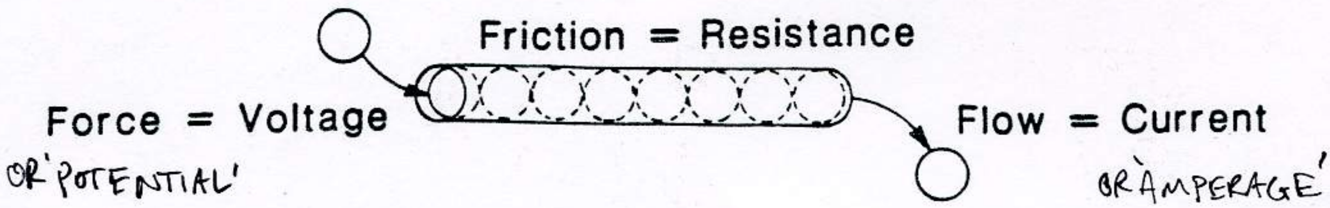
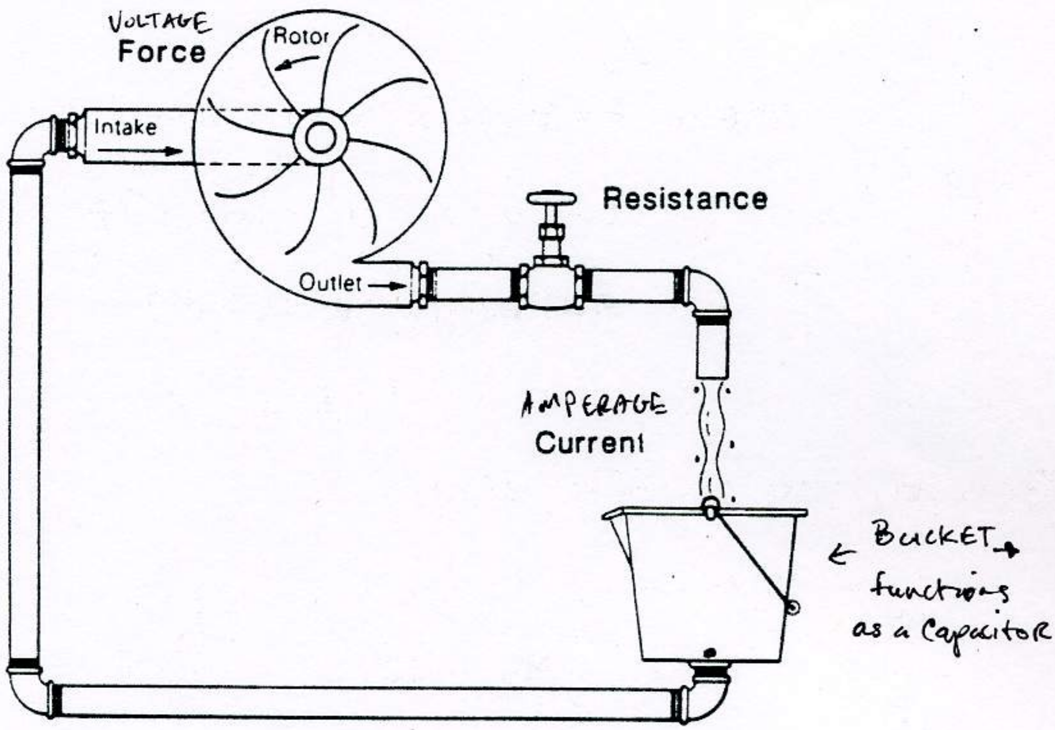
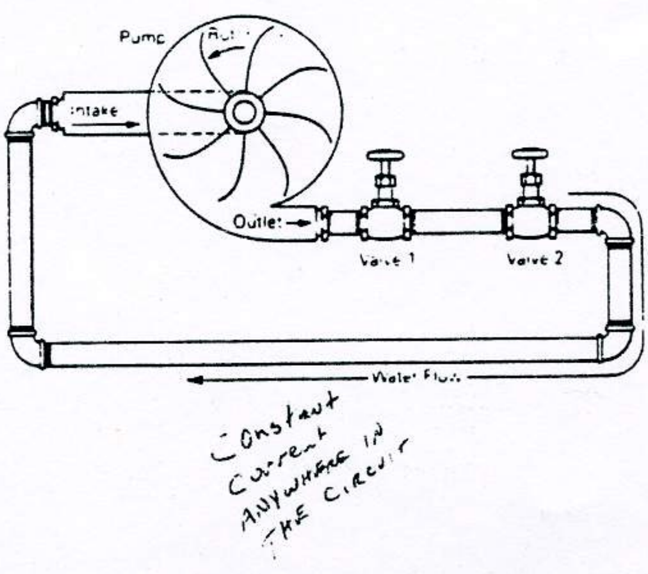
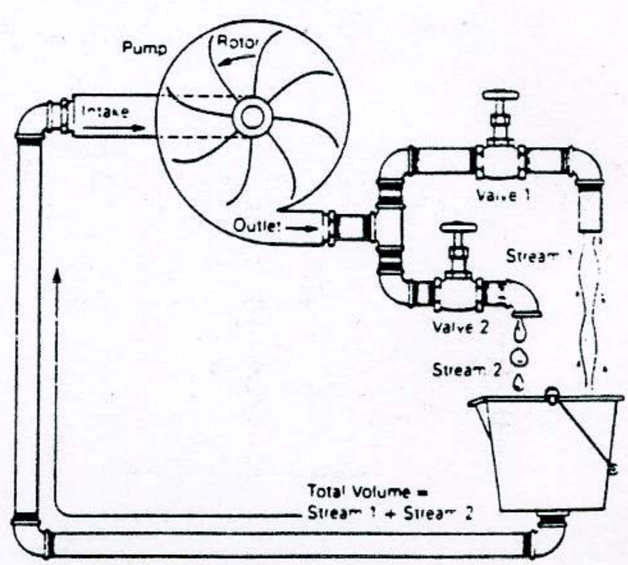
Current







