Basic Electronics

Chapter 2

Basic Electrical Principles and the Functions of Components

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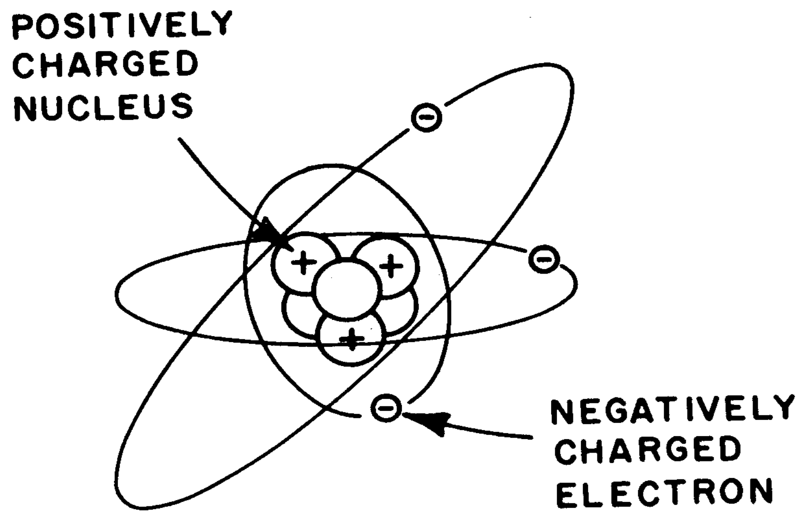
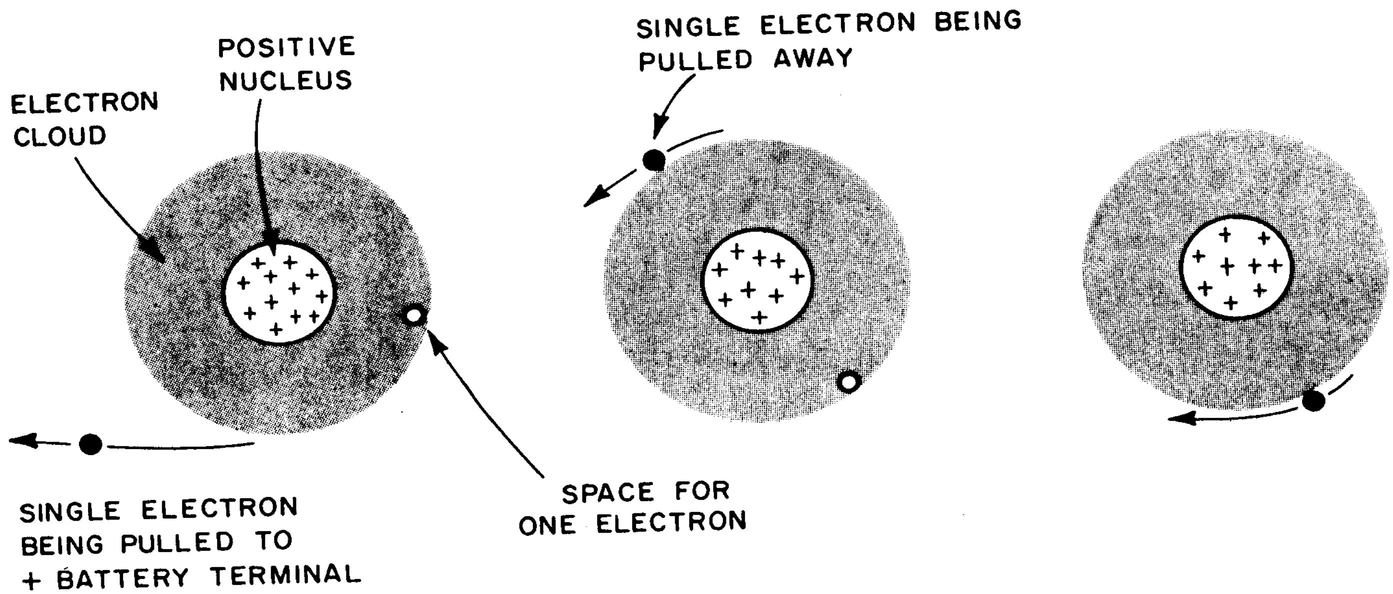
This booklet was compiled by John P. Cross AB5OX

Basic Electrical Principles

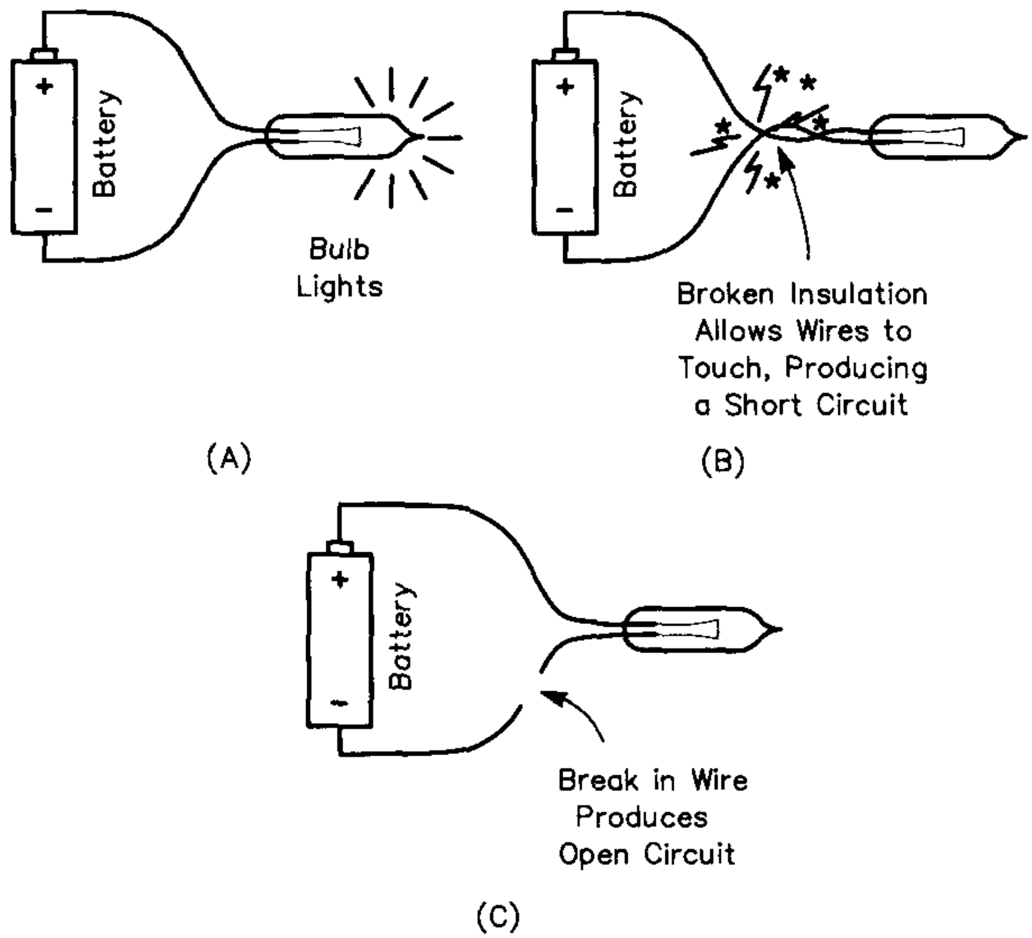
- Conductors - keep loose grip on their electrons and allow electrons to move freely. Metals are usually good conductors.
- Insulators - keep close hold of their electrons and do not allow free movement of electrons. Glass, wood, plastic, mica, fiberglass and air are good insulators.
- Electromotive Force (EMF) is the force that moves electrons through conductors. Its unit of measure is the Volt. Think of it as pressure.
- Voltage Source - has two terminals (+ and -). Some examples are car batteries (12 volts DC), D cell batteries (1.5 volts DC) and a wall socket (120 volts AC).
- Current - is the flow of electrons. It is measured in amperes.
- Resistance (ohms, Ω) is the ability to oppose an electrical current.


