-wound Resistor – Metallic bodies for heatsink mounting, very high wattage ratings

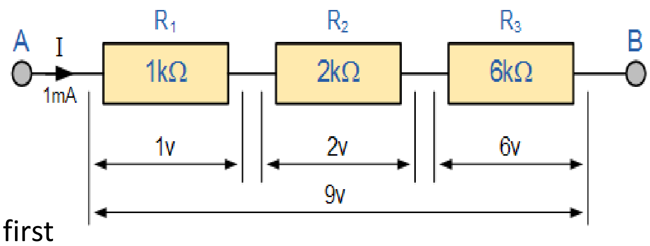



- Semiconductor Resistor – High frequency/precision surface-mount thin film technology



RESISTORS IN SERIES

Resistors are said to be connected in series when they are daisy chained together in a single line resulting in a common current flowing through them.



Since all the current flowing through the first resistor has no other way to go it must also pass through the second resistor and the third and so on. Then, resistors in series have a Common Current flowing through them as the current that flows through one resistor must also flow through the others as it can only take one path.

Then the amount of current that flows through a set of resistors in series will be the same at all points in a series resistor network.

$$IR_1 = IR_2 = IR_3 = IR_{AB} = 1mA$$

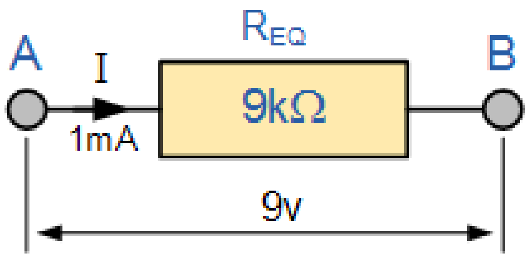
In the following example the resistors R_1, R_2, and R_3 are all connected together in series between points A and B with a common current, I flowing through them.

As the resistors are connected together in series the same current passes through each resistor in the chain and the total resistance, R_T of the circuit must be equal to the sum of all the individual resistors added together. That is

$$R_T = R_1 + R_2 + R_3$$

and by taking the individual values of the resistors in our simple example above, the total equivalent resistance, R_{EQ} is therefore given as:

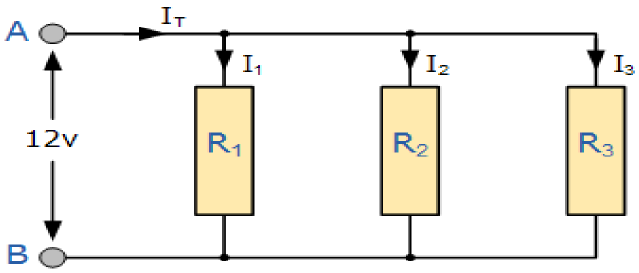
$$R_{EQ} = R_1 + R_2 + R_3 = 1k\Omega + 2k\Omega + 6k\Omega = 9k\Omega$$



Series Resistor Equation

$$R_T = R_1 + R_2 + R_3 \dots . + R_n$$

RESISTORS IN PARALLEL



In the previous series resistor network, we saw that the total resistance, R_T of the circuit was equal to the sum of all the individual resistors added together. For resistors in parallel the equivalent circuit resistance R_T is calculated differently.

Here, the reciprocal (1/R) of the individual resistance are all added together instead of the resistances themselves with the inverse of the algebraic sum giving the equivalent resistance as shown.

Parallel Resistor Equation

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_N}$$

Then the inverse of the equivalent resistance of two or more resistors connected in parallel is the algebraic sum of the inverses of the individual resistances.

HOW RESISTANCE WORKS

People who make electric or electronic circuits to do particular jobs often need to introduce precise amounts of resistance. They can do that by adding tiny components called resistors. A resistor is a little package of resistance: wire it into a circuit and you reduce the current by a precise amount. From the outside, all resistors look more or less the same. As you can see in the top photo on this page, a resistor is a short, worm-like component with colored stripes on the side. It has two connections, one on either side, so you can hook it into a circuit.