Series Circuit



Parallel Circuit

Current

Definition:

A flow of electrical charge through a conductor. The rate of that flow is measured in a unit called Ampere.

Key Facts:

- Current can be thought of as marbles moving through a foam rubber pipe just big enough to contain the marbles. Force must be applied to the marbles to overcome the friction between the marbles and the inner walls of the pipe.
- The force used to overcome the friction and push the marbles through the pipe is analogous to voltage overcoming the resistance in a conductor and causing electrical current to flow.
- The friction in the pipe is analogous to the resistance in a conductor.
- The basic unit of measure of current is the Ampere. The Ampere is used to measure the rate of flow of charges through a conductor or component.
- One Ampere of current is equal to the movement of 6,250,000, 000,000,000,000 electrons past any one point in a circuit during one second of time.
- Either positive particles or negative particles may be involved in a current. It should be noted that the effect of negative charges moving in one direction is the same as positive charges moving in the opposite direction. Consequently, the designation of current direction is arbitrary.
- The movement of positive charged particles, atoms, (toward a negative charge) is called Conventional Current flow.
- The movement of negative charged particles, electrons, (toward a positive charge) is called Electron Current flow.
- In this manual and during the course, we will generally be speaking of conventional current flow. There are, however, cases where the electron current flow is more appropriate. We will point out those special cases as needed. The student should not feel overly concerned about this, because for our purposes it makes no difference which is used.
- Direct Current is a current that always flows in the same direction.
- Alternating Current is a current that is continually varying in magnitude and periodically changing direction of flow.

Section 3. Electrics

The following section is in no way a comprehensive or theoretically sound education in electricity. It is, at best, a survival and safety guide for simple practical use.

3.1. Electricity, AC and DC, volts, amps and watts

An object is said to hold a charge when it contains more or less electrons than it does at equilibrium. When that charge is moving it constitutes what we call electricity. The two basic unit of electrical measurement are the Volt and the Amp. The Volt is the measure of potential difference or electro-motive force (emf) or 'pressure', with respect to 'Ground'. 'Ground' can be an arbitrary locally determined value, or it can be the potential of the planet itself.The Amp is the measure of current flow or 'volume'.

The 'water analogy' is useful in explaining basic electrical phenomena. Water pressure is equivalent to Volts, pipe diameter is equivalent to Amps. A restriction in the pipe is equivalent to a Resistance. The unit of resistance is the Ohm (Ω) (water diag)

Ohms law relates Voltage, Current and Resistance. $E=IR$. It is the most important and most basic law of electricity. (diag) Total power is measured in Watts. $W=VA$

P (watts) = Potential Difference (volts) x Flow (amps)

AC and DC. Electricity supplied by the utilities comes in the form of Alternating Current. The voltage is oscillating (wildly, 60 times a second, 60 Hertz (60hz)) in a sinusoidal fashion, between approximately 170volts and -170 volts with respect to ground.(see diag AC) What does this graphical representation mean? What does it mean that the voltage is oscilating between a negative and a positive value? According to the 'water analogy' it means that the current is moving backwards and forwards in the wire, pushing and pulling. AC is used for lighting, heating and some motorized appliances and tools. AC power is delivered on two lines, Active and Neutral, usually with the addition of Ground.