POSITIVELY
CHARGED
NUCLEUS
NEGATIVELY
CHARGED
ELECTRON


ELECTRON
CLOUD
POSITIVE
NUCLEUS
SINGLE ELECTRON BEING
PULLED AWAY
SINGLE ELECTRON
BEING PULLED TO
+ BATTERY TERMINAL
SPACE FOR
ONE ELECTRON

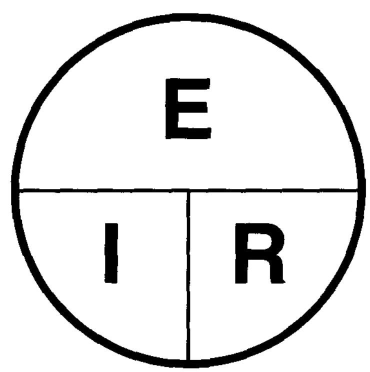
Circuit Definitions

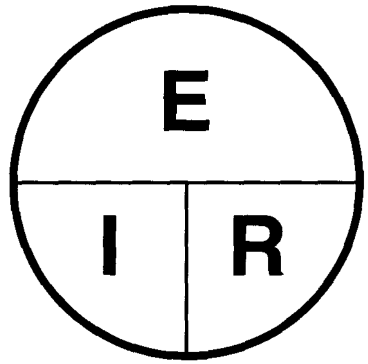
A circuit must close to be complete!



Ohm's Law

- Ohm's Law relates Current (I), Voltage (E) and Resistance (R)
- The relationship can be written three ways:
  - » $E = I \times R$
  - » $I = E / R$
  - » $R = E/I$





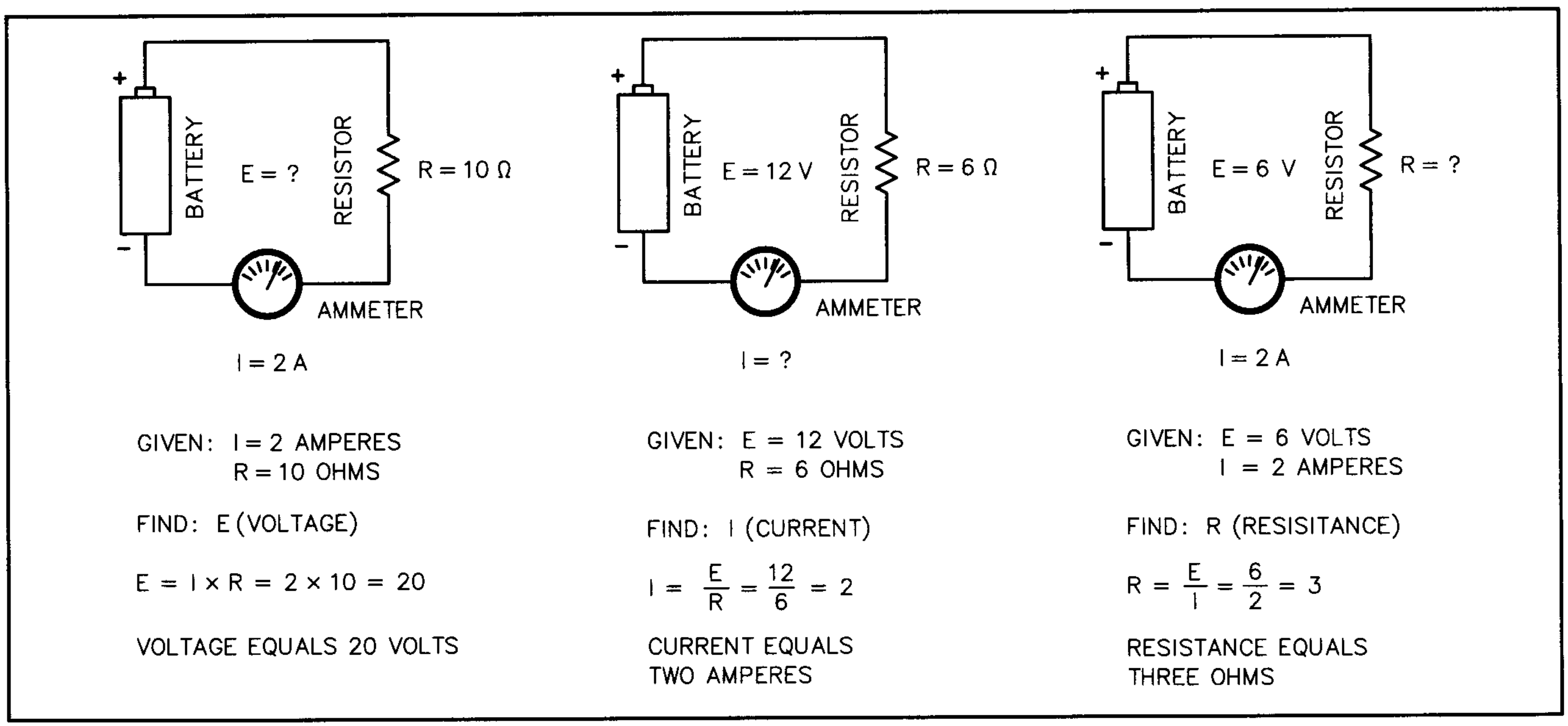


Figure 5-8—This drawing shows some Ohm's Law problems and solutions.

Resistors

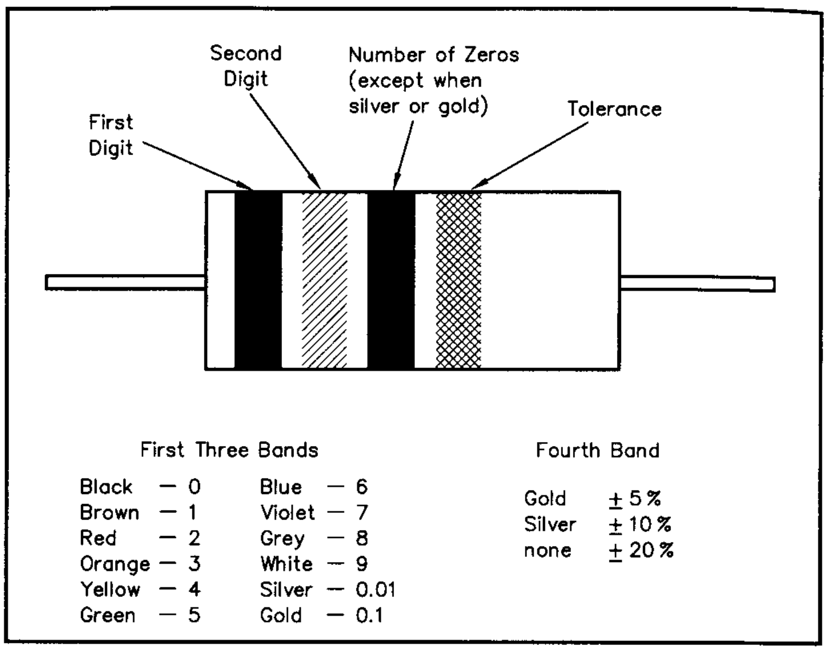
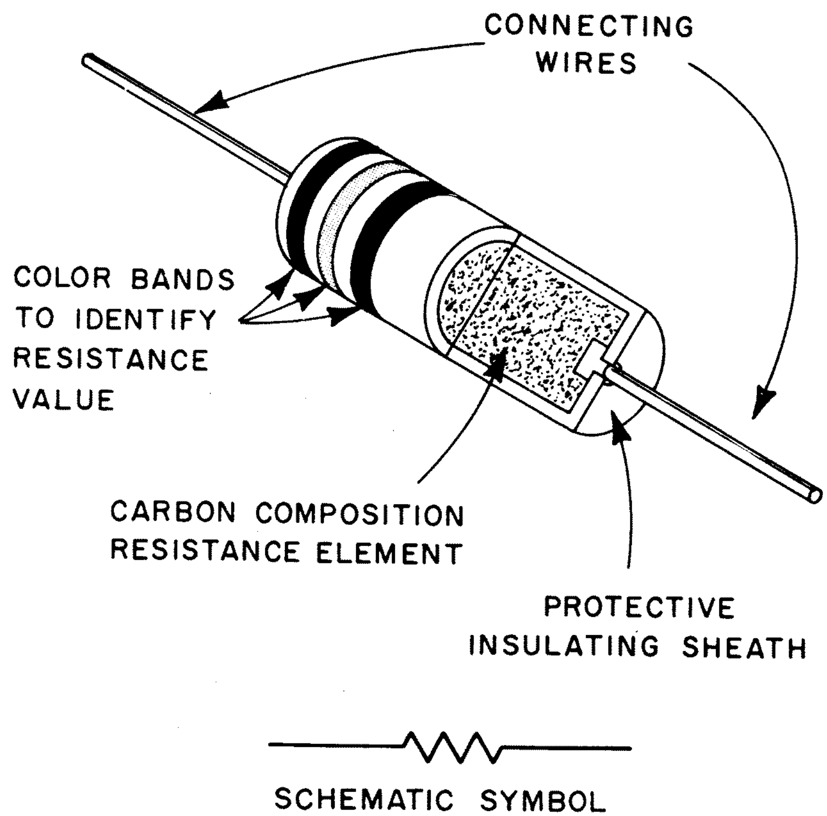
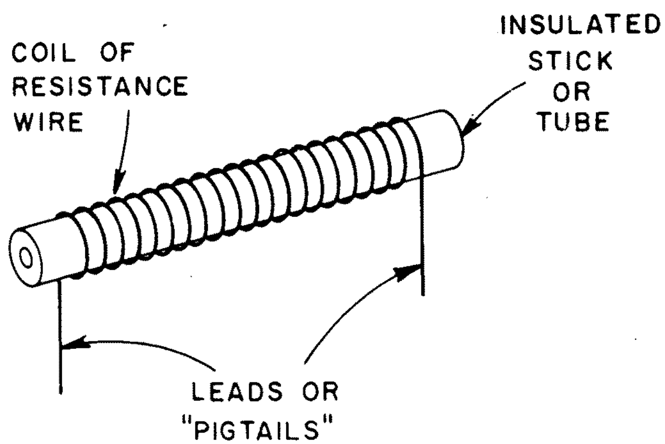


