Week 1: INTRODUCTION TO ELECTRONICS

Electronics

- **It is the art of controlling the movement of electrons in order to design components and circuits that are put together to create the technology of the modern world.**
- **It is branch of physics and electrical engineering that deals with the emission, behavior, and effects of electrons and with electronic devices.**

Analog and Digital electronics

There are two very different ways of storing information—known as analog and digital. It sounds like quite an abstract idea, but it's really very simple. Suppose you take an old-fashioned photograph of someone with a film camera. The camera captures light streaming in through the shutter at the front as a pattern of light and dark areas on chemically treated plastic. The scene you're photographing is converted into a kind of instant, chemical painting—an "analogy" of what you're looking at. That's why we say this is an analog way of storing information. But if you take a photograph of exactly the same scene with a digital camera, the camera stores a very different record. Instead of saving a recognizable pattern of light and dark, it converts the light and dark areas into numbers and stores those instead. Storing a numerical, coded version of something is known as digital.

Types of Electronic Components

All Electronic components can be broadly classified into two classes, namely Active Components and Passive components. These components are diametrically different from each other based on their functional properties and operation.

1. Passive Components

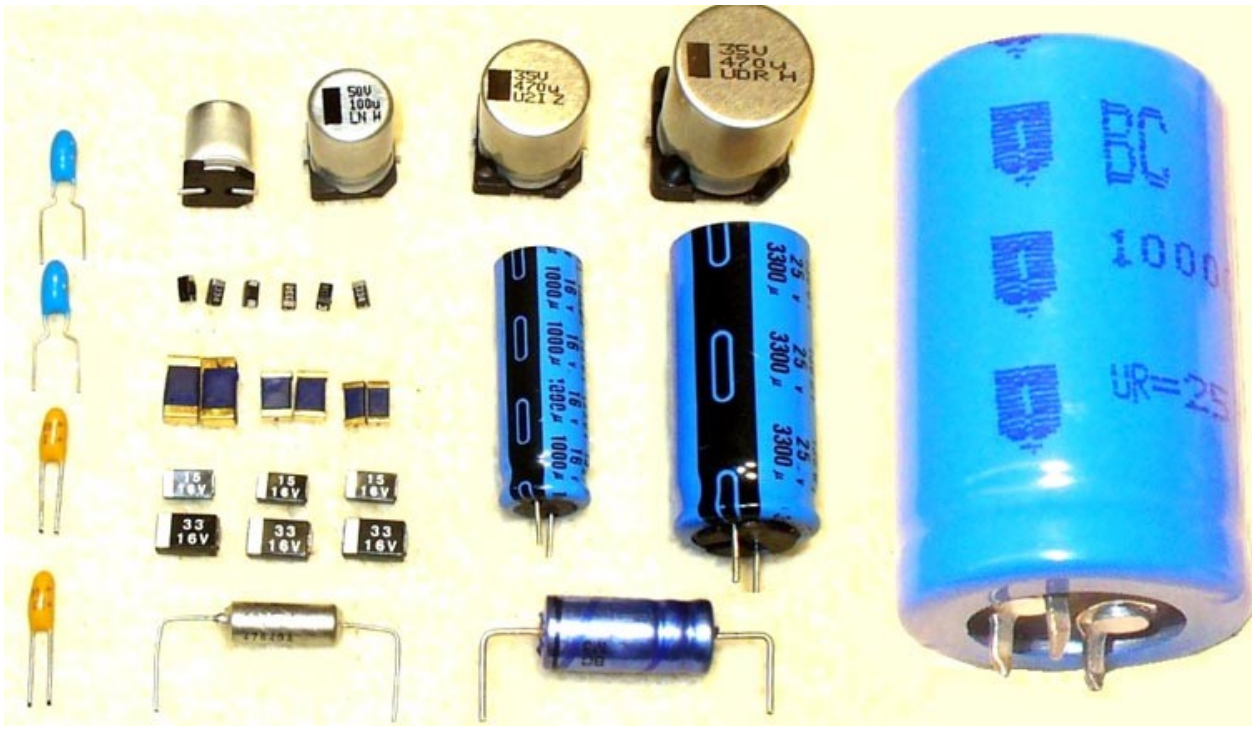
These components are those that do not have gain or directionality. They are also called Electrical elements or electrical components. Passive components cannot control electric current utilizing a second electrical signal. Some important passive components are capacitors, resistors, inductors, and transformers. Passive components do not require energy to operate barring the AC circuit. Example: Resistors, Capacitors, Diodes, Inductors.