Direct Current has a steady (usually positive) value or 'pressure' with respect to ground. Batteries produce DC as do DC power supplies. DC is delivered on two lines, Positive ('hot') and Negative (ground). Sometimes there will be three lines, with a positive above 'ground' and a negative below 'ground'. Electronic devices require DC.

Grounding. As a matter of safety, all electrical devices should be grounded, by as short a connection as possible. Electricty will go to ground by the path of least resistance. If the ground connection is long, this path of least resistance may be the body of the operator. (Not a desirable thing)

The concept of 'ground' is not one of absolute neutrality. Even the planet itself has a potential, with respect to the outer atmosphere etc. Lightening is the discharge of a giant capacitor formed by the earth and the clouds.

In DC work, ground is an arbitrary reference point. A useful analogy is cars on the freeway. Most cars are driving at 55mph. If we call 55 the 'ground' reference, then 'fast' cars are +ve. Slow cars are negative with respect to ground.

3.2 switches and switch theory.

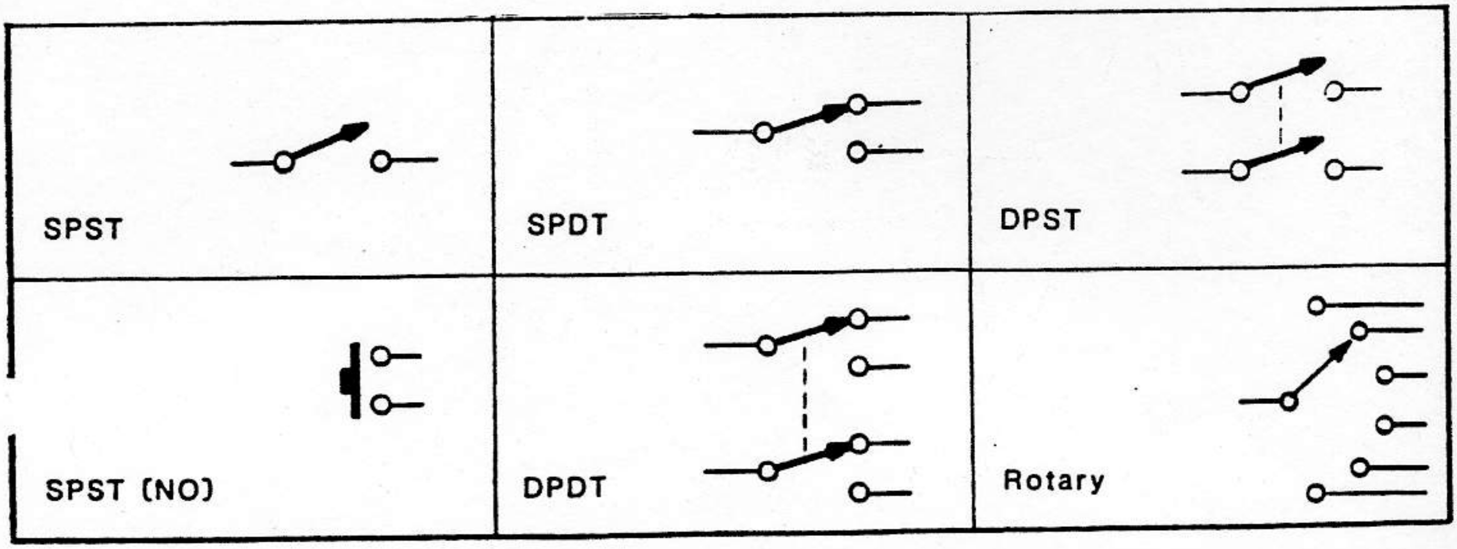
The simplest electrical device is the switch. When a switch is Open, no current flows. When a switch is Closed, current flows. Closed means On. If the switch stays in the position you put it (like a light switch) it is called a 'latching' switch. Switches can be spring loaded, in which case they are called 'Momentary'.

A simple switch can be Normally Open (NO) or Normally Closed (NC). (diag) This type of switch is called Single Pole, Single Throw (SPST).

A switch which switches between two positions is called Single Pole Double Throw (SPDT).

A switch which switches two separate signals or voltages is called Double Pole (DP). these come in ST and DT forms.

More complex switches can have more poles and more throws.



3.3 Specialty switches: limit switches, reed switches, mercury switches, pressure mats.

A switch which is switched by a moving object is called a limit switch. An automatic garage door has a limit switch which, when hit by the end of the door, switches the motor off.
A reed switch is two metal leaves in an evacuated glass tube. A magnet moving close to the reed can cause the switch leaves to connect. this kind of switch is used in burgular alarm systems, the magnet is in the door, the reed is in the door frame.
A mercury switch is a glass vial with two paralled contacts and a bead of mercury. If the switch is tipped, the mercury form a connection between the contacts. this type of switch is sensitive to angle.
A pressure mat is a pad usually laid under carpet. When someone stands on it, it switches on.