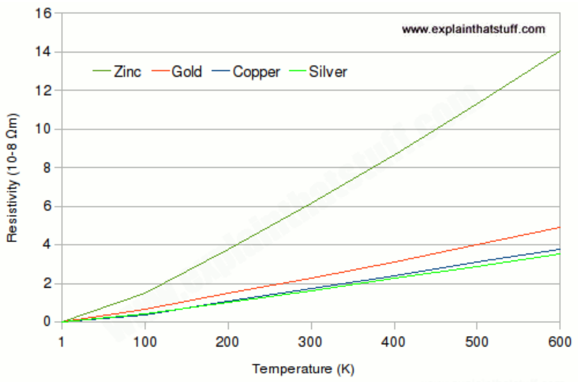
What's going on inside a resistor? If you break one open, and scratch off the outer coating of insulating paint, you might see an insulating ceramic rod running through the middle with copper wire wrapped around the outside. A resistor like this is described as wire-wound. The number of copper turns controls the resistance very precisely: the more copper turns, and the thinner the copper, the higher the resistance. In smaller-valued resistors, designed for lower-power circuits, the copper winding is replaced by a spiral pattern of carbon. Resistors like this are much cheaper to make and are called carbon-film. Generally, wire-wound resistors are more precise and more stable at higher operating temperatures.

HOW DOES THE SIZE OF A RESISTOR AFFECT ITS RESISTANCE?

Suppose you're trying to force water through a pipe. Different sorts of pipes will be more or less obliging, so a fatter pipe will resist the water less than a thinner one and a shorter pipe will offer less resistance than a longer one. If you fill the pipe with, say, pebbles or sponge, water will still trickle through it but much more slowly. In other words, the length, cross-sectional area (the area you see looking into the pipe to see what's inside), and stuff inside the pipe all affect its resistance to water.

Electrical resistors are very similar—affected by the same three factors. If you make a wire thinner or longer, it's harder for electrons to wiggle through it. And, as we've already seen, it's harder for electricity to flow through some materials (insulators) than others (conductors). Although Georg Ohm is best known for relating voltage, current, and resistance, he also researched the relationship between resistance and the size and type of material from which a resistor is made. That led him to another important equation:

$$\mathbf{R = \rho \times L / A}$$

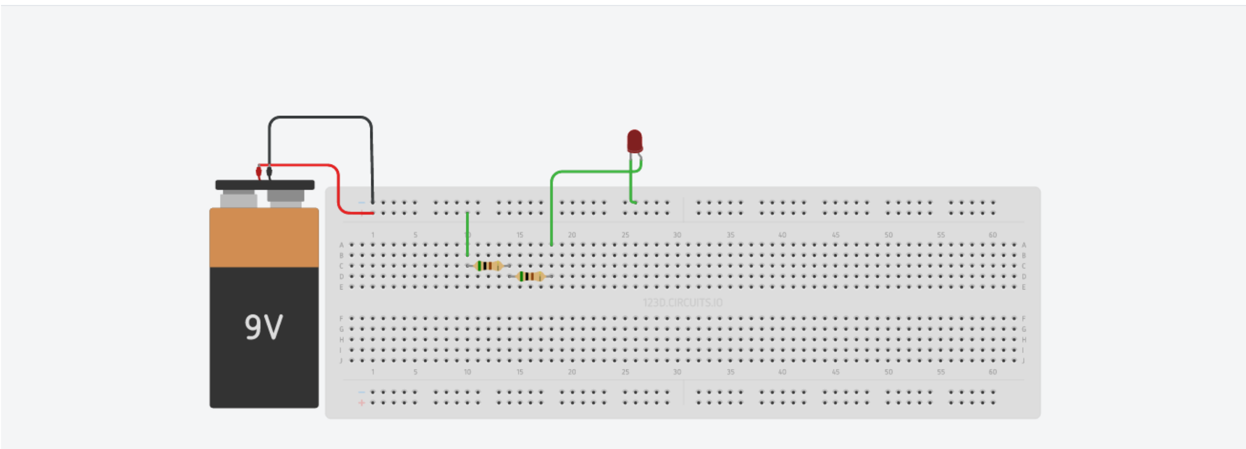


In simple words, the resistance (R) of material increases as its length increases (so longer wires offer more resistance) and increases as its area decreases (thinner wires offer more resistance). The resistance is also related to the type of material from which a resistor is made, and that's indicated in this equation by the symbol ρ, which is called the resistivity and measured in units of Ωm (ohm-meters). Different materials have very different resistivities: conductors have much lower resistivity than insulators. At room temperature, aluminum comes in at about 2.8 x 10−8 Ωm, while copper (a better conductor) is significantly lower at 1.7 −8 Ωm. Silicon (a semiconductor) has a resistivity of about 1000 Ωm and glass (a good insulator) measures about 1012 Ωm. You can see from these figures how vastly different conductors and insulators are in their ability to carry electricity: silicon is about 100 billion times worse than copper and glass is about a billion times worse again!