Types of passive components

Lossy or Dissipative: These cannot absorb power from an external circuit. Resistors are an example of lossy passive components.

Lossless: These do not have any input or output net level flow. A few examples of lossless components are inductors, transformers, and gyrators.

Example of Passive Components



Capacitors

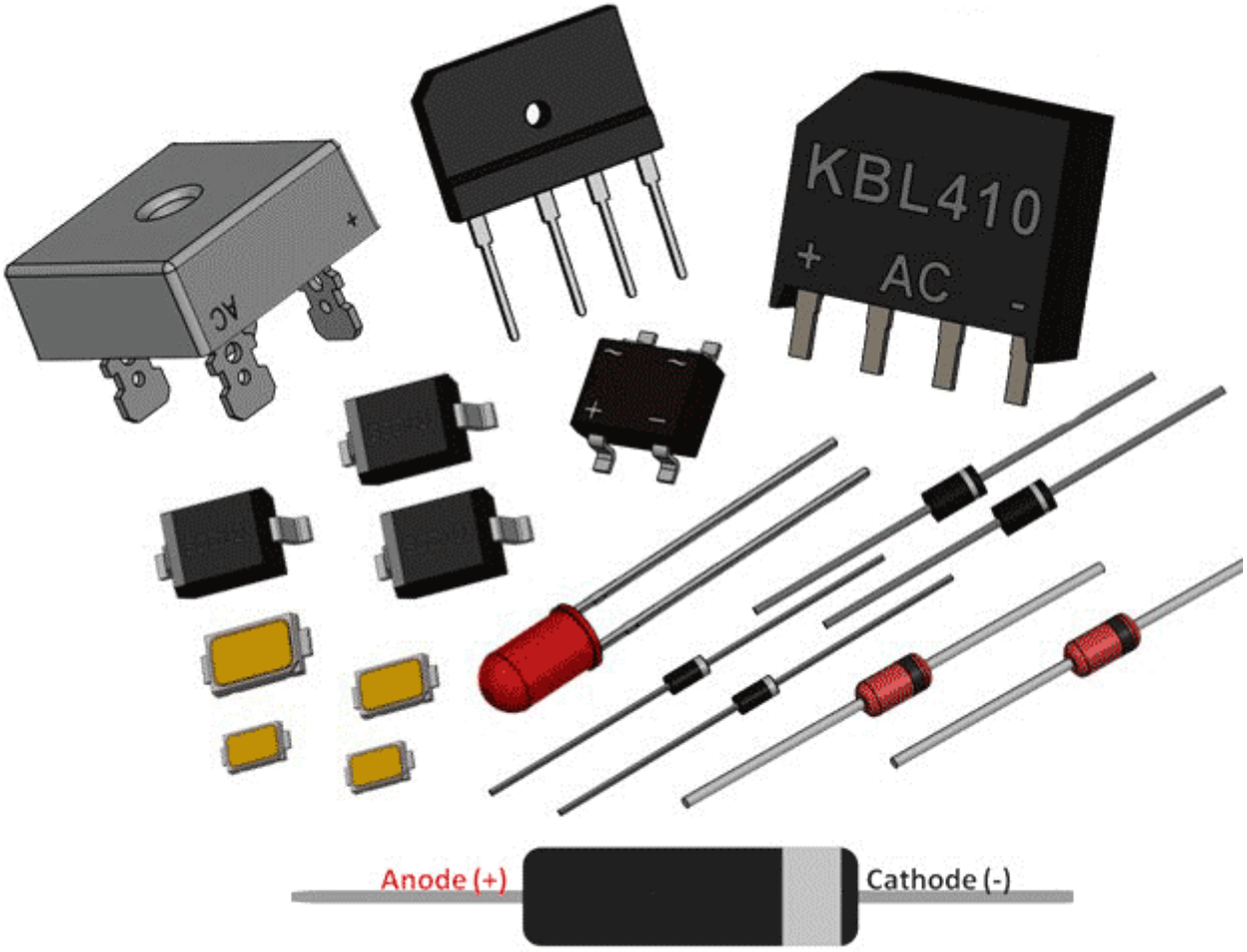
Capacitors can store energy in the electric field located between plates. They are commonly used in electronic circuits for storage. They can also be used in filter circuits to differentiate between high and low-frequency signals. Capacitors can be majorly classified into Ceramic Capacitors, Electrolytic Capacitors, Mylar capacitors, and X-rated Capacitors. You can also read this article on Capacitors to understand the basics of a capacitor, its types, and applications. Capacitors have many purposes including energy storage, filtering, timing, and decoupling

Resistors

As the name implies their job is to resist or oppose the flow of current. They are meant to control the flow of electric current to the circuit by automatically bringing down the voltage in the device. 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.