Figure 6-23 — Small resistors are labeled with a color code to show their value. For example, proceeding from left to right, a resistor with color bands of yellow/violet/brown/gold is a 470-Ω resistor with a 5% tolerance.

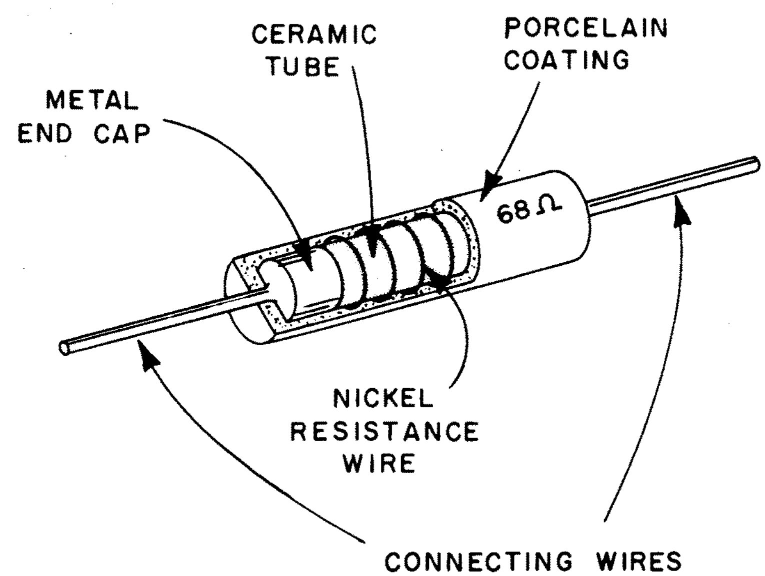


Mnemonic: "Black Bears Run On Young Grass By Violets Growing Wild"

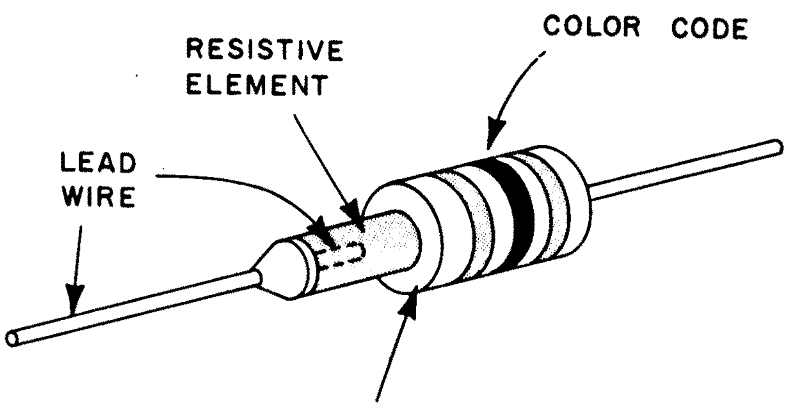
Resistor Types - Precision



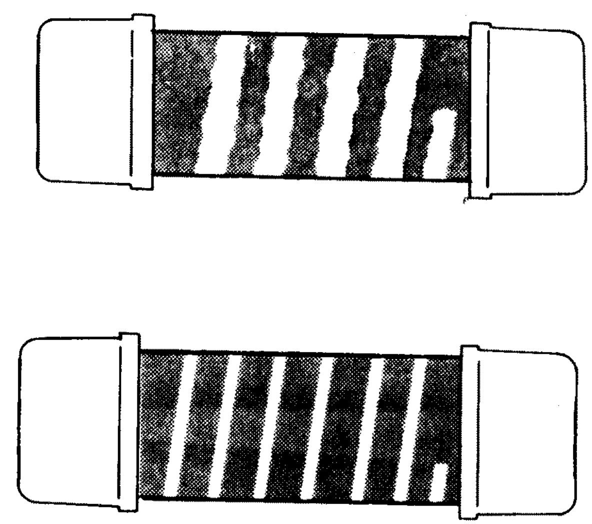
(A)



