Modeling Voltage

A waterfall is used, as a model, to demonstrate voltage. Water flows when there is a change in the **gravitational potential energy** (elevation). Electricity will not flow unless there is a change in **electrical potential** (voltage).

Voltmeters measure voltage difference (**voltage drop**).

Ammeters measure current (rate of flow) in amperes. Small currents are measured using **galvanometers**.

Multimeters can measure voltage, current and resistance in a circuit.

Modeling Resistance and Current

Flow of water in pipes is used, as a model, to demonstrate resistance. The size of pipe determines the volume of water allowed through it. The amount of resistance, in a circuit, determines the size of the current.

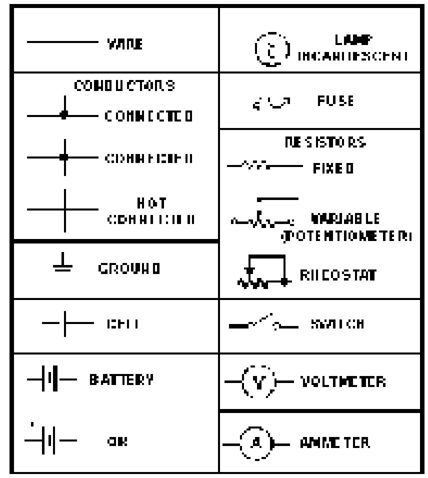
Analyzing and Building Circuits

Engineers and designers of electrical circuits use symbols to identify components and connections. A drawing made with these symbols is called a schematic or schematic diagram.

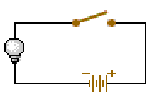
All circuit diagrams have four basic parts:

- **sources** - provides energy and a supply of electrons for the circuit
- **conductors** - provides a path for the current
- **switching mechanisms** - controls the current flow, turning it off and on, or directing it to different parts of the circuit
- **loads** - converts electrical energy into another form of energy

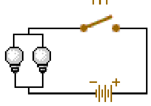
Basic Electrical Circuit Symbols



Series and Parallel Circuits

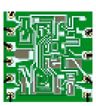


A **series circuit** provides only one path for the current to flow,



A **parallel circuit** has multiple pathways.

Microcircuits (Integrated Circuits) - transistors are used with three layers of specially treated silicon, with the middle layer (receiving a small voltage, allowing it to control the voltage in the outer layers, allowing them to act as switches. Microcircuits are made up of transistors and resistors and are built on an extremely small scale.

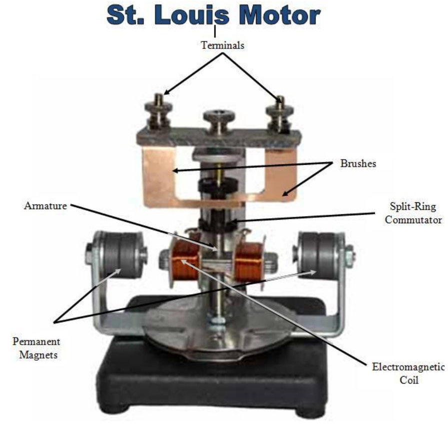


Integrated circuits put all of the components in one chip, reducing the size of the circuit.

Electric Motors

Oersted found that an electric current created a magnetic field by the deflection of a compass needle - demonstrating that electricity and magnetism are related. **Faraday** constructed the first motor. By coiling (copper) wire around a (iron) metal core a strong **electromagnet** can be made. When attached to an electrical source it will produce a strong magnetic field. To keep this electromagnet spinning in a magnetic field, the direction that the current is traveling through the coil must be switched. This is accomplished by with a gap, which allows the polarity of the electromagnet to change just before it aligns with the permanent magnet. Many electric motors use a **split ring commutator** that breaks the flow of electricity for a moment and then reverses the flow in the coil, when the contact is broken and **brushes** (contact points) to reverse the flow of electricity through the magnetic field. The **armature** (the rotating shaft with the coil wrapped around it) continues to spin because of momentum, allowing the brushes to come into contact once again with the commutator.

St. Louis Motor



Direct and Alternating Current

Some motors run on direct current (DC). It is 'direct', because the electricity flows in only one direction. Alternating current (AC) flows back and forth 60 times per second.

Generating Electricity

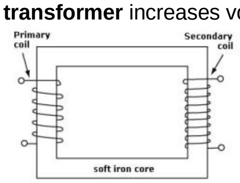
Michael Faraday discovered **electromagnetic induction** in 1831. He demonstrated that moving a conducting wire through a magnetic field by moving it back and forth through the field, Faraday created the first electricity-producing generator, which could generate electrical current. Massive coils of wire rotating in huge generators can produce enough electricity to power an entire city.

Generating DC and AC

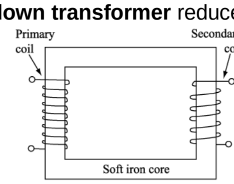
A **DC generator** is much the same as a DC motor. The spinning armature produces the electricity (if electricity is passed through a DC generator, it will spin like a motor). The central axle of an **AC generator** has a loop of wire attached to two slip rings. The current is switched as the loops move up and down alternatively through the magnetic field. The slip rings conduct the alternating current to the circuit through the brushes (the brush and ring assembly allows the whole loop to spin freely). In large AC generators many loops of wire are wrapped around an iron core.

Transformers are used to change the amount of voltage with hardly any energy loss. Voltage change is necessary because the most efficient way to transmit current over long distances is at high voltage and then reduced when it reaches its destination, where it will be used.

A **step-up transformer** increases voltage,



A **step-down transformer** reduces voltage.



Power *is the rate at which a device converts energy*. The unit of power is the **watt** (**W**), which is equal to 1 **joule** per second. For an electrical device the power is the current multiplied by the voltage.

(P) Power in watts (I) current in amperes
(V) voltage in volts

$P = I \times V$ $\quad I = P / V$ $\quad V = P / I$

Shortcut $\frac{P}{I\ V}$

(E) Energy in joules (P) Power in watts (J/s)
(t) time in seconds

$E = P \times t$ $\quad P = E / t$ $\quad t = E / P$

Shortcut $\frac{E}{P\ t}$

Energy

The power rating of a device can be used to determine the amount of energy the device uses. Multiply the power rating by the time the device is operating.