Inductors

Diodes:



Diodes are tiny active components that are used to direct the flow of energy within the boundaries of the circuit. The function of the diode is extremely important because it controls energy flow disabling the damage that could be caused due to the poor flow of energy. The most popular and commonly used Diodes are 1N4007 Rectifier Diode, 1N4732A 4.7V Zener Diode, and 1N5817 Schottky diode

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).

2. Active Components

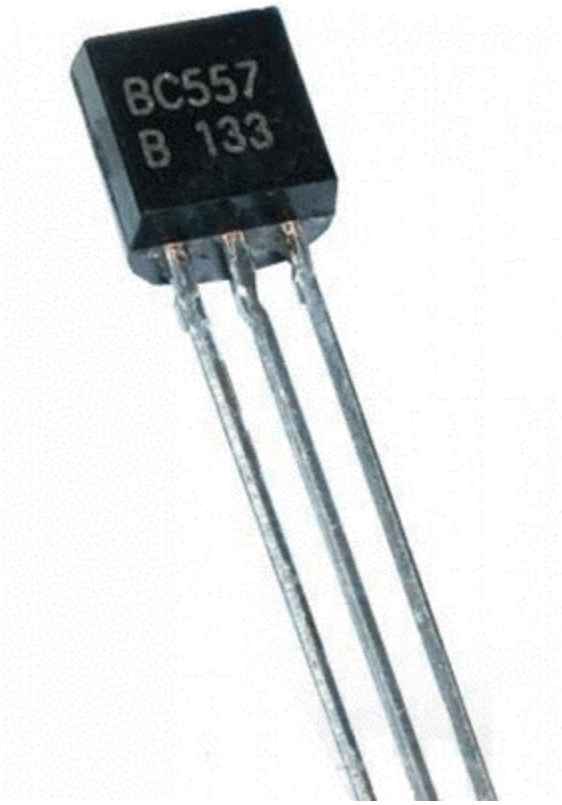
These components are those that have gain or directionality. Active components are devices that can amplify an electric signal and produce power. Any characteristic active component will comprise an oscillator, transistor or an integrated circuit. An active component functions as an alternating current circuit in devices. This helps the device to augment power and voltage. This component can execute its operations because it is powered by a source of electricity. All active components necessitate some source of energy which commonly is extracted from a DC circuit.

Example: Transistors, Integrated Circuits or ICs, Logic Gates.

Example of Active Components

Active components, by their characteristics, rely on external sources for their operation. They have the power to augment and put more power into the circuit. Given below are the different types of active components.

Transistors:

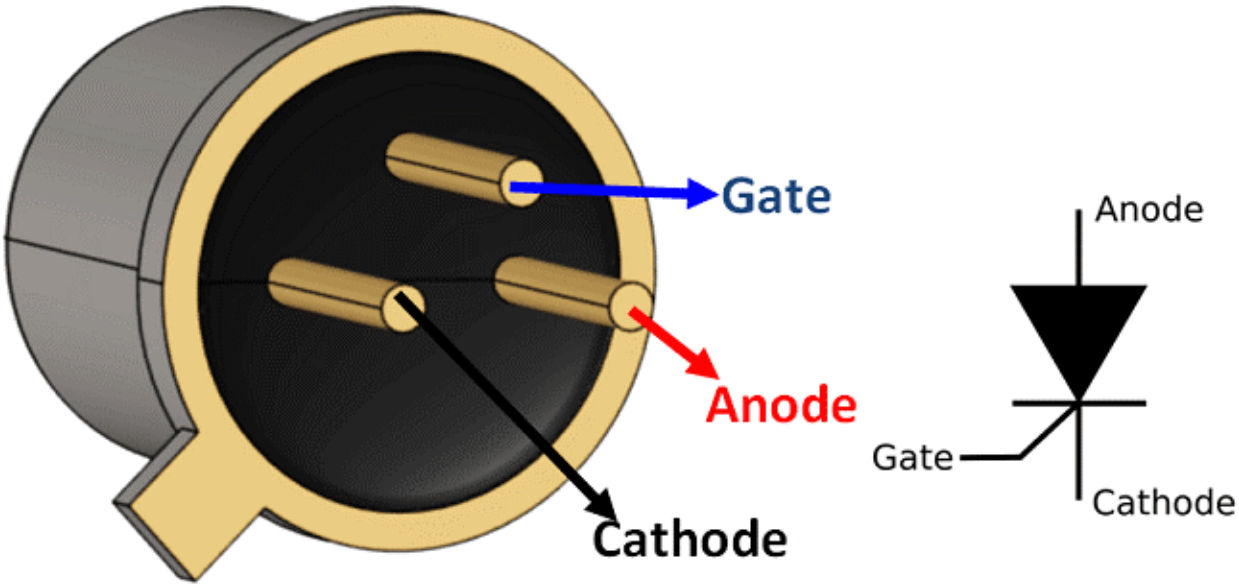


Transistors are used to amplify current by taking in a small voltage of energy and giving a larger output of energy. This semiconductor device is one of the most important components that can be found in many circuit designs. The most popular and commonly used transistors are BC547, 2N2222, and BC557. They can be individualistic or packaged together depending on the planning of the device. They have much functionality that includes regulation of voltage, amplification, adjusting signals, etc.

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.

Silicon Controlled Rectifiers (SCRs):

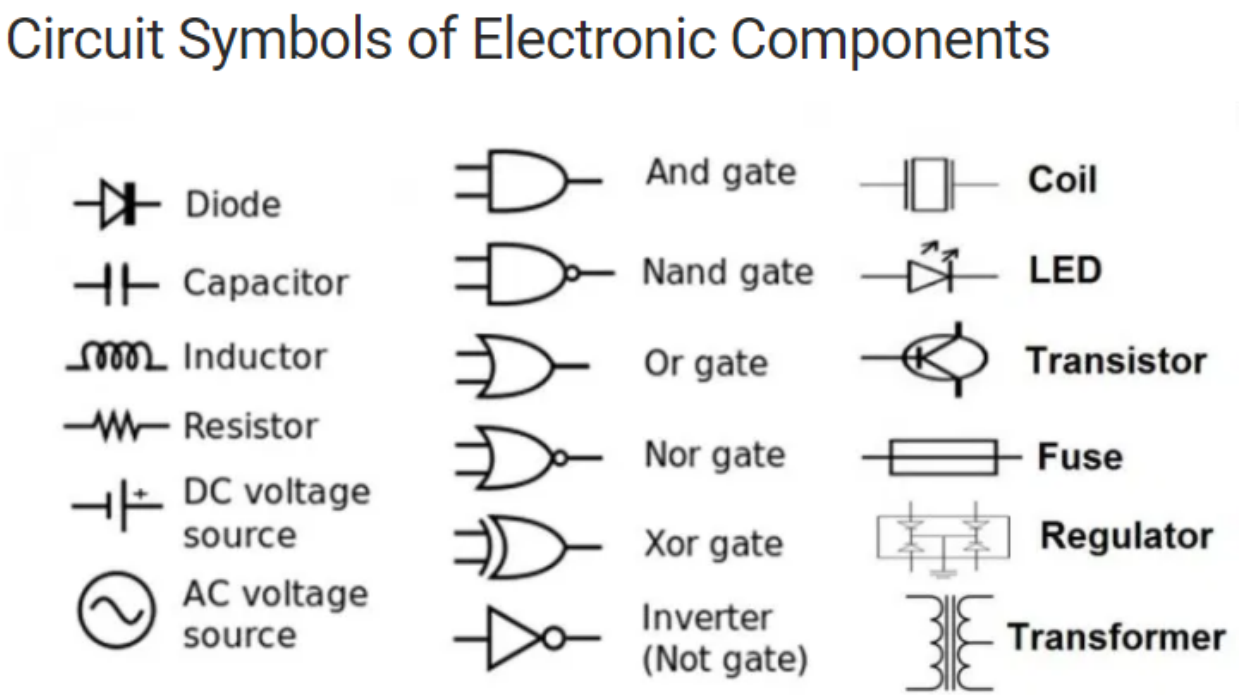
Silicon Controlled Rectifiers or SCRs for short is a type of power electronics switch. It has three terminals called Anode, Cathode, and Gate. By default, the switch is open and no current flows between the Anode and Cathode terminals of the SCR. When a small current is applied to the gate pin, the switch is closed and a large amount of current can be allowed to pass between the Anode and Cathode terminals. Using a Thyristor/SCR is very similar to that of a BJT (Transistor). The load to be switched is connected between the anode and cathode and the Thyristor can be switched ON or OFF by applying a gate current to the gate pin of the Thyristors. The most popular and commonly used Thyristors are 2N2324 and 2N1595.