3.4 Power supplies: rectification, smoothing and regulation: transformers, diodes, rectifies, capacitors, voltage regulators

Many devices require DC supply. Thus the conversion of AC to DC is a basic necessity. Conversion occurs in 4 steps: Transformation, Rectification, Smoothing and Regulation. This is is done by Transformers, Rectifiers, Capacitors and Voltage Regulators respectively.
A **transformer** is a highly effiecent device which converts one AC voltage to another in a ratio specific to the transformer. A 120v to 12v transformer converts in a ratio of 10:1. The 120 side is called the 'primary', the 12 side is called the 'secondary'. The same transformer may be used to convert 240v to 24v. This is called a Step Down transformer. A Step Up transformer increases voltage.
Transformers are limited in the amount of current they will pass. This power capacity is roughly proportional to weight, about 1amp per pound. If you put too much load (demand for power) on the Secondary side of a transformer it will fry irrevocably.
Rectification is achieved by means of diodes. A diode is an electrical 'valve' which allows current to pass in one direction but not the other. A single diode produces what is called Half Wave Rectification. (diag)
Generally more useful is Full Wave Rectification which is achieved by a Wheatstone Bridge of four diodes, usually called a Bridge Rectifier. (diag). The 'bridge' achieves the clever result of inverting the negative sides of the AC signal, resulting in an oscilating but positive voltage.
Smoothing is achieved by the use of a big capacitor. ~~A capacitor can be visualized as a~~

3.5 Reading Schematics

The electronic schematic is a fascinating type of drawing which functions simultaneously as a map or plan, a text and a virtual machine. In order to make our schematics readable we adopt certain conventions. The electrical process should 'move' from left to right. Positive lines should be drawn above negative lines. Wires that cross but do not join should be indicated by a short break in one wire at the crossing (there are several conventions for this, but we'll observe the 'break' convention).

A schematic is seldom drawn as the wires would be placed on the board. It is always useful to draw a second 'geographical' schematic before beginning to build, with all components drawn to scale, in their correct shape, with terminals indicated.

Those of us who are dislexic are often confused by inversions such as flipping the board. I always draw two geographical schematics, one for each side. This can be very useful when troubleshooing (boards seldon work right first time), or when coming back to the board to make changes sometime later. Store your schematics in an orderly way in a notebook of folder.

3.6 Construction: perfboard, soldering, wire and connectors.

Electronic construction is simplified by use of standardized 'perfboard'. This is an insulating material with a regular grid of holes 0.1" apart. Components are manufactured to fit this spacing. Perfboard is not a structural material. It should always be mounted in four corners to a base by means of nuts, bolts and 'standoffs'.

Compoments are mounted on one side of the board only, allowing connecting wires to be arranged on the flip-side. Connecting wires sould be color coded. Use red for +ve, black for -ve and various colors for other signals. Keep a pair of red and black magic markers for marking bare wires and for making notes on the back of the board.

Wire comes in two basic types, stranded and solid. Use solid wire on the board, its easier to solder. Never use solid wire where movement may occur, as it will fatigue and break. Stranded wire is made specifically for this purpose.

The longer one works in electrics and electronics, the more important terminals and connectors become. It is unwise to solder wires from external components directly to the board, both for reasons of reliability and convenience. Always use screw or plug terminals of some sort.

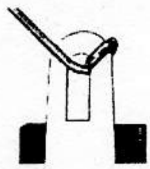
Soldering makes an electrical connection. It is not structural.

1. In order to make a connection, both contacts need to be clean, if they are not shiny, clean them with steel wool. (take care not to leave fibres of steel wool on your circuit board!) The solder contains 'resin flux' which removes some corrosion.
2. Heat one contact with the soldering iron, bring the solder to the contact and 'tin' its surface.
3. do the same to the second contact.
4. Bring the contacts together and touch them with the iron, the solder on the contacts should fuse. Use as little solder as possible.

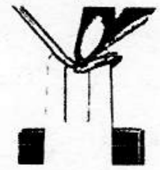
Note: A good solder joint is shiny and smooth. If the surface is rough and dull, it means that the contacts were dirty or were not hot enough. This can produce a dry-joint, one which appears connected but in which layers of oxide prevent conduction. It can be very time consuming to locate a dry joint on a circuit, so solder carefully!

Note: Solder is mostly lead, wich is poisonous. Don't eat it. Fumes from the resin are also poisonous, use good ventilation.