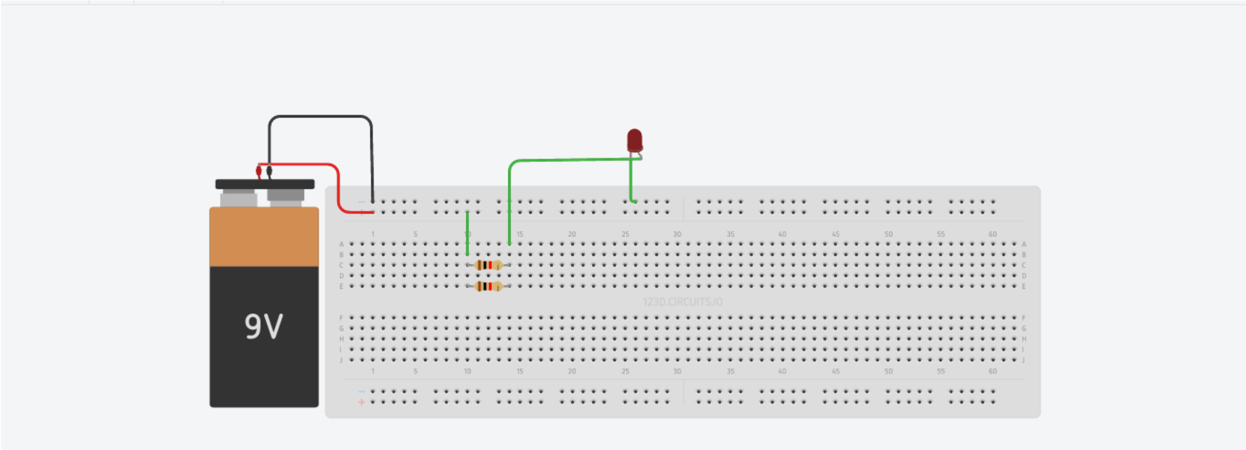
Activity

Make a Series and parallel circuit

Circuit Diagram (Series)



Circuit Diagram (Parallel)



Material Required

Name	Quantity
9V Battery	1
Resistors	2
LED	1
Breadboard	1

Instructions

For Series circuit

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now record your observations in the table below.

For Parallel circuit

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.

- Now connect the battery to the circuit.
- Now record your observations in the table below.

Observations

	Intensity of LED(Dim)	Intensity of LED(Bright)
Series		
Parallel		

What is the difference between series and parallel connection?

What will happen when you increase the resistance?

CHAPTER 5: CAPACITORS

INTRODUCTION TO CAPACITORS

A capacitor is a component that stores electricity and then discharges it back into the circuit when there is a drop in the voltage.

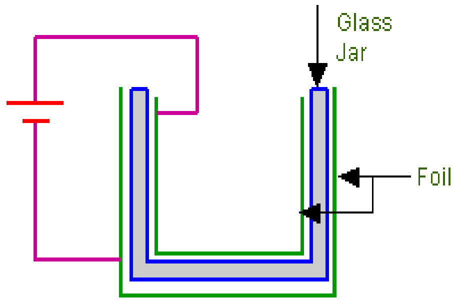
It is important to stress that capacitors do not equal batteries.

The difference between a battery and a capacitor is that in a battery power is generated through a chemical reaction, and in a capacitor a charge is stored and maintained in an electrical field. A battery can yield much more energy for a longer period than a capacitor. On the other hand, a capacitor - even with much less power storage - can discharge considerably more energy exponentially faster than a battery.

Capacitors are measured in Farads (F), which simply is symbolized with a capital F. Although, keep in mind that the values that you will typically encounter are in the picofarad (pF), nanofarad (nF) or microfarad (uF) ranges.

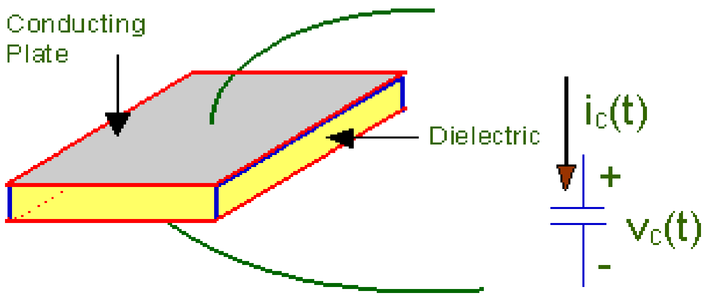
This is the schematic symbol of capacitor.