Thyristors 2N2324

Functions of Basic Electronic Components

1. Terminals and Connectors: Components to make electrical connection.
2. Resistors: Components used to resist current.
3. Switches: Components that may be made to either conduct (*closed*) or not (*open*).
4. Capacitors: Components that store electrical charge in an electrical field.
5. Magnetic or Inductive Components: These are Electrical components that use magnetism.
6. Network Components: Components that use more than 1 type of Passive Component.
7. Piezoelectric devices, crystals, resonators: Passive components that use piezoelectric. effect.
8. Semiconductors: Electronic control parts with no moving parts.
9. Diodes: Components that conduct electricity in only one direction.
10. Transistors: A semiconductor device capable of amplification.
11. Integrated Circuits or ICs: A microelectronic computer circuit incorporated into a chip or semiconductor; a whole system rather than a single component.



A Brief History of Electronics

- **1874: Irish scientist George Johnstone Stoney (1826–1911) suggests electricity must be "built" out of tiny electrical charges. He coins the name "electron" about 20 years later.**
- **1875: American scientist George R. Carey builds a photoelectric cell that makes electricity when light shines on it.**
- **1879: Englishman Sir William Crookes (1832–1919) develops his cathode-ray tube (similar to an old-style, "tube"-based television) to study electrons (which were then known as "cathode rays").**
- **1883: Prolific American inventor Thomas Edison (1847–1931) discovers thermionic emission (also known as the Edison effect), where electrons are given off by a heated filament.**
- **1887: German physicist Heinrich Hertz (1857–1894) finds out more about the photoelectric effect, the connection between light and electricity that Carey had stumbled on the previous decade.**
- **1897: British physicist J.J. Thomson (1856–1940) shows that cathode rays are negatively charged particles. They are soon renamed electrons.**
- **1904: John Ambrose Fleming (1849–1945), an English scientist, produces the Fleming valve (later renamed the diode). It becomes an indispensable component in radios.**
- **1906: American inventor Lee De Forest (1873–1961), goes one better and develops an improved valve known as the triode (or audion), greatly improving the design of radios. De Forest is often credited as a father of modern radio.**

- **1947: Americans John Bardeen (1908–1991), Walter Brattain (1902–1987), and William Shockley (1910–1989) develop the transistor at Bell Laboratories. It revolutionizes electronics and digital computers in the second half of the 20th century.**
- **1958: Working independently, American engineers Jack Kilby (1923–2005) of Texas Instruments and Robert Noyce (1927–1990) of Fairchild Semiconductor (and later of Intel) develop integrated circuits.**
- **1971: Marcian Edward (Ted) Hoff (1937–) and Federico Faggin (1941–) manage to squeeze all the key components of a computer onto a single chip, producing the world's first general-purpose microprocessor, the Intel 4004.**
- **1987: American scientists Theodore Fulton and Gerald Dolan of Bell Laboratories develop the first single-electron transistor.**
- **2008: Hewlett-Packard researcher Stanley Williams builds the first working memristor, a new kind of magnetic circuit component that works like a resistor with a memory, first imagined by American physicist Leon Chua almost four decades earlier (in 1971)**

Basic Test and Measurement Equipment

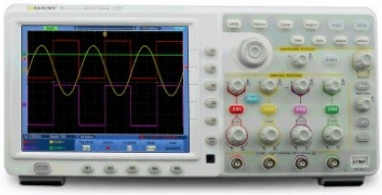
When it comes to designing electronic circuits, testing and measuring various parameters like current, voltage, frequency, resistance, capacitance, etc. is very important. Hence, the Test and Measurement Equipment like Oscilloscopes, Multimeters, Logic Analyzers, Function Generators (or Signal Generators) are often used regularly.