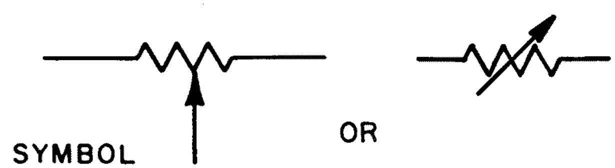
Resistors - Film Type

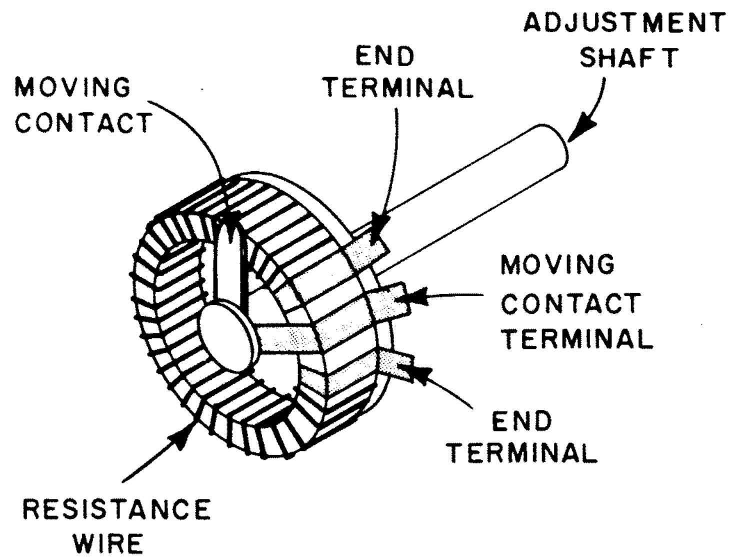


FILM TYPE RESISTOR

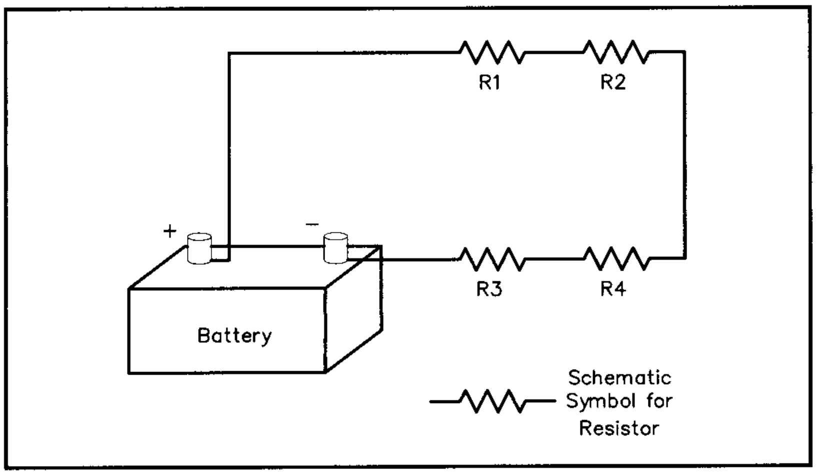


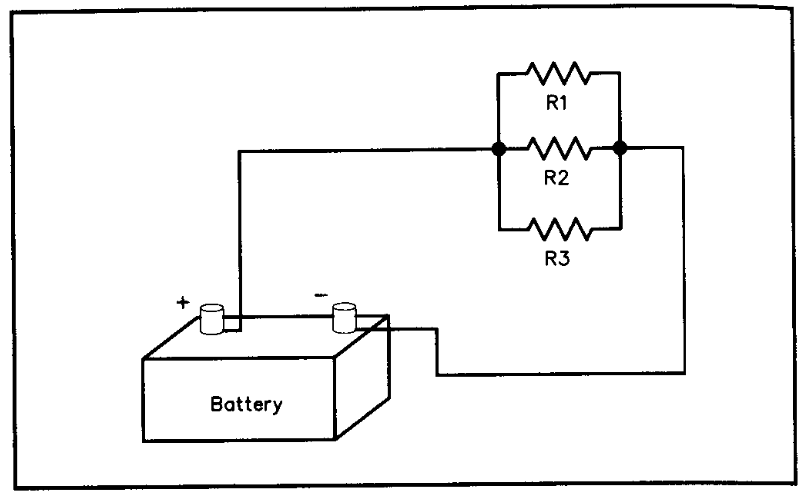
Resistors - Variable





Calculating Resistance





- Series:

R=R1+R2+R3+R4

(the voltage adds up)

- Parallel:

1/R=1/R1+1/R2+1/R3

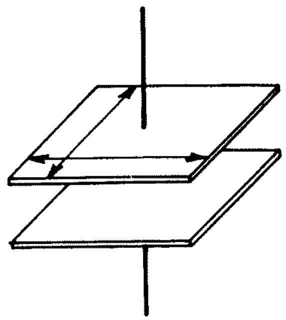
(the current adds up)

Capacitors

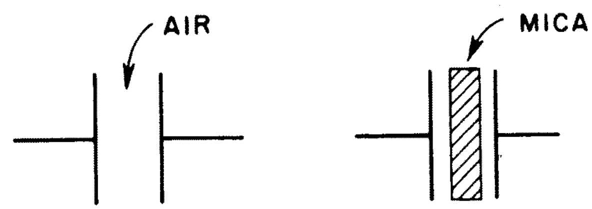
- Capacitors store energy in an electric field
- Basic unit of capacitance is the farad (f)
- Series: $1/C=1/C1+1/C2+1/C3$
- Parallel: $C=C1+C2+C3$
- Capacitance is determined by 3 factors:
  - » plate surface area
  - » plate spacing
  - » insulating material (dielectric)

Variables Determining Capacitance

CAPACITANCE VARIES DIRECTLY WITH PLATE SURFACE AREA



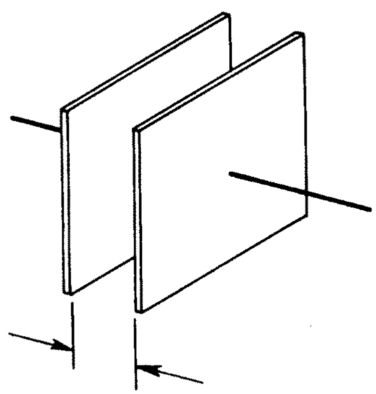
CAPACITANCE VARIES WITH THE TYPE OF INSULATING MATERIAL USED