Capacitors and inductors are both elements that can store energy in purely electrical forms. These two elements were both invented early in electrical history. The capacitor appeared first as the legendary Leyden jar, a device that consisted of a glass jar with metal foil on the inside and outside of the jar, kind of like the picture below. This schematic/picture shows a battery attached to leads on the Leyden jar capacitor.



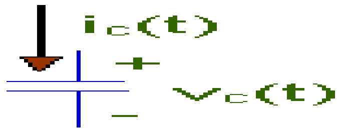
Although this device first appeared in Leyden, a city in the Netherlands sometime before 1750. It was discovered by E. G. von Kleist and Pieter van Musschenbroek. Although it has been around for about 250 years, it has all of the elements of a modern capacitor, including: Two conducting plates. That's the metallic foil in the Leyden jar. An insulator that separates the plates so that they make no electrical contact. That's the glass jar - the Leyden jar.
The way the Leyden jar operated was that charge could be put onto both foil elements. If positive charge was put onto the inside foil, and negative charge on the outside foil, then the two charges would tend to hold each other in place. Modern capacitors are no different and usually consist of two metallic or conducting plates that are arranged in a way that permits charge to be bound to the two plates of the capacitor. A simple physical situation is the one shown at the right. If the top plate contains positive charge, and the bottom plate contains negative charge, then there is a tendency for the charge to be bound on the capacitor plates since the positive charge attracts the negative charge (and thereby keeps the negative charge from flowing out of the capacitor) and in turn, the negative charge tends to hold the positive charge in place. Once charge gets on the plates of a capacitor, it will tend to stay there, never moving unless there is a conductive path that it can take to flow from one plate to the other.

There is also a standard circuit symbol for a capacitor. The figure below shows a sketch of a physical capacitor, the corresponding circuit symbol, and the relationship between Q and V. Notice how the symbol for a capacitor captures the essence of the two plates and the insulating dielectric between the plates.



VOLTAGE-CURRENT RELATIONSHIP IN CAPACITORS

There is a relationship between the charge on a capacitor and the voltage across the capacitor. The relationship is simple. For most dielectric/insulating materials,charge and voltage are linearly related.



where: V is the voltage across the plates.
You will need to define a polarity for that voltage. We've defined the voltage above. You could reverse the "+" and "-".

Q is the charge on the plate with the "+" on the voltage polarity definition.

C is a constant - the capacitance of the capacitor.

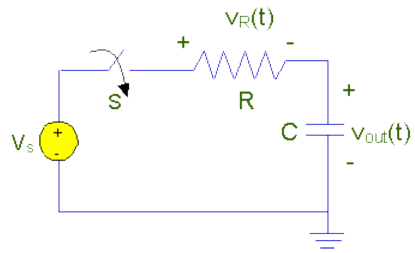
The relationship between the charge on a capacitor and the voltage across the capacitor is linear with a constant, C, called the capacitance.

$$\mathbf{Q = C\,V}$$

When V is measured in volts, and Q is measured in coulombs, then C has the units of farads. Farads are really coulombs/volt.

The relationship, Q = C V, is the most important thing you can know about capacitance. There are other details you may need to know at times, like how the capacitance is constructed, but the way a capacitor behaves electrically is determined from this one basic relationship.

Shown to the right is a circuit that has a voltage source, Vs, a resistor, R, and a capacitor, C. If you want to know how this circuit works, you'll need to apply KCL and KVL to the circuit, and you'll need to know how voltage and current are related in the capacitor. We have a relationship between voltage and charge, and we need to work with it to get a voltage current relationship.

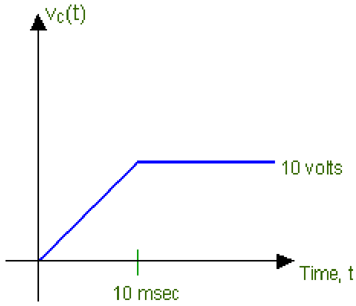


The basic relationship in a capacitor is that the voltage is proportional to the charge on the "+" plate. However, we need to know how current and voltage are related. To derive that relationship you need to realize that the current flowing into the capacitor is the rate of charge flow into the capacitor. Here's the situation. We'll start with a capacitor with a time-varying voltage, v(t), defined across the capacitor, and a time-varying current, i(t), flowing into the capacitor. The current, i(t), flows into the "+" terminal taking the "+" terminal using the voltage polarity definition. Using this definition we have:

ic(t) = C dvc(t)/dt

This relationship is the fundamental relationship between current and voltage in a capacitor. It is not a simple proportional relationship like we found for a resistor. The derivative of voltage that appears in the expression for current means that we have to deal with calculus and differential equations here - whether we want to or not.

