Basic Electrical Principles

Some Terminology Related to a Circuit:

- When analyzing either DC circuits or AC circuits using Kirchoffs Circuit Laws, a number of definitions and terminologies are used to describe the parts of the circuit being analyzed such as: node, paths, branches, loops and meshes. These terms are used frequently in circuit analysis so it is important to understand them.

Circuit:

The Open Circuit

The Short Circuit

Fuse / Circuit Breaker:

Parameters:

Various elements of an electric circuit are called its parameters like resistance, inductance, capacitance etc.

Linear Circuit:

A linear circuit is one whose parameters are constant i.e. they do not change with voltage or current.

Non-linear Circuit:

A non-linear circuit is one whose parameters change with voltage or current.

Bilateral Circuit:

A bilateral circuit is one whose properties are the same in either direction. The usual transmission line is bilateral, because it can be made to perform its action equally well in either direction.

Unilateral Circuit:

A unilateral circuit is one whose properties change with the direction of its operation. A diode rectifier is a unilateral circuit, because it can perform rectification in both directions.

Electric Network:

A combination of various electric elements, connected in any manner whatsoever, is called an electric network.

Passive Network:

It is a kind of electric network which contains no source of e.m.f. in it.

Active Network:

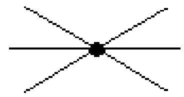
It is a kind of electric network which contains one or more than one source of e.m.f. in it.

Path:

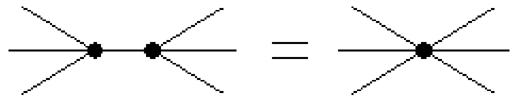
a line of connecting elements or sources with no elements or sources included more than once.

Node:

- It is a junction, connection or terminal in a circuit where two or more circuit elements are connected together.
- A node is indicated by a dot.
- Nodes have no electrical properties of their own and are only a mean to connect circuit parts together.
- Figure below shows an example of a simple node.
- A node acts like an intersection of flowing currents.

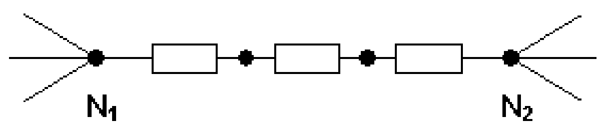


- Note that, two nodes connected together with a short are one. Because the length of a short doesn't matter and you can put these two nodes it the same spot, making just one node, as shown below:



Branch:

- It is a part of a network which lies between any two nodes, consisting of one or more components connected in series.
- There would be no other branches connected in-between the two nodes of one branch.
- Figure below shows an example of a branches between nodes N_1 and N_2.

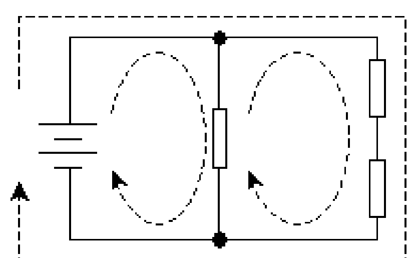


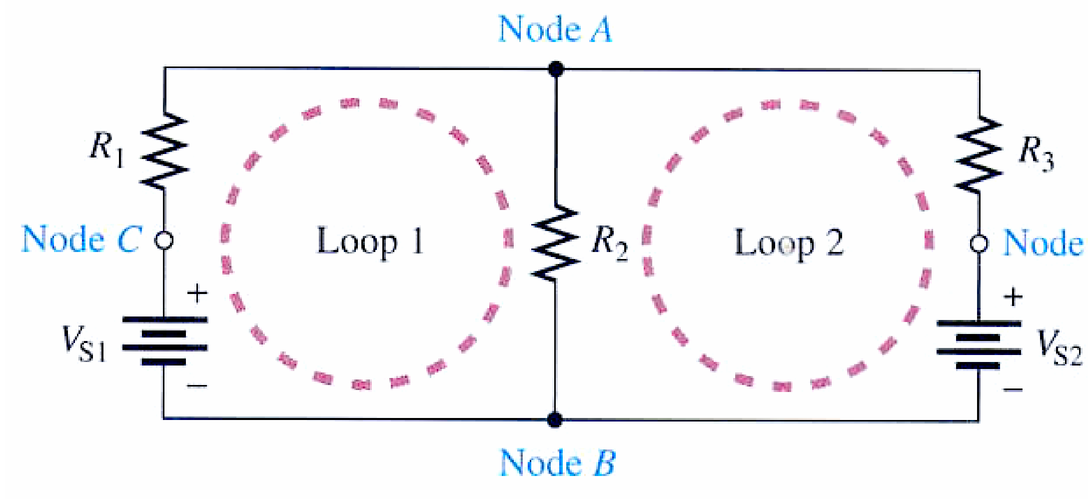
Loop:

It is a close path in a circuit in which no elements or node is encountered more than once.