LOW CAPACITANCE

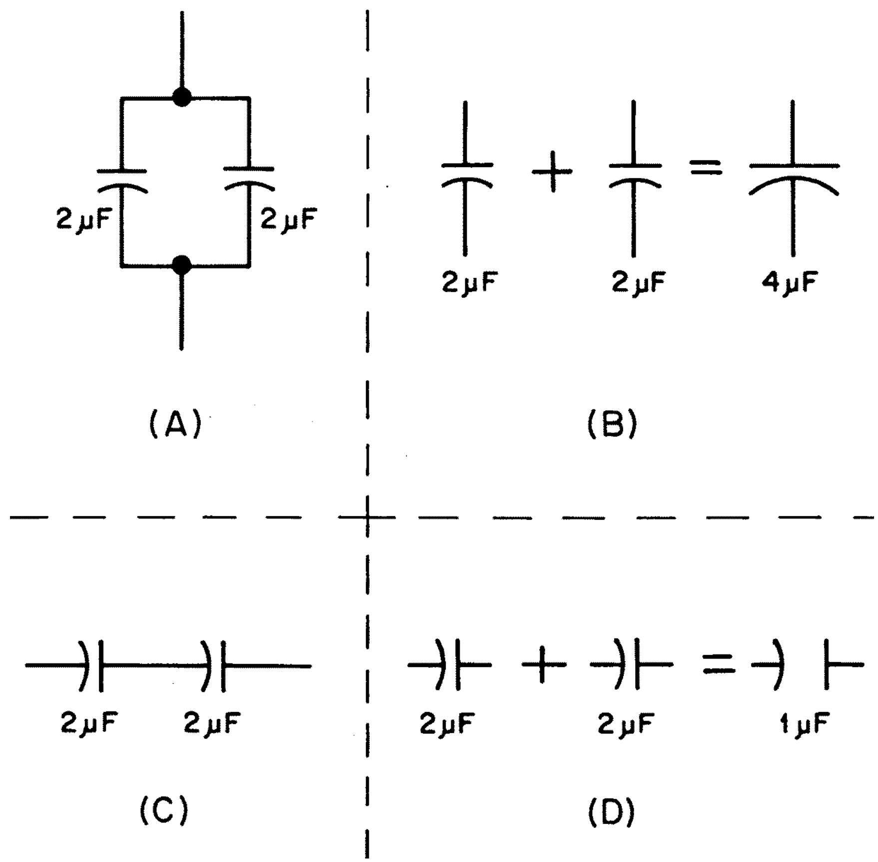
HIGH CAPACITANCE

DISTANCE BETWEEN PLATES

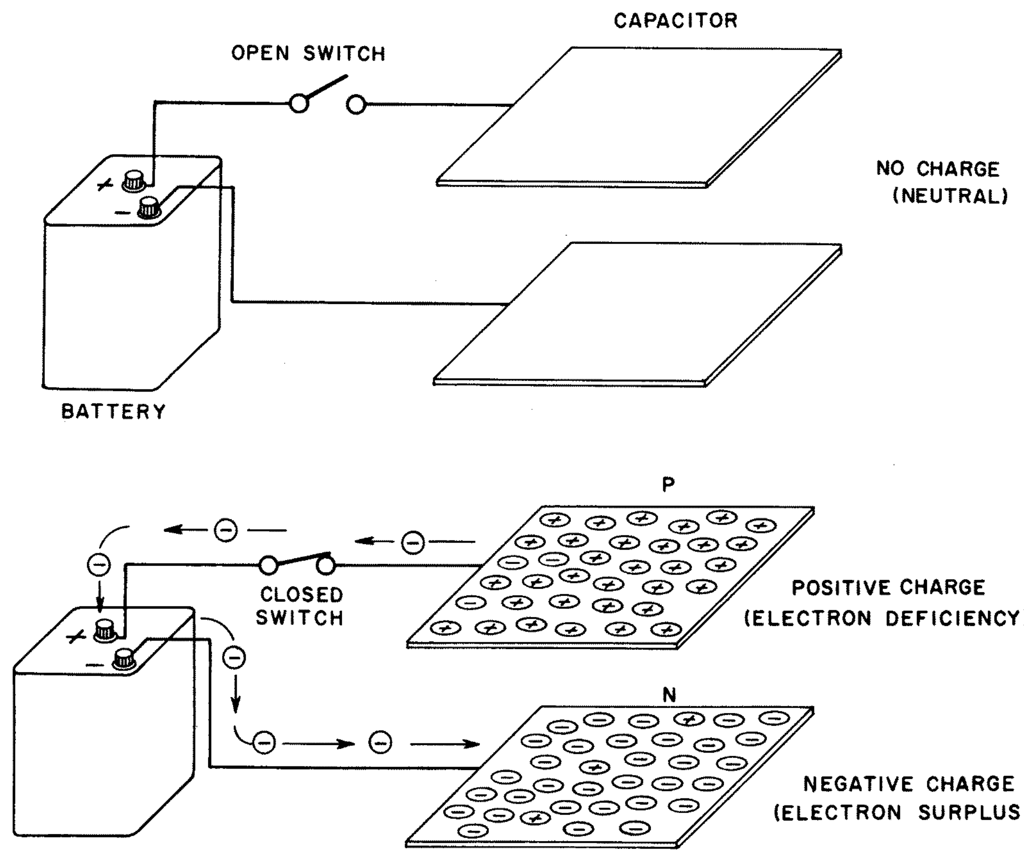


CAPACITANCE VARIES INVERSELY WITH THE DISTANCE BETWEEN PLATE SURFACES

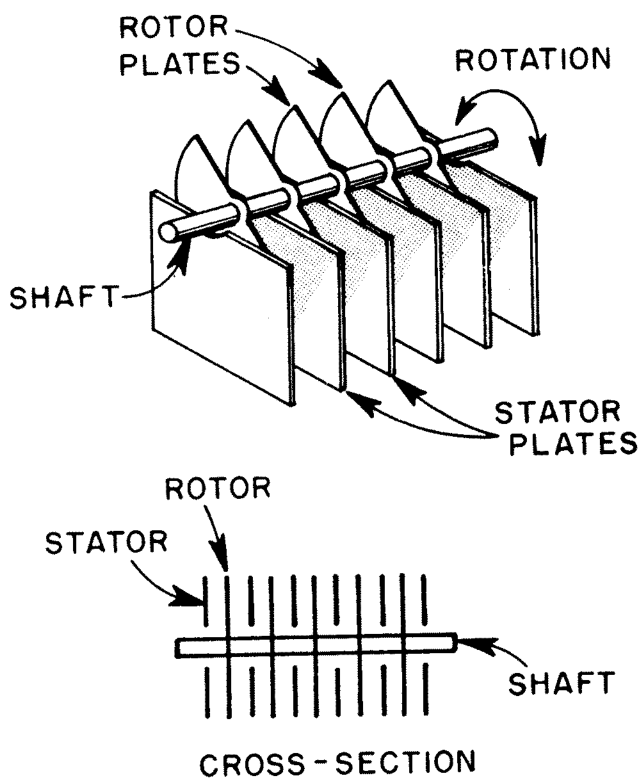
Parallel Capacitors Increase Plate Area; increase charge so C



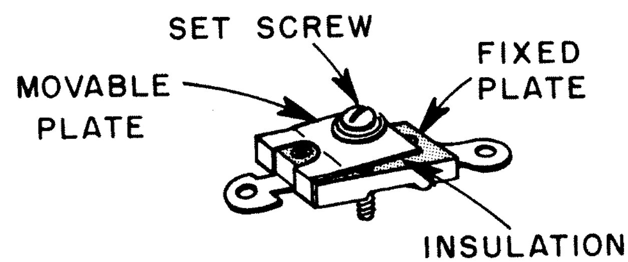
Capacitors Store Energy in Electric Field



Variable Capacitors



(A) AIR VARIABLE

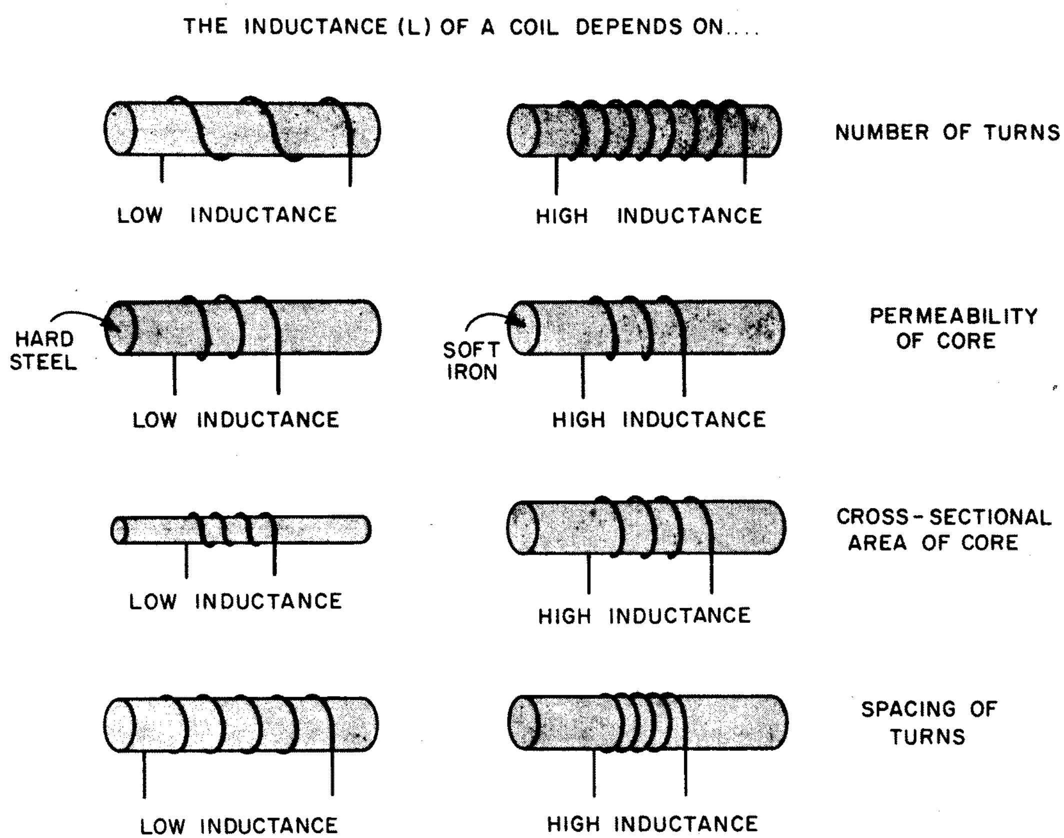


(B) COMPRESSION TRIMMER

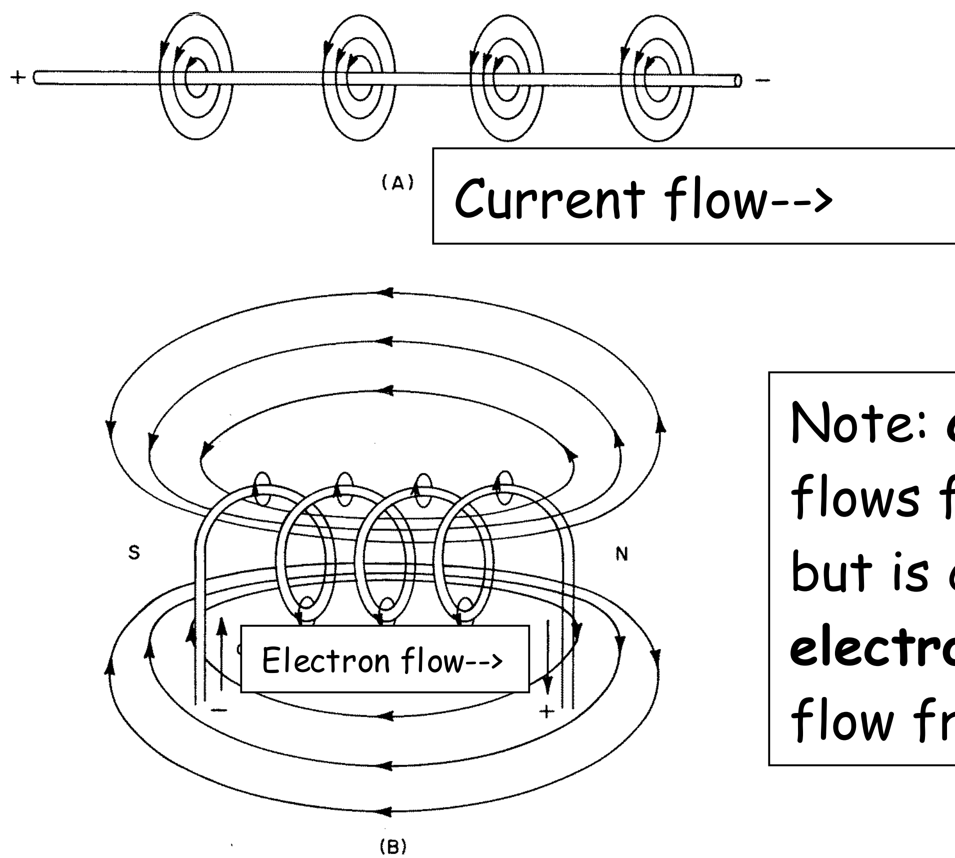
Inductors

- Inductors store energy in a magnetic field (like a little electromagnet)
- Basic unit of inductance is the henry (h)
- Parallel: 1/L=1/L1+1/L2+1/L3
- Series: L=L1+L2+L3
- Inductance is determined by 4 factors:
  - » number of turns
  - » permeability of the core
  - » cross sectional area of the core
  - » spacing of the turns