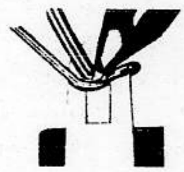
How to solder correctly, easily on point-to-point wiring



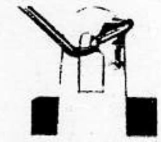
1. Attach the end of the wire to the terminal.



2. Place a flat side of the soldering iron tip against the wire and the terminal.



3. Place the solder against the connection; the solder will melt and flow into the connection.

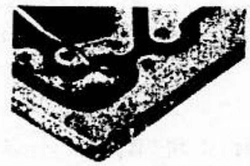


4. Remove the solder, and then the iron from the connection. A good solder joint should look smooth and bright.

and on circuit boards

1. Place the tip of the soldering iron firmly against the circuit board foil *and* the wire or lug to be soldered.

2. Touch the solder to *the iron, the foil, and the wire* at the point where they meet. Remove the solder as soon as it begins to melt and flow onto the foil and wire; then remove the iron.



3. Check the connection; a good solder joint should look smooth and bright, and the solder should adhere evenly to both the wire and the foil.

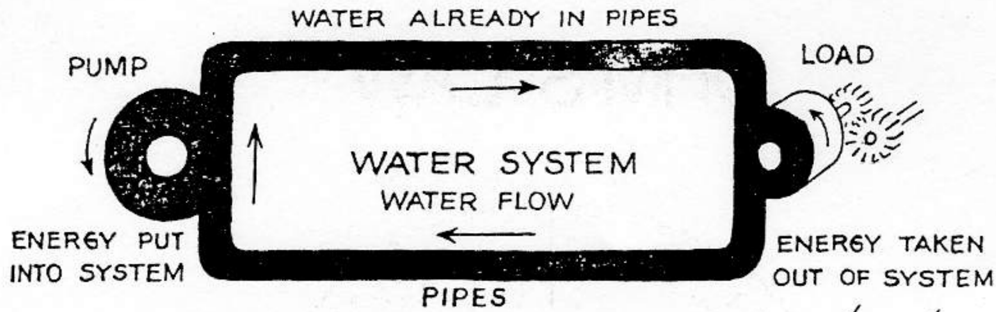
4. After the solder has hardened, clip off the wire close to the foil.

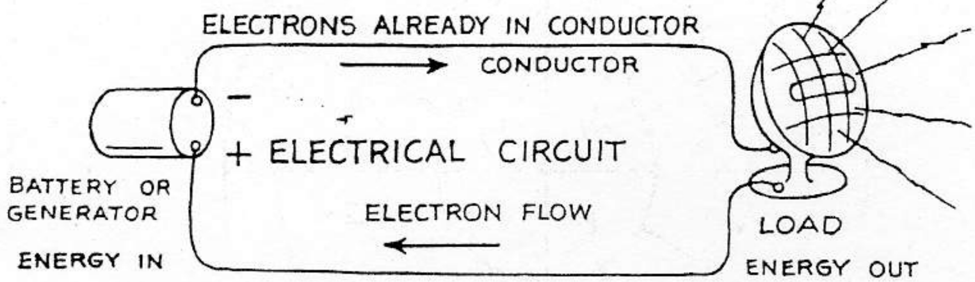
3.7 Using the Multimeter. The multimeter is a number of test devices in one. It tests voltage and current in both AC and DC. It also tests resistance and continuity. It is critical that you use the correct ranges for measuring particular variables.
Note: current is measured in series and voltage is measured in parallel. If you want to measure the voltage output of a transformer or battery, always do it across a load, a resistor or lamp. See video.