Mesh:

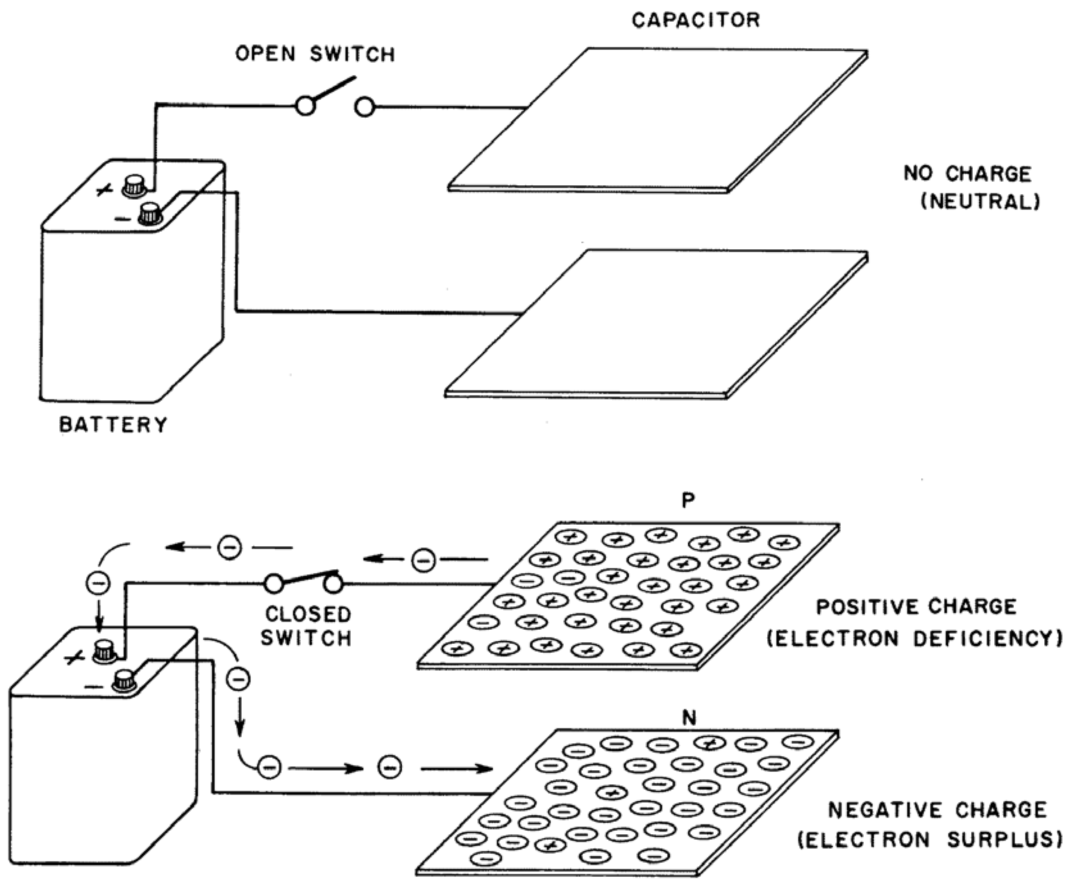
- A mesh in a circuit is any close loop starting and ending with the same node, not passing any node or branch twice.
- A mesh contains no other loop within it.
- Figure below shows three different meshes for a circuit.




Node A
R_1
Node C
+
V_{S1}
−
Loop 1
R_2
Loop 2
R_3
Node
+
V_{S2}
−
Node B

Capacitors

- Capacitors store energy in an electric field.
- A capacitor essentially consists of two conducting surfaces separated by a layer of an insulating medium called dielectric.



Capacitance:

- Capacitance is the property of a capacitor that store electricity.
- The capacitance of a capacitor may be defined as the amount of charge required to create a unit potential difference between its plates.
- Suppose, we give Q coulombs of charge to one of the two plates of a capacitor. If a potential difference of V volts is established between the two, then its capacitance is:

$$C=Q/V$$

- Basic unit of capacitance is the farad (f) or coulomb/volt.
- One farad is actually too large for practical purposes. Hence much smaller units like microfarad (μF), picofarad (pF) are generally used.

Types of Capacitors:

A few of the commonly used capacitors are as follows:

(i) Ceramic capacitors

(ii) Mica capacitors

(iii) Paper capacitors

(iv) Electrolytic capacitors

Calculating Capacitance

While in series:

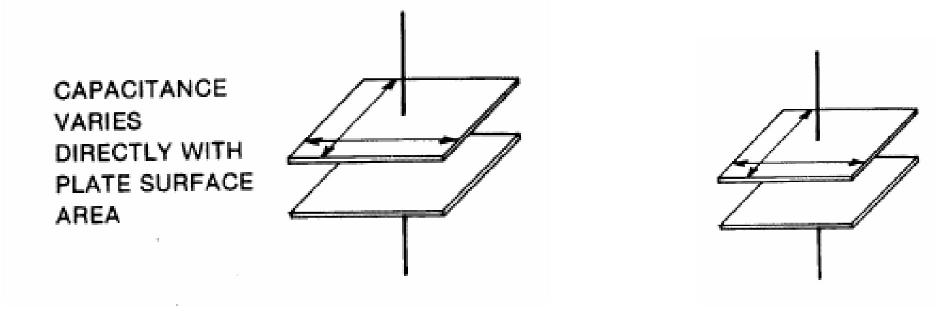
- 1/C=1/C1+1/C2+1/C3

While in parallel:

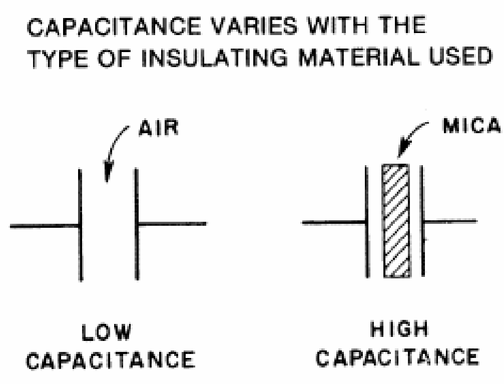
- C=C1+C2+C3

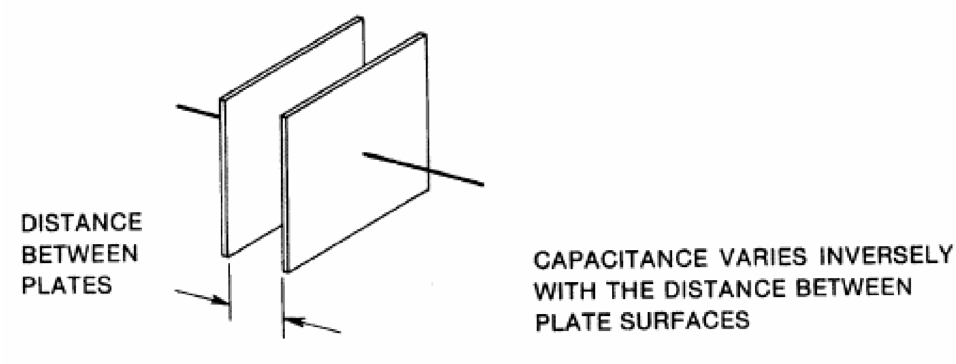
Parameters or Variables determining capacitance:

- Capacitance is determined by 3 factors:
  - » plate surface area
  - » plate spacing
  - » insulating material (dielectric)
- Parallel capacitors increase plate area; so increase charge and hence increase capacitance.
- Series capacitors decrease plate area; so decrease charge and hence decrease capacitance.



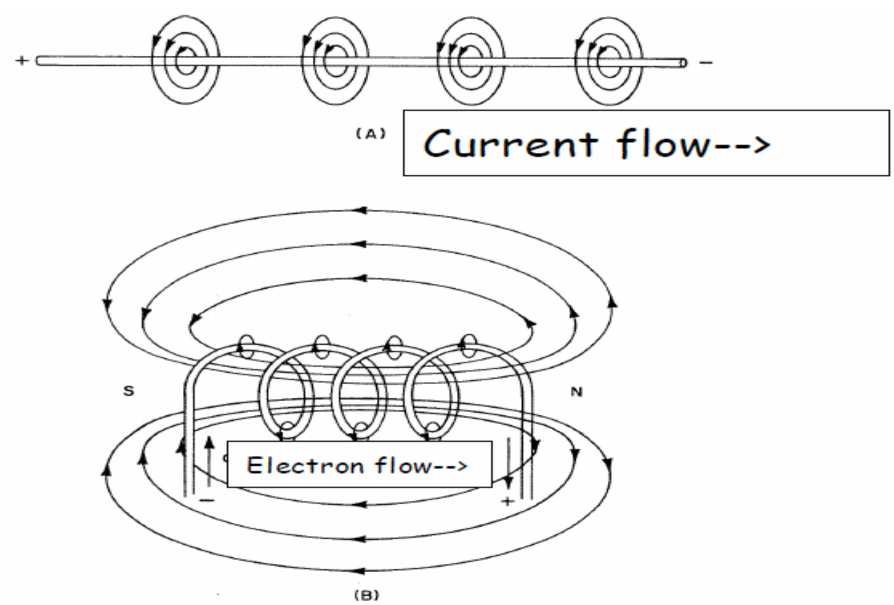
HIGH CAPACITANCE LOW CAPACITANCE





Inductors

- There are two fundamental principles of electromagnetics:
  1. Moving electrons create a magnetic field.
  2. Moving or changing magnetic fields cause electrons to move.
- An inductor is a coil of wire through which electrons move, and energy is stored in the resulting magnetic field.
- Like capacitors, inductors temporarily store energy.
- Unlike capacitors:
  - Inductors store energy in a magnetic field, not an electric field.
  - The magnetic field is proportional to the current. When the current drops to zero, the magnetic field also goes to zero.
- Basic unit of inductance is the henry (h).
- Alphabetically, it is expressed as L.
- The rate at which current through an inductor changes is proportional to the voltage across it.
- A coil (or inductor) has a property called its inductance. The larger the inductance, slower the rate at which the current changes.



Note:

- Current flows from + to -, but is carried by electrons which flow from - to +.