Variables Determining Inductance

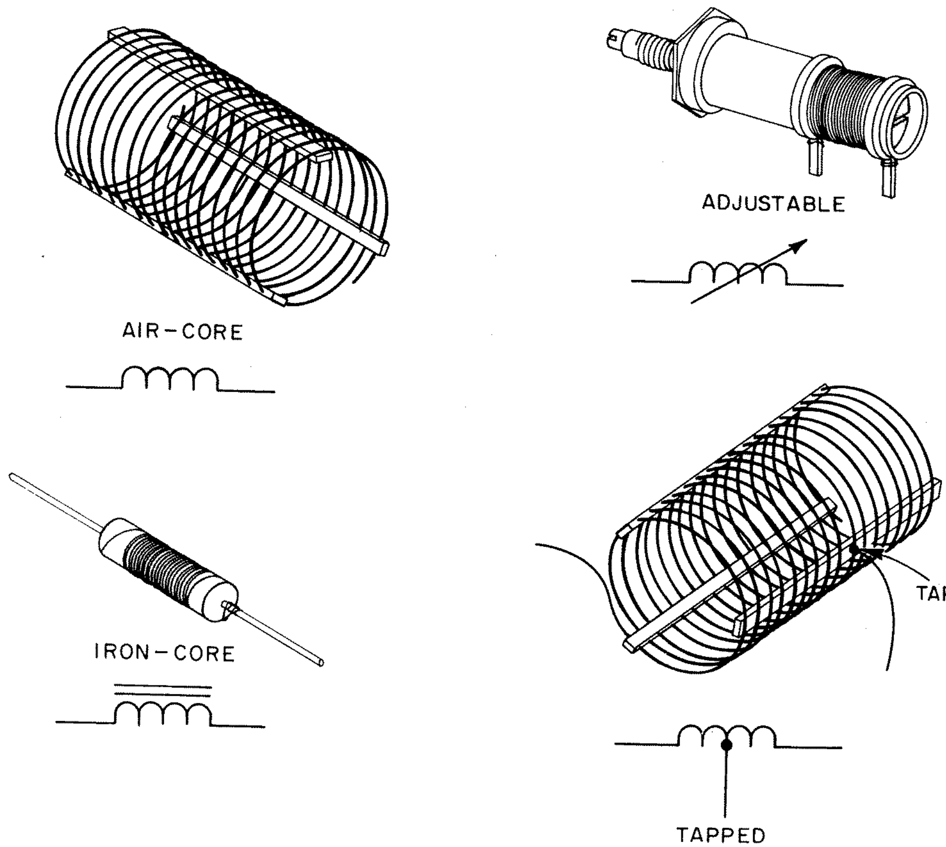


Inductors Store Energy in Magnetic Field



Note: **current** flows from + to -, but is carried by **electrons** which flow from - to +

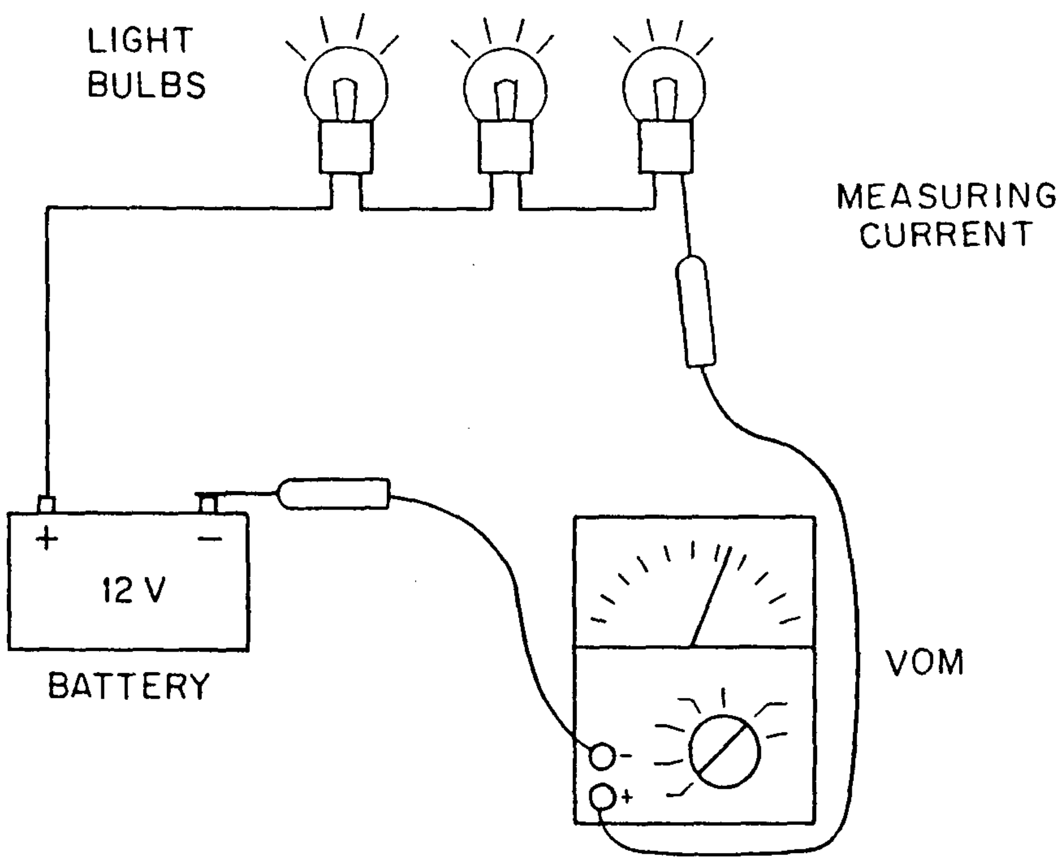
Types of Inductors



Power

- Power is the rate of energy consumption.
- The basic unit of power is the watt (W)
- Power can be calculated as follows:
  - » $P = I \times E$
- Since $E = I \times R$, you can also say:
  - » $P = I^2 \times R$
- Since $I = E / R$, you can also say:
  - » $P = E^2 / R$