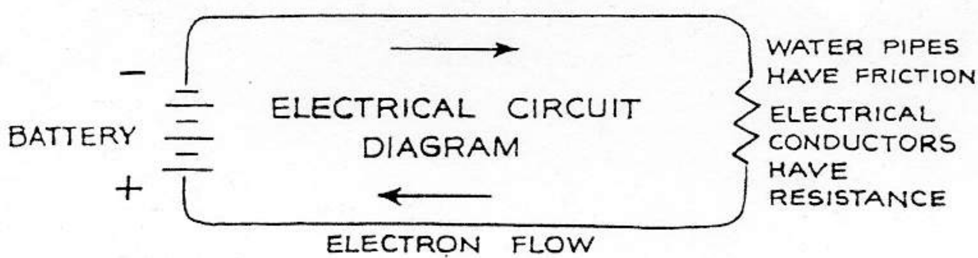
Project 3: build a power supply

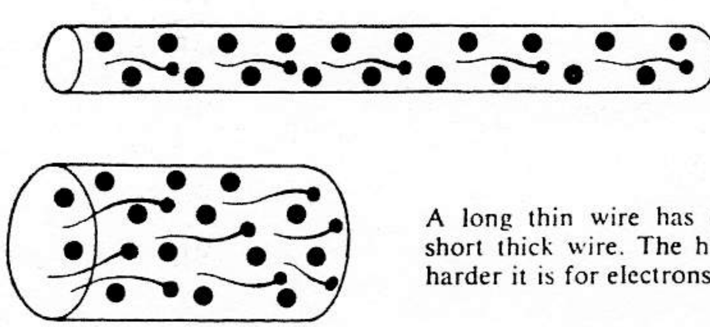
1. Identify your components and their terminals.
2. Draw two geographical schematics, one for each side of the board. (This may seem tedious in the case of this simple circuit, but is a very good habit to get into.) Lay out components in an efficient, tidy and compact way. Connecting wires should be as short as possible.
Note: try to lay out the board using only the wires on the components.
Note: Do not use the entire board for the power supply, we will build other things on it which utilise the DC supply.
3. Test the outputs using a meter.

Appendices





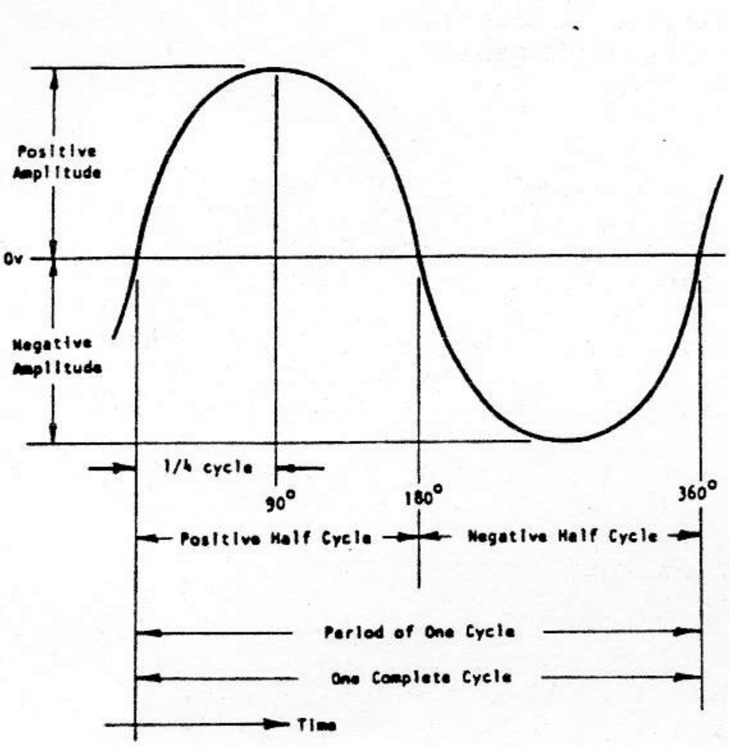




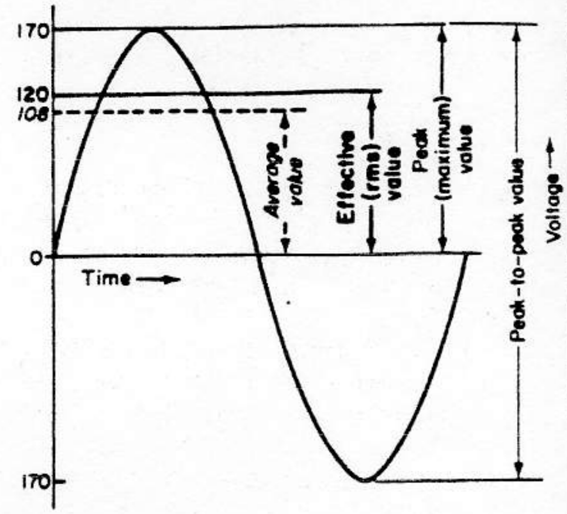
A long thin wire has more resistance than a short thick wire. The higher the resistance, the harder it is for electrons to pass through.

This phenomenon is otherwise known as Impedence

Alternating Current - A.C.



Period = Time for one cycle = $T = \frac{1}{f}$



Peak, or maximum, value = amplitude
Effective, or rms, value = 70.7% of amplitude
Average, or mean, value = 63.7% of amplitude
Peak-to-peak value = 2 x amplitude

Definition:

A current that is continually varying in magnitude and periodically changing direction of flow, caused by a continuously changing and reversing polarity voltage source.