Calculating Inductance

While in series:

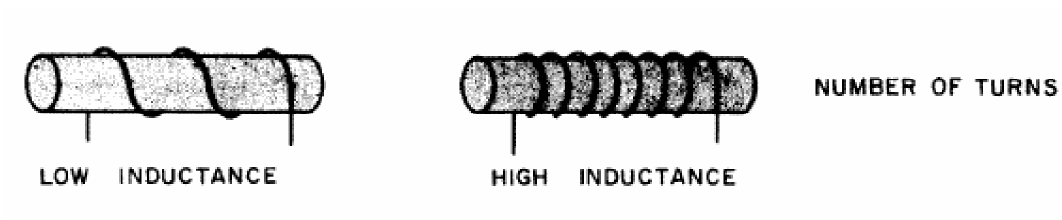
- L=L1+L2+L3

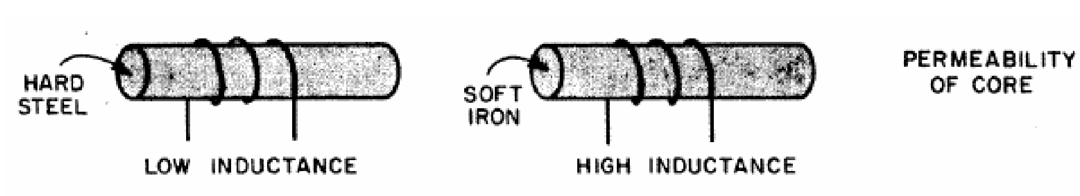
While in parallel:

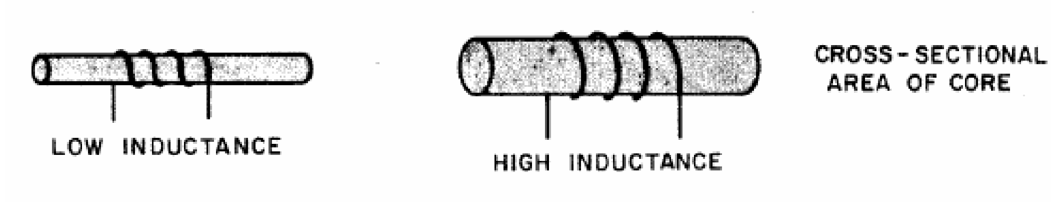
- 1/L=1/L1+1/L2+1/L3

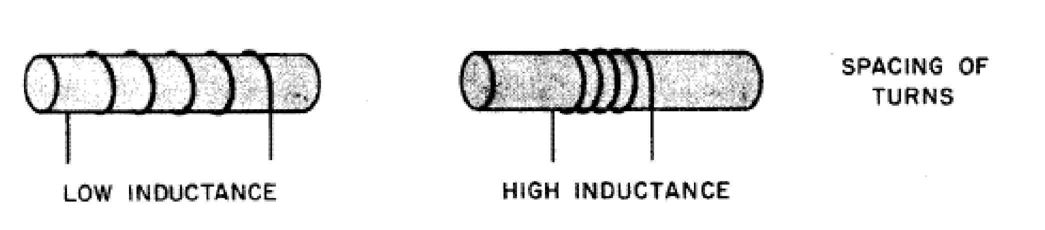
Parameters or Variables determining inductance:

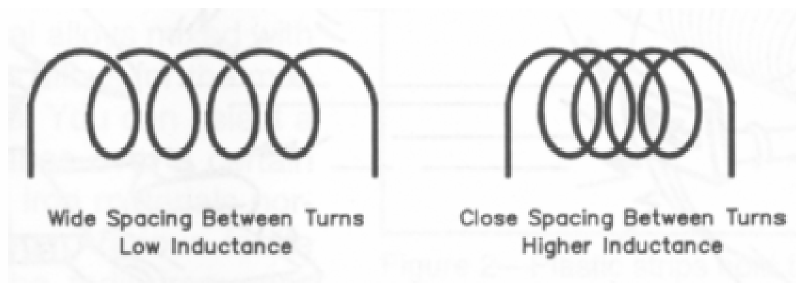
- Inductance (L) of a coil is influenced by 4 factors:
    - » number of turns of the coil
    - » permeability of the core
    - » cross sectional area of the core
    - » spacing of the turns
    - » diameter of the coil
    - » spacing between turns
    - » size of the wire used
    - » type of material used inside the coil