This derivative kind of relationship also has some implications for what happens in a capacitor, and we are going to spend some time exploring that relationship. Clearly, we need to understand what this relationship implies, and then we need to learn how it affects things when we write circuit equations using KVL and KCL.



We'll start by considering a time varying voltage across a capacitor. To have something specific, let's say that we have a 4.7mf capacitor, and that the voltage across the capacitor is the voltage time function shown below. That voltage rises from zero to ten volts in one millisecond, then stays constant at ten volts. Before you go on try to determine what the current through the capacitor looks like, then answer these questions.

TYPES OF CAPACITOR

There are 2 types of capacitor:

- Polarized Capacitor
- Non-Polarized Capacitor

POLARISED CAPACITOR

A polarized capacitor has a positive lead which needs to be connected to power, and a negative lead which needs to get connected to ground. Electrolytic capacitors are polarized.

NON – POLARISED CAPACITOR

Non-polarized capacitors can be connected any which way. Ceramic disc and Mylar film capacitors are non-polarized.

WHY IS CAPACITOR IMPORTANT

The capacitor is a widely used electrical component. It has several features that make it useful and important:

- A capacitor can store energy, so capacitors are often found in power supplies.
- A capacitor has a voltage that is proportional to the charge (the integral of the current) that is stored in the capacitor, so a capacitor can be used to perform interesting computations in op-amp circuits, for example.
- Circuits with capacitors exhibit frequency-dependent behavior so that circuits that amplify certain frequencies selectively can be built.

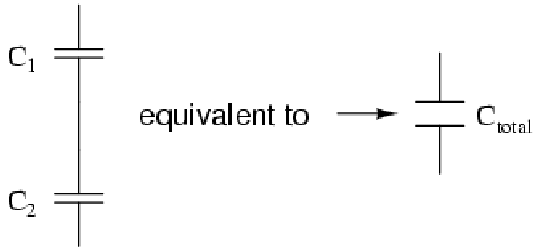
GOALS OF CAPACITOR

You need to know what you should get from this lesson on capacitors. Here's the story.

- **Given a capacitor**
  Be able to write and use the voltage-current relationship for the capacitor. Be able to compute the current through a capacitor when you know the voltage across a capacitor.
- **Given a capacitor that is charged**
  Be able to compute the amount of energy that is stored in the capacitor.

CAPACITORS IN SERIES AND PARALLEL

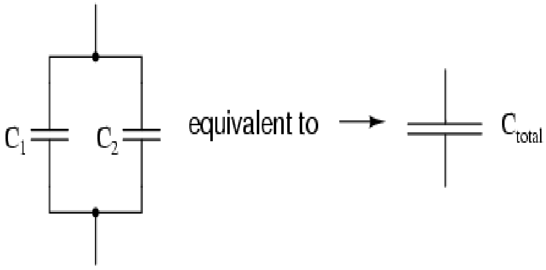
- CAPACITORS IN SERIES - When capacitors are connected in series, the total capacitance is less than any one of the series capacitors' individual capacitances. If two or more capacitors are connected in series, the overall effect is that of a single (equivalent) capacitor having the sum total of the plate spacing's of the individual capacitors. As we've just seen, an increase in plate spacing, with all other factors unchanged, results in decreased capacitance.



Series Capacitances

$$C_{total} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_n}}$$

- CAPACITORS IN PARALLEL- When capacitors are connected in parallel, the total capacitance is the sum of the individual capacitors' capacitances. If two or more capacitors are connected in parallel, the overall effect is that of a single equivalent capacitor having the sum total of the plate areas of the individual capacitors. As we've just seen, an increase in plate area, with all other factors unchanged, results in increased capacitance.