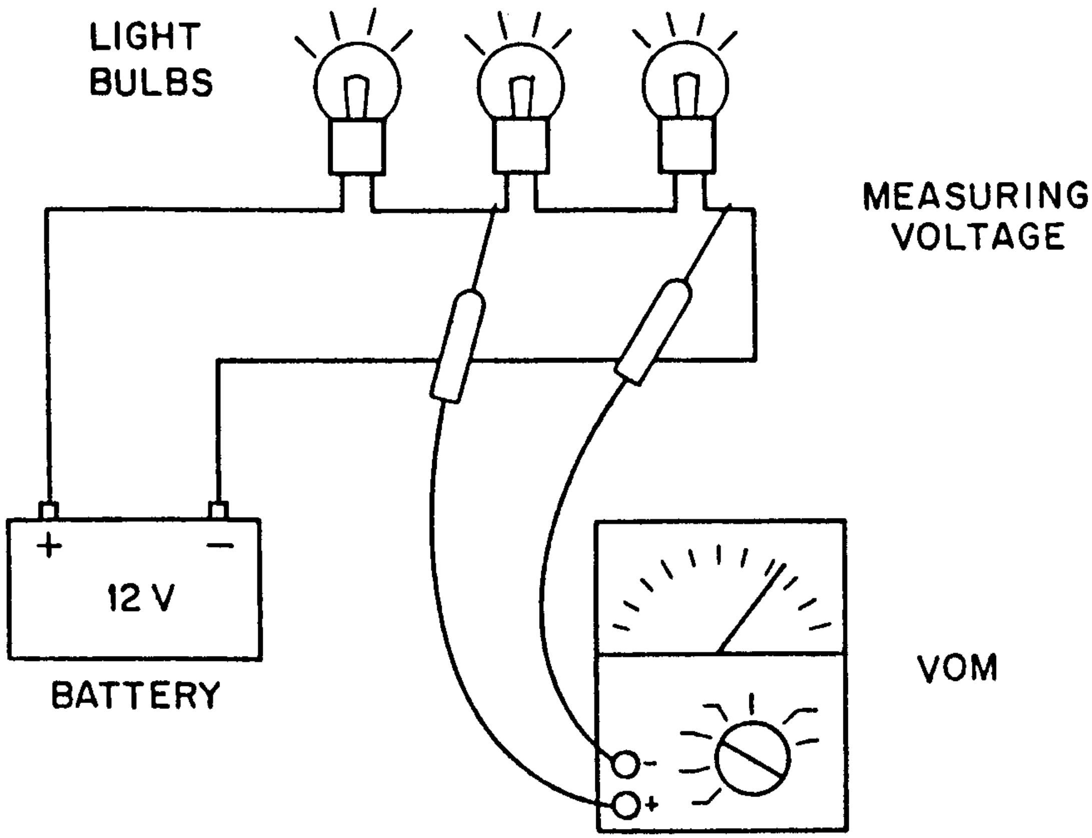
Meters - Measuring Current



Ammeter must be part of the circuit to measure the current

VOM - multimeter that measures E, I, R

Meters - Measuring Voltage



Voltmeter measures **across** the circuit (in parallel to the voltage to be measured)

Meters - Measuring Resistance

Ohmmeter: measures **across** the resistor (but be sure the circuit is not turned on “hot”). Puts in a known voltage and measures the current, so it requires a battery. If the circuit is energized, will give the wrong reading!

Never leave a multimeter set at “ohms” - will run down its battery!

Meters - Changing Range

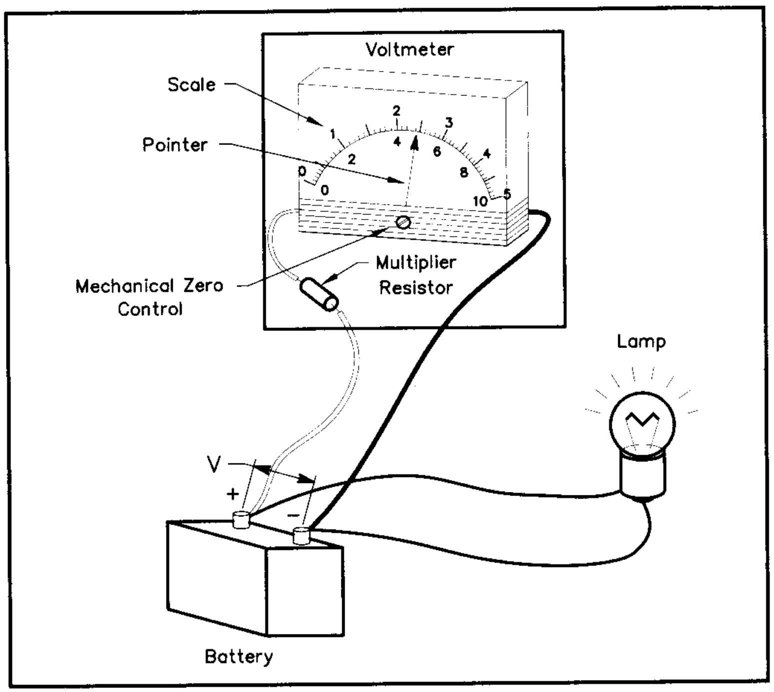


Figure 4-12—When you use a voltmeter to measure voltage, the meter must be connected in parallel with the voltage you want to measure.

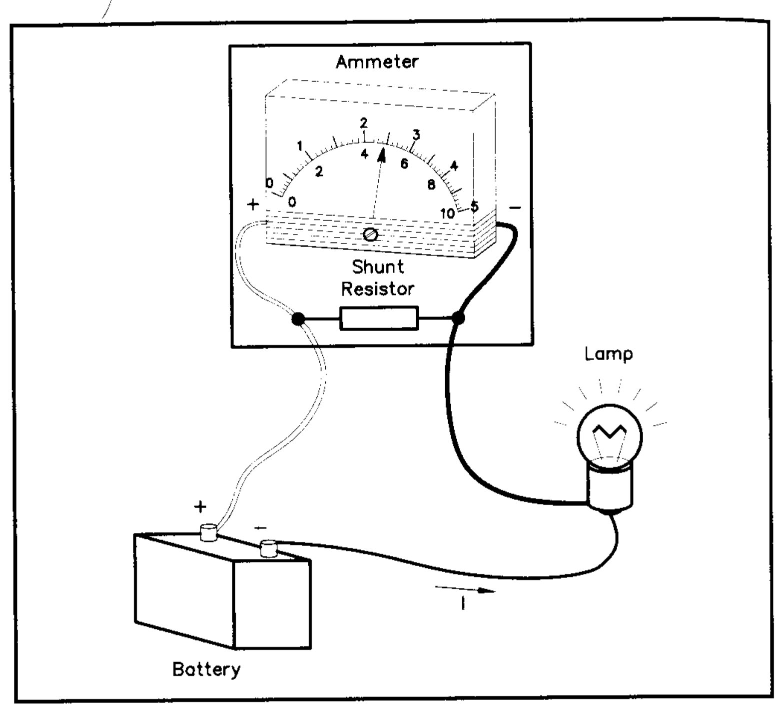
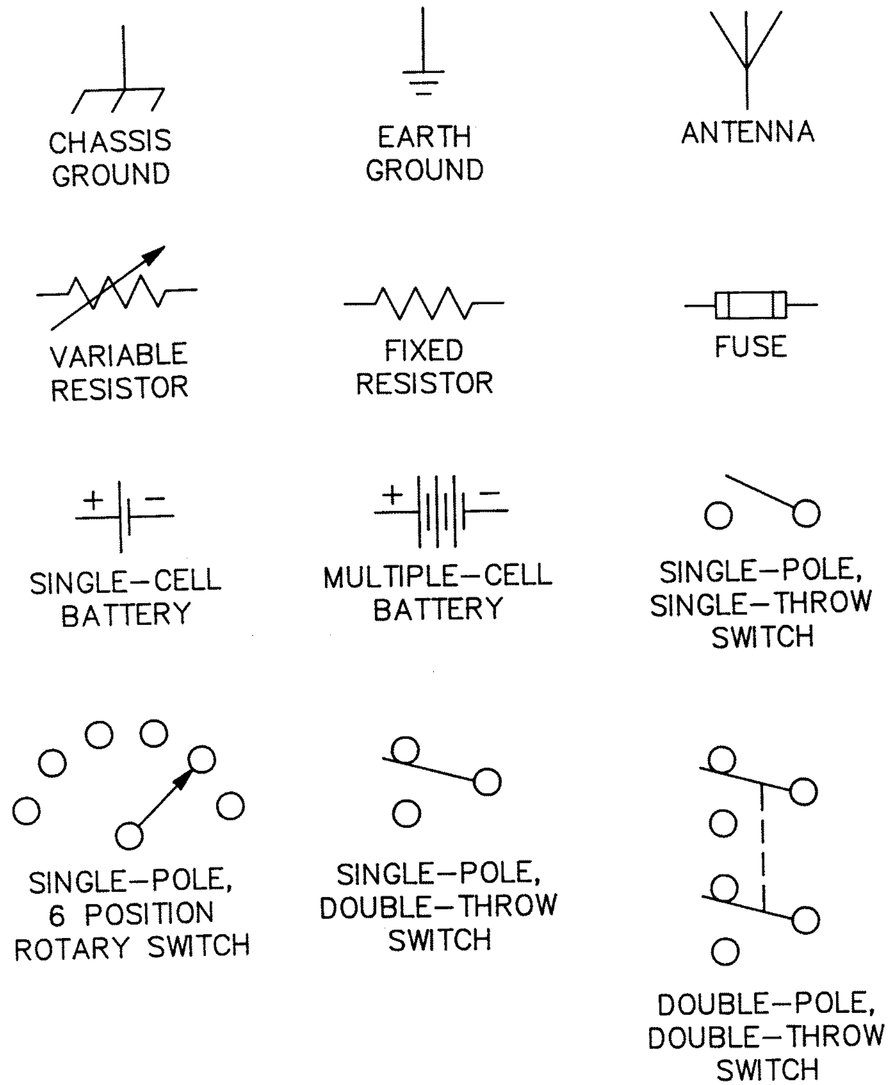
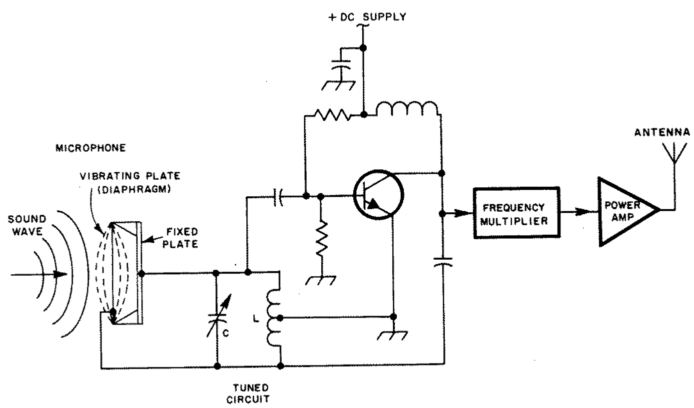