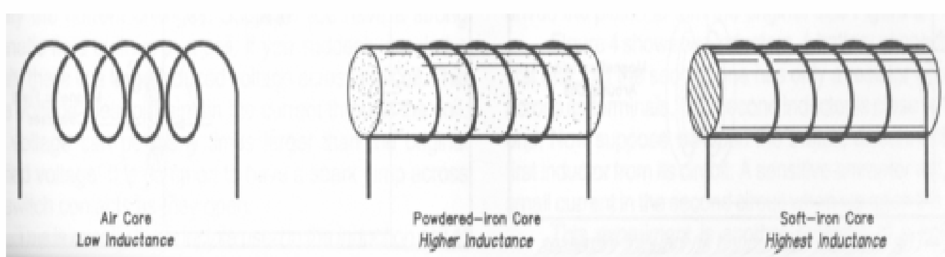




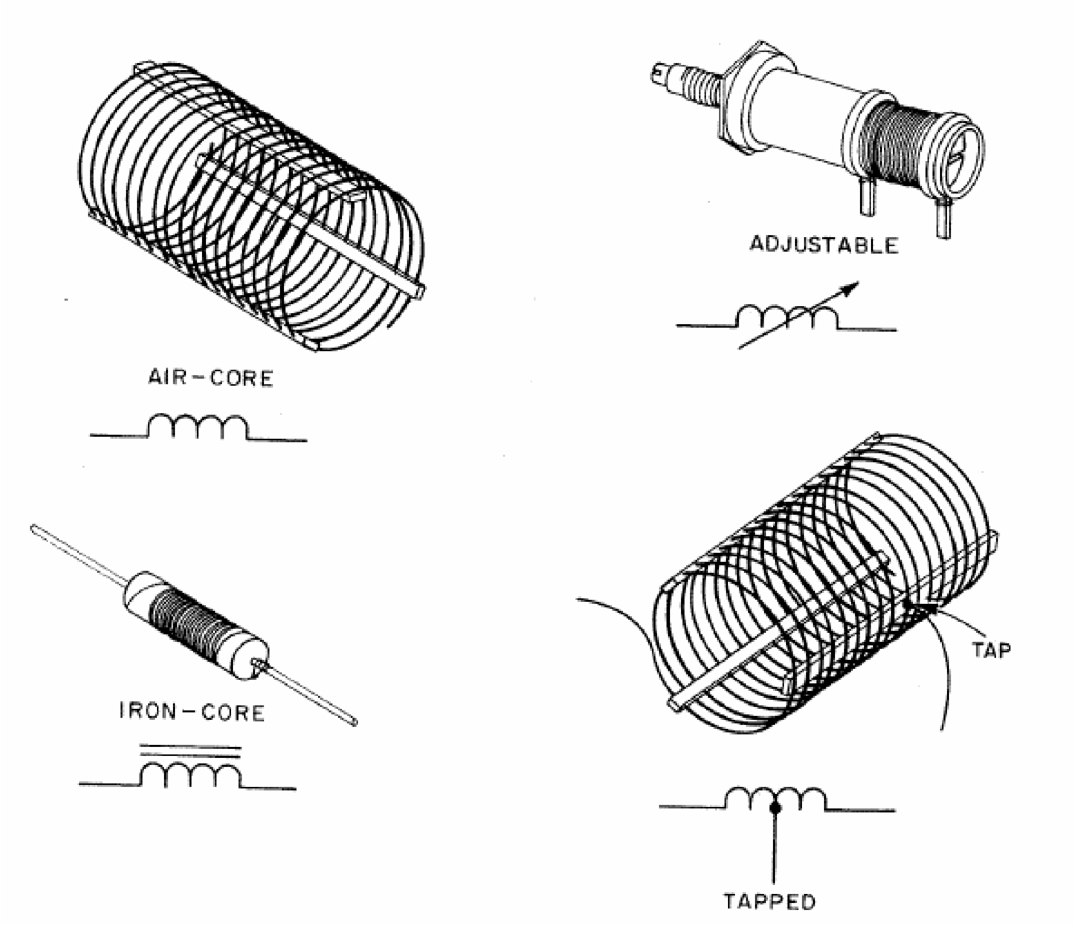

LOW INDUCTANCE
HIGH INDUCTANCE
CROSS-SECTIONAL AREA OF CORE


LOW INDUCTANCE
HIGH INDUCTANCE
SPACING OF TURNS


Wide Spacing Between Turns
Low Inductance
Close Spacing Between Turns
Higher Inductance


Air Core
Low Inductance
Powdered-Iron Core
Higher Inductance
Soft-Iron Core
Highest Inductance