Key Facts:

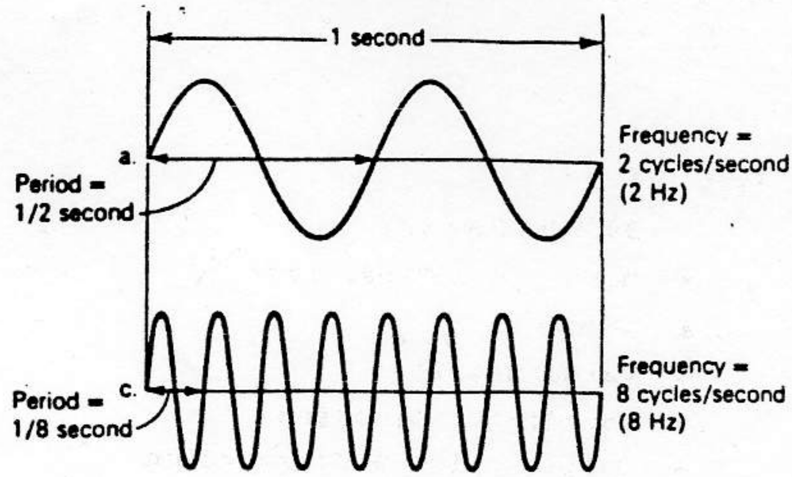
- Approximately 90% of all electric power consumed throughout the world is developed by AC generators.

- A major advantage of AC is that its voltage can be increased or reduced to suit an application, without a major loss of power.

Frequency

4000

Frequency and period of a sine wave.



Definition:

- The number of cycles per unit of time of a reoccurring event, wave or oscillation. Usually measured in cycles per second, known as Hertz.

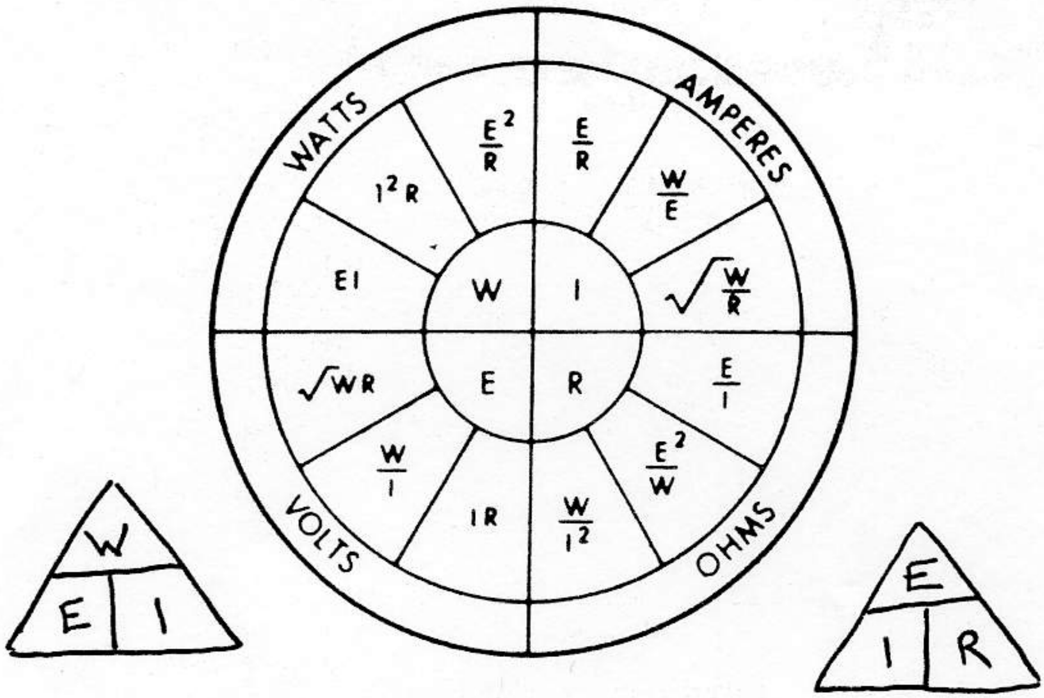
Key Facts:

- Frequency = Number of cycles per second = CPS = f = Hertz = Hz.
- Frequency also equals 1 divided by the period of one cycle.
- 1000 Hz = 1 KHz, 1000 KHz = 1 MHz, 1000 MHz = 1 GHz

Spectrum:

Frequency Band	Classification	Abbreviation
16 Hz - 18KHz	Audio Frequency	AF
60 Hz	Power Line	AC
3 KHz - 30KHz	Very Low Frequency	VLF
30 KHz - 300 KHz	Low Frequency	LF
300 KHz - 3000 KHz	Medium Frequency	MF
535 KHz - 1605 KHz	AM Broadcasting	AM
3 MHz - 30 MHz	High Frequency	HF
30 MHz - 300MHz	Very High Frequency	VHF
54-72, 77-88 MHz	Television Broadcasting	Ch 2-4, 5 & 6
88 MHz - 108 MHz	FM Broadcasting	FM
174 MHz - 216 MHz	Television Broadcasting	Ch 7-13
300 MHz - 3000 MHz	Ultra High Frequency	UHF
471 MHz - 890 MHz	Television Broadcasting	Ch 14-83
3 GHz - 30 GHz	Super High Frequency	SHF
30 GHz - 300 GHz	Extremely High Frequency	EHF