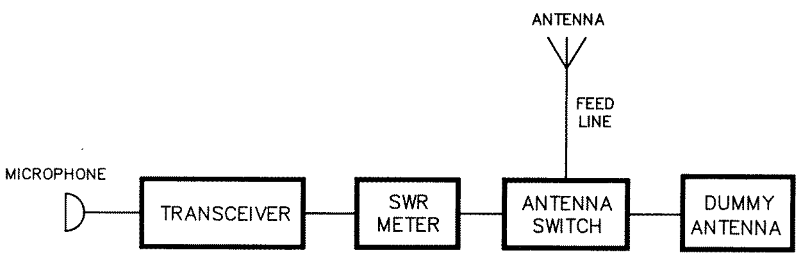
Figure 4-13—To measure current you must break the current at some point and connect the meter in series at the break. A shunt resistor expands the scale of the meter to measure higher currents than it could normally handle.

Schematic Symbol Examples



Schematic and Block Diagrams





- Schematic diagrams include all the individual components and how they are connected.
- Block diagrams show larger components (black boxes) and how they are connected

International System of Units (SI)
Metric Units

Prefix	Symbol			Multiplication Factor
exa	E	10^{18}	=	1,000,000,000,000,000,000
peta	P	10^{15}	=	1,000,000,000,000,000
tera	T	10^{12}	=	1,000,000,000,000
giga	G	10^{9}	=	1,000,000,000
mega	M	10^{6}	=	1,000,000
kilo	k	10^{3}	=	1,000
hecto	h	10^{2}	=	100
deca	da	10^{1}	=	10
(unit)		10^{0}	=	1
deci	d	10^{-1}	=	0.1
centi	c	10^{-2}	=	0.01
milli	m	10^{-3}	=	0.001
micro	µ	10^{-6}	=	0.000001
nano	n	10^{-9}	=	0.000000001
pico	p	10^{-12}	=	0.000000000001
femto	f	10^{-15}	=	0.000000000000001
atto	a	10^{-18}	=	0.000000000000000001

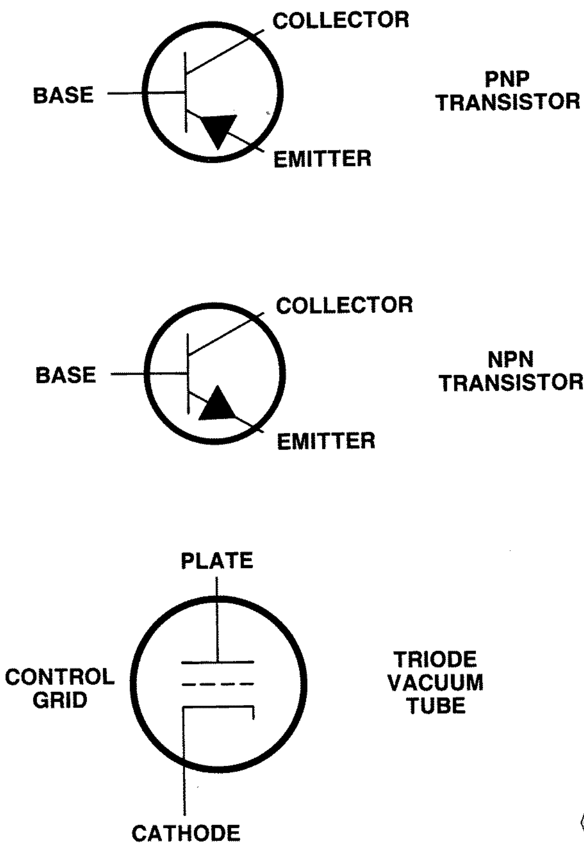
Metric Conversion Practice

Use these problems to practice converting between various units in the metric system. The following chart will help you decide which direction and how far to move the decimal point. Remember to move the decimal point to the right when the final unit you want is to the right of the beginning unit. Move the decimal point to the left when the final unit is to the left of the beginning unit. Count the number of places from the beginning unit to your final unit. That tells you how many places to move the decimal point.

G	M	k	h	da	UNIT	d	c	m	μ	n	p
10^9	10^6	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}	10^{-12}

	Change		To
1)	1200 megahertz (MHz)	________	gigahertz (GHz)
2)	7150 kilohertz (kHz)	________	megahertz (MHz)
3)	1.4 gigahertz (GHz)	________	megahertz (MHz)
4)	3.525 megahertz (MHz)	________	kilohertz (kHz)
5)	3725 kilohertz (kHz)	________	hertz (Hz)
6)	400 centimeters (cm)	________	meters (m)
7)	3000 milliamperes (mA)	________	amperes (A)
8)	3500 millivolts (mV)	________	volts (V)
9)	500,000 microfarads (μF)	________	farads (F)
10)	1,000,000 picofarads (pF)	________	microfarads (μF)
11)	25,000,000 picofarads (pF)	________	farads (F)
12)	25 microhenrys (μH)	________	henrys (H)
13)	1270 megahertz (MHz)	________	gigahertz (GHz)
14)	21.230 megahertz (MHz)	________	kilohertz (kHz)
15)	28,300 kilohertz (kHz)	________	megahertz (MHz)
16)	7.150 megahertz (MHz)	________	kilohertz (kHz)
17)	3700 kilohertz (kHz)	________	hertz (Hz)
18)	21,000,000 hertz (Hz)	________	kilohertz (kHz)
19)	28,100,000 hertz (Hz)	________	megahertz (MHz)
20)	7.100 megahertz (MHz)	________	hertz (Hz)

Amplifiers



- Tubes and transistors amplify signals applied to base or control grid.
- Transistors have advantages:
  - size
  - power consumption
  - cooling
  - robustness
- Tubes have advantages:
  - high power

Test Equipment

- Voltmeter - an instrument that is used to measure voltage.
  - It is used in parallel with a circuit to be measured.
  - a series resistor extends the range of the meter.
- Ammeter - an instrument used to measure amperage in a circuit.
  - It is hooked up in series with the circuit to be tested.
  - A shunt resistor (in parallel w/meter) extends the range of the meter.
- Multimeter - combines the functions above with resistance and others to make a versatile piece of test equipment.
- Wattmeter - a device that measures power coming from a transmitter through the antenna feed line. A directional wattmeter measures forward and reflected power. Wattmeters generally are useful in certain frequency ranges
- Signal Generator - a device that produces a stable, adjustable low level signal (AF or RF). It can be used to tune circuits.