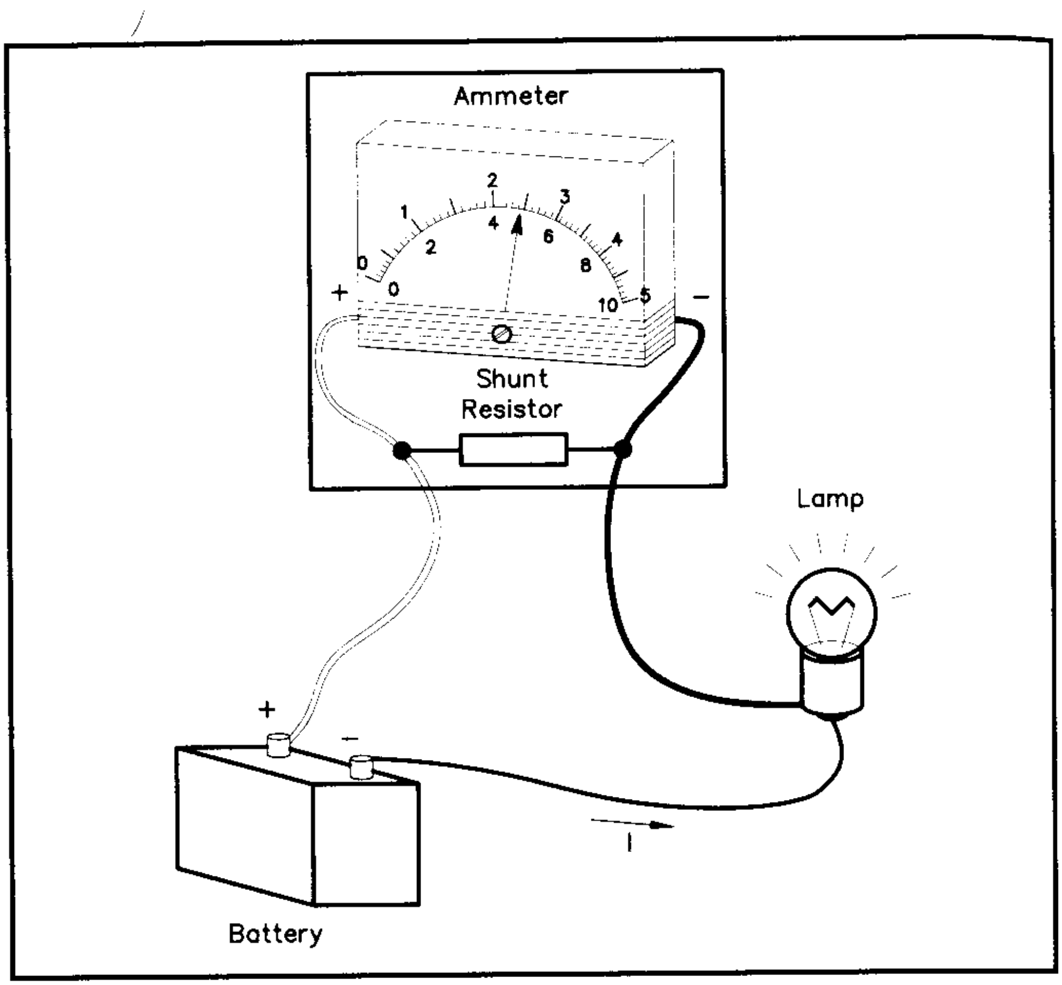
Types of Inductors:



Testing Equipments

Ammeter:

- It is a kind of instrument that measures current.
- To measure current, you must break the current at some point and connect the meter in series at the break. That is, it is hooked up in series with the circuit to be tested.
- A shunt resistor in parallel with the ammeter expands the scale of the meter to measure higher currents than it could normally handle.