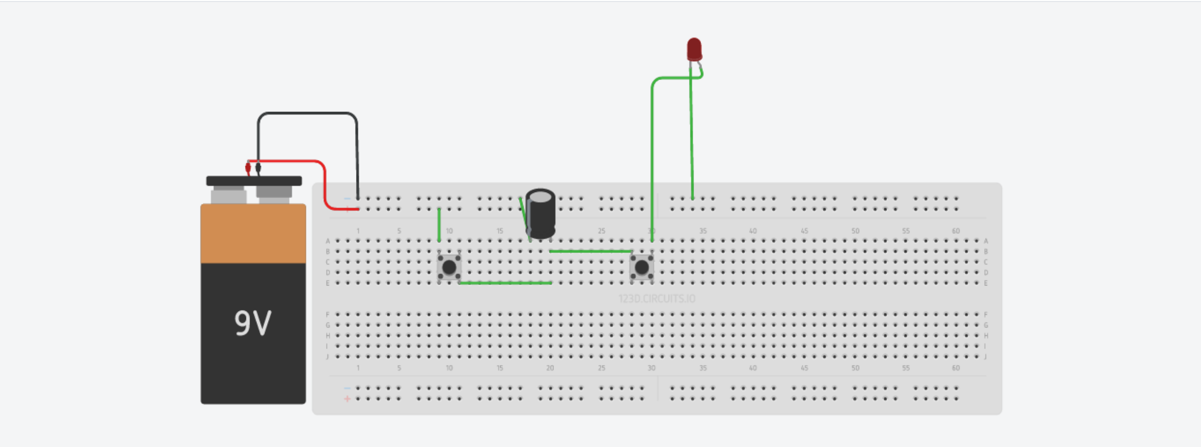
Parallel Capacitances

$$C_{total} = C_1 + C_2 + \ldots C_n$$

ACTIVITY

CHARGING AND DISCHARGING EXPERIMENT FOR A CAPACITOR

CIRCUIT DIAGRAM



MATERIAL REQUIRED

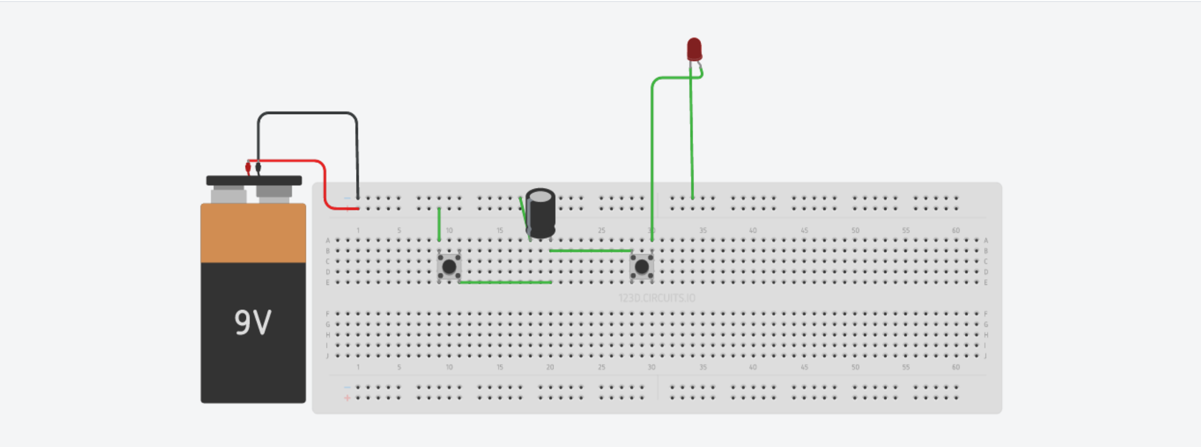
Name	Quantity
9V Battery	1
Pushbutton	2
Polarized Capacitor (1000µF)	1
LED	1

INSTRUCTIONS

- Gather all the components from the list.
- Assemble all the components except the battery according to the circuit diagram shown above.
- Now connect the battery to the circuit.
- Now press the button1for 10 seconds and then release it.
- Does not press the button1 for more than 10 seconds.
- Now press the second button.

BASED ON YOUR OBSERVATIONS NOW ANSWER THE FOLLOWING QUESTIONS

IDENTIFY THE COMPONENTS IN THE CIRCUIT



- **What will happen when you press button 1.**

1. Capacitor will Charge.
2. Capacitor will Discharge.
3. LED will Glow.
4. None of the above.

- **What will happen when you press button 2.**

1. Capacitor will Charge.
2. Capacitor will Discharge.
3. LED will Glow.
4. Both 2 & 3.

What will happen when you replace the capacitor, with another capacitor of smaller value?

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What will happen when you press button 1 for more than 10 seconds.

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