Oscilloscope

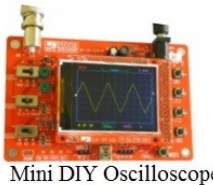
The most reliable Test Equipment for observing continuously varying signals is an Oscilloscope. With the help of an Oscilloscope, we can observe the changes in an electrical signal like voltage, over time.

Oscilloscopes are used in a wide range of field like Medical, Electronic, Automobile, Industrial and Telecommunication Applications.

Cathode Ray Oscilloscope



Digital Oscilloscope



Mini DIY Oscilloscope

OSCILLOSCOPES

Originally, Oscilloscopes are made up of Cathode Ray Tube (CRT) displays but nowadays, almost all Oscilloscopes are Digital Oscilloscopes with advanced features like storage and memory.

Multimeter

A multimeter is a combination of Voltmeter, Ammeter and Ohmmeter. They provide an easy way to measure different parameters of an electronic circuit like current, voltage etc.

Multimeters can measure values in both AC and DC. Earlies Multimeters are Analog and consists of a pointing needle. Modern Multimeters are Digital and are often called as Digital Multimeters or DMMs.

Analog Multimeter

Digital Multimeter

Bench Multimeter

MULTIMETERS

DMMs are available as handheld devices as well as bench devices. A Multimeter can be very handy in finding basic faults in a circuit.

Function Generator or Signal Generator

A Signal Generator, as the name suggests, generates a variety of signals for testing and troubleshooting electronic circuits. The most common types of signals are Triangular Wave, Sine Wave, Square Wave and Sawtooth Wave.

FUNCTION GENERATORS

Along with a bench power supply and oscilloscope, a function generator is also an important piece of equipment when designing electronic circuits.

Voltage / Current / Power

It all starts with voltage and current. The most common analogy for understanding voltage and current is water flowing from an elevated tank down through a pipe.

Voltage is represented by water pressure which is determined by the height of the water tank. The higher the tank, the higher the pressure. However, the arbitrary height of the tank isn't what matters. Instead, what matters is the *difference* between the tank height and the ground height for the pipes.

The same is true of electrical voltage which is measured in Volts (V). Voltage is measured as a difference between two points. For example, when you say something is 5 volts that really means 5 volts with respect to ground voltage (which is 0 volts).

Electrical current, on the other hand, is equivalent to the amount of water flowing through the pipe, and is measured in Amps (A). It takes voltage to do the work in order to create this current flow. The more voltage that is applied the more current will be produced.

Power is the rate at which work is done and is measured in Watts. There are various equations for calculating electrical power but the easiest one to understand is that power is simply voltage multiplied times current.

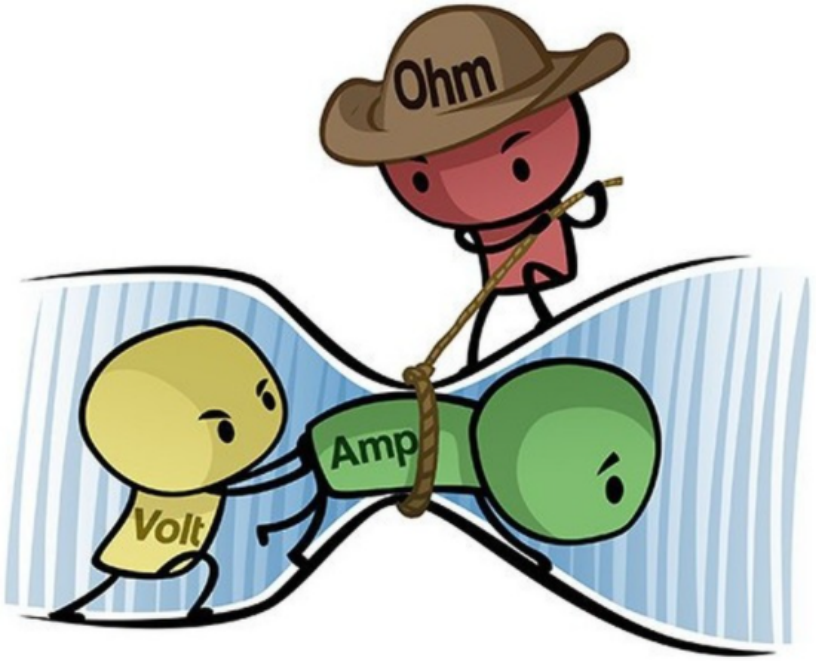


Illustration of voltage, current, and resistance – Provided by Build-Electronic-Circuits.com