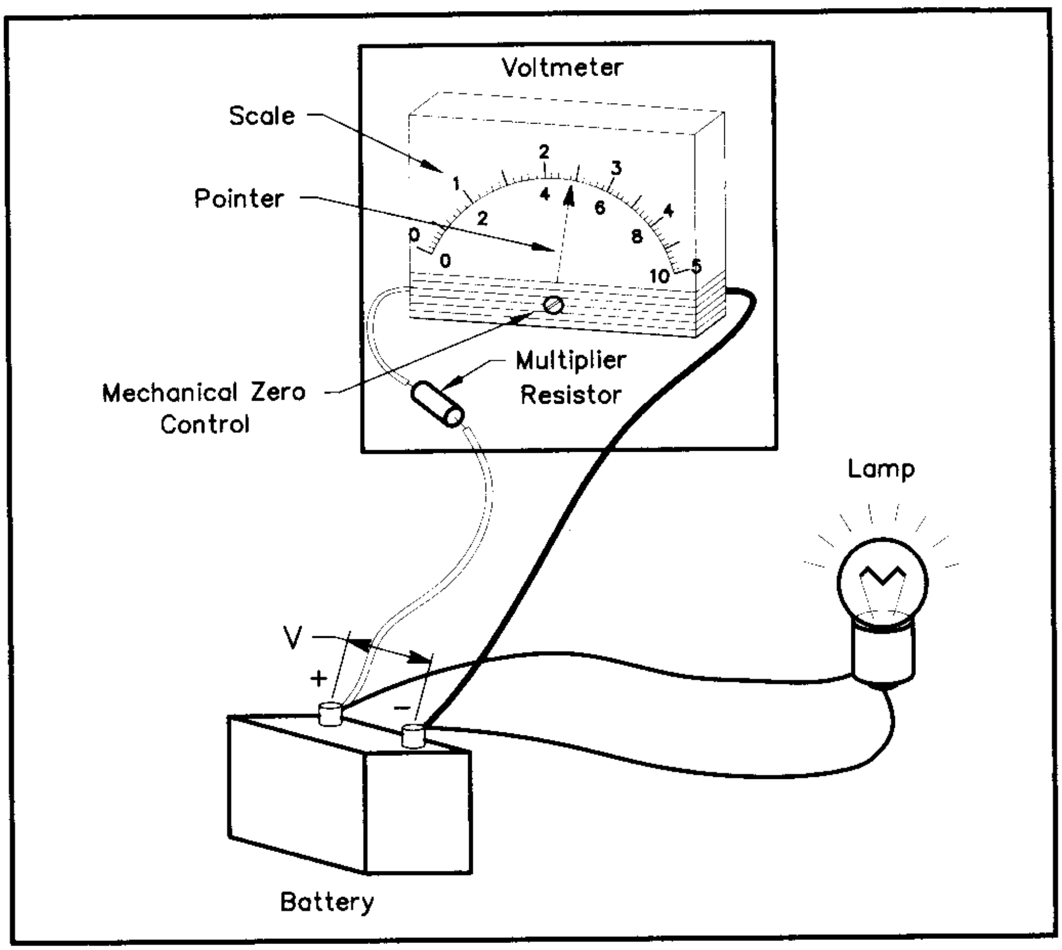


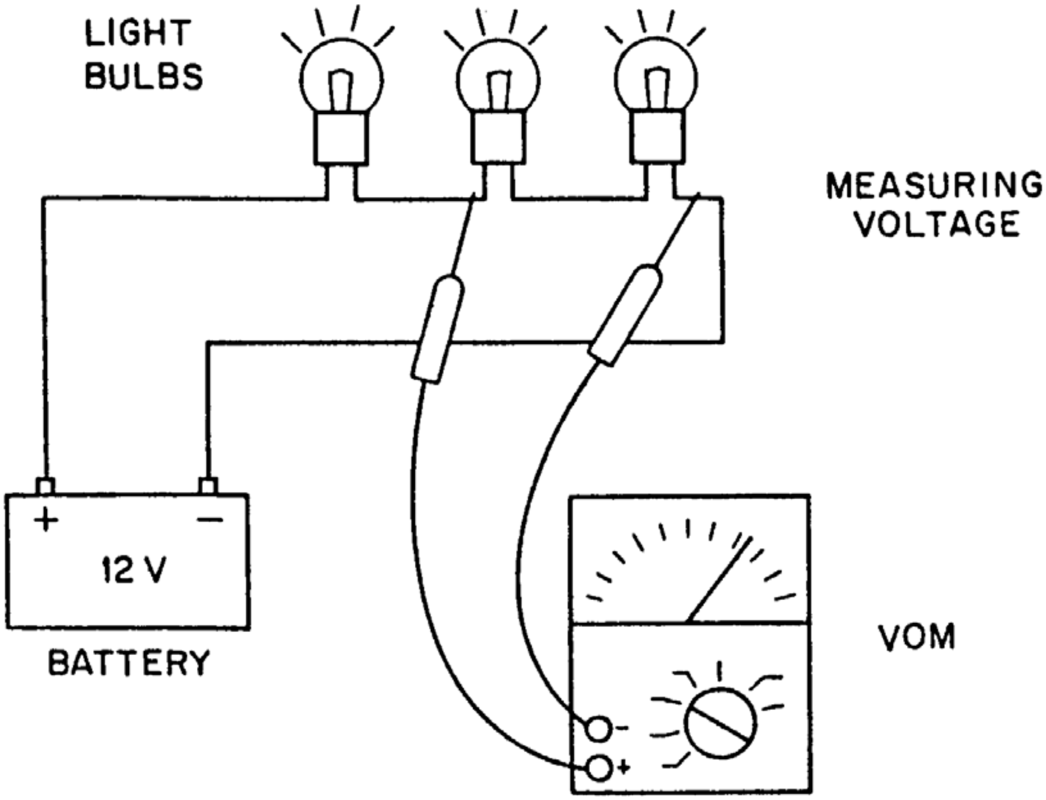
Multimeter (VOM):

- A kind of instrument that combines the function of ammeter, voltmeter, and ohmmeter. It is used to measures volt, resistance, and current.

Voltmeter:

- It is a kind of instrument that measures voltage.
- When you use a voltmeter to measure voltage, the meter must be connected in parallel with the voltage you want to measure. That is, it is used in parallel with a circuit to be measured.
- A series resistor, called the **multiplier resistor** extends the range of the meter.