OHM'S LAW



$$\text{WATTS} = \frac{\text{VOLTS}^2}{\text{OHMS}}$$

$$\text{WATTS} = \text{AMPERES}^2 \times \text{OHMS}$$

$$\text{WATTS} = \text{VOLTS} \times \text{AMPERES}$$

$$\text{VOLTS} = \sqrt{\text{WATTS} \times \text{OHMS}}$$

$$\text{VOLTS} = \frac{\text{WATTS}}{\text{AMPERES}}$$

$$\text{VOLTS} = \text{AMPERES} \times \text{OHMS}$$

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

$$\text{AMPERES} = \frac{\text{WATTS}}{\text{VOLTS}}$$

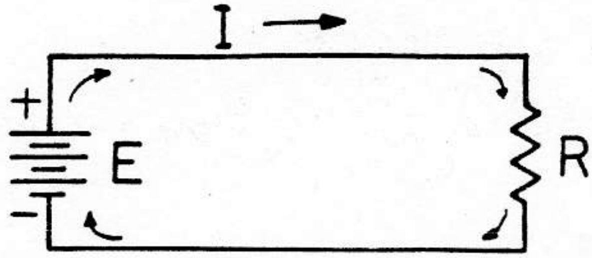
$$\text{AMPERES} = \sqrt{\frac{\text{WATTS}}{\text{OHMS}}}$$

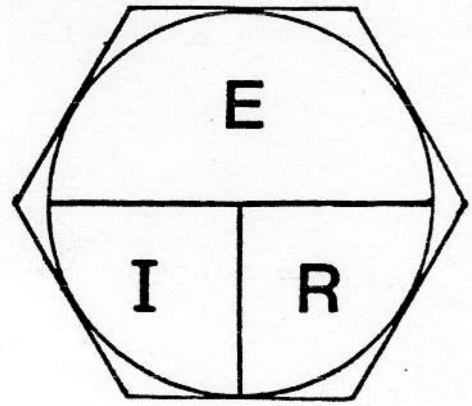
$$\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

$$\text{OHMS} = \frac{\text{VOLTS}^2}{\text{WATTS}}$$

$$\text{OHMS} = \frac{\text{WATTS}}{\text{AMPERES}^2}$$

Ohm's Law





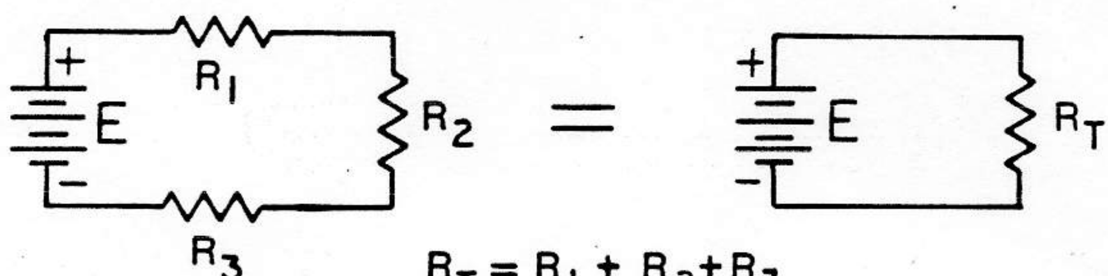
Where: E = Electromotive Force (Voltage) or EMF

I = Current Flow (Amperes)

R = Resistance (Ohms)

$E = I \times R$ $I = E/R$ $R = E/I$

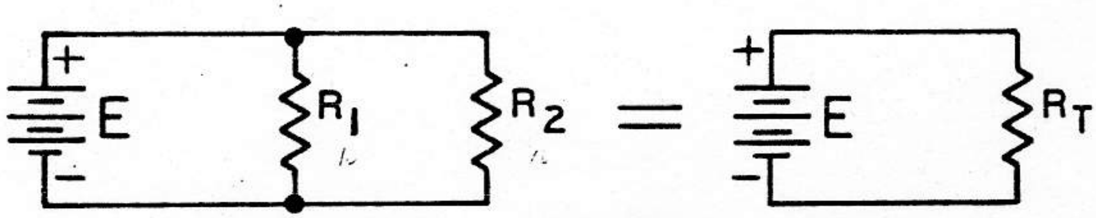
Resistors in Series



$$R_T = R_1 + R_2 + R_3$$

R_T = Resistance Total

Two Resistors in Parallel



$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$ 100 = 5