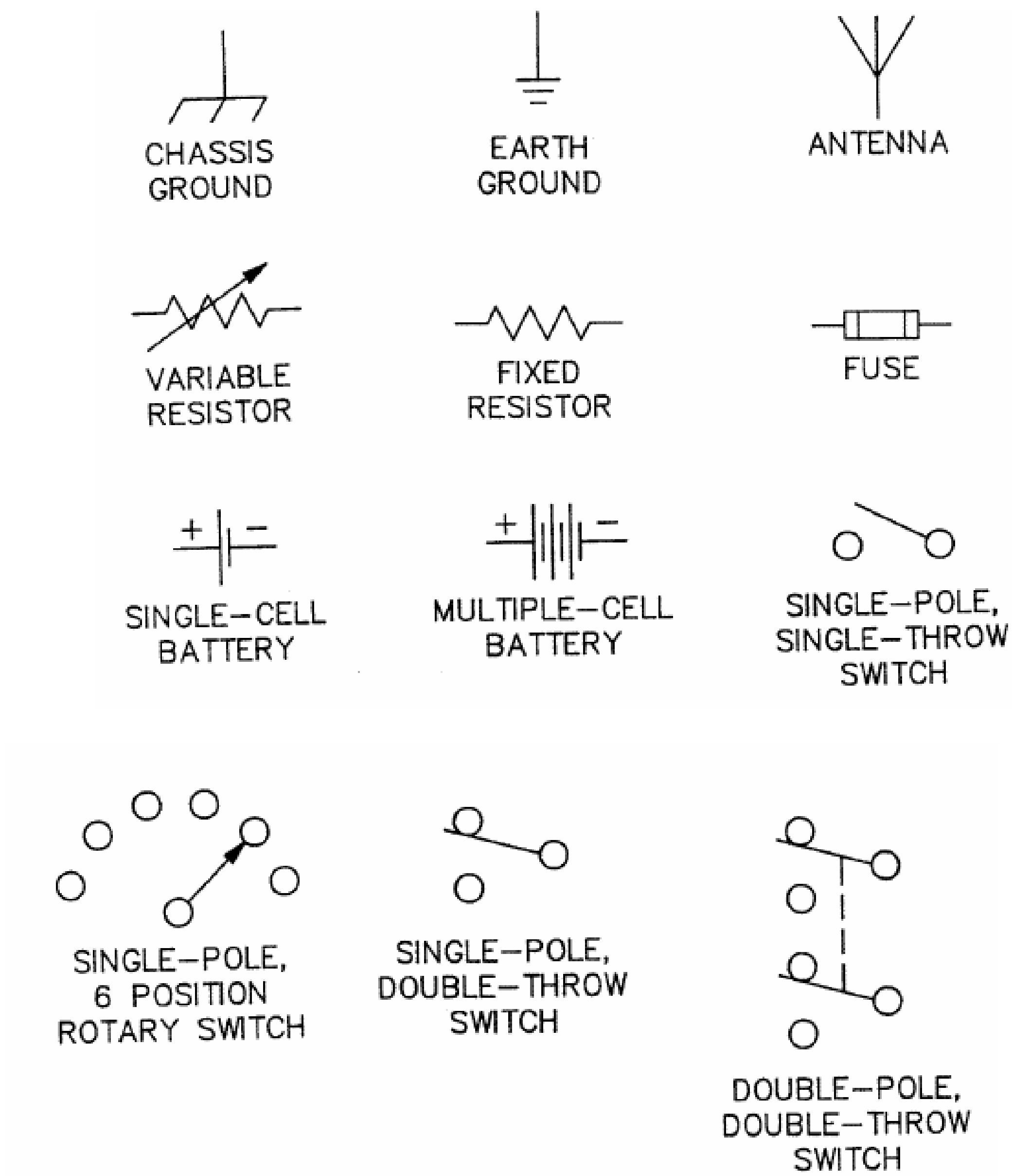
Ohmmeter:

- It is a kind of meter that measures the resistance across a resistor.

Wattmeter:

- It is a device that measures power coming from a transmitter through the antenna feed line.
- A directional wattmeter measures forward and reflected power. Wattmeter generally is useful in certain frequency ranges.

Schematic Symbol of Various Electrical Quantities:



Electrical Units of Measure

- The standard SI units used for the measurement of voltage, current and resistance are the Volt [V], Ampere [A] and Ohms [Ω] respectively.
- Sometimes in electrical or electronic circuits and systems it is necessary to use multiples or sub-multiples (fractions) of these standard units when the quantities being measured are very large or very small.
- The following table gives a list of some of the standard units used in electrical formulas and component values.

Standard Electrical Units

Parameter	Symbol	Measuring Unit	Description
Voltage	Volt	V or E	Unit of Electrical Potential **$V = I \times R$**
Current	Ampere	I or i	Unit of Electrical Current **$I = V \div R$**
Resistance	Ohm	R or Ω	Unit of DC Resistance **$R = V \div I$**
Conductance	Siemen	G or ☐	Reciprocal of Resistance **$G = 1 \div R$**
Capacitance	Farad	C	Unit of Capacitance **$C = Q \div V$**
Charge	Coulomb	Q	Unit of Electrical Charge **$Q = C \times V$**
Inductance	Henry	L or H	Unit of Inductance **$V_L = -L(di/dt)$**
Power	Watts	W	Unit of Power **$P = V \times I$ or $I^2 \times R$**
Impedance	Ohm	Z	Unit of AC Resistance **$Z^2 = R^2 + X^2$**
Frequency	Hertz	Hz	Unit of Frequency **$f = 1 \div T$**

Multiples and Sub-multiples of SI Units

- There is a huge range of values encountered in electrical and electronic engineering between a maximum value and a minimum value of a standard electrical unit. For example, resistance can be lower than 0.01Ω's or higher than 1,000,000Ω's.
- By using multiples and submultiple's of the standard unit we can avoid having to write too many zero's to define the position of the decimal point.
- The table below gives their names and abbreviations.

Prefix	Symbol	Multiplication Factor
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	106
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
UNIT		10^{0}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}