Basic Electronics

Chapter 2, 3A (test T5, T6)

Basic Electrical Principles and the Functions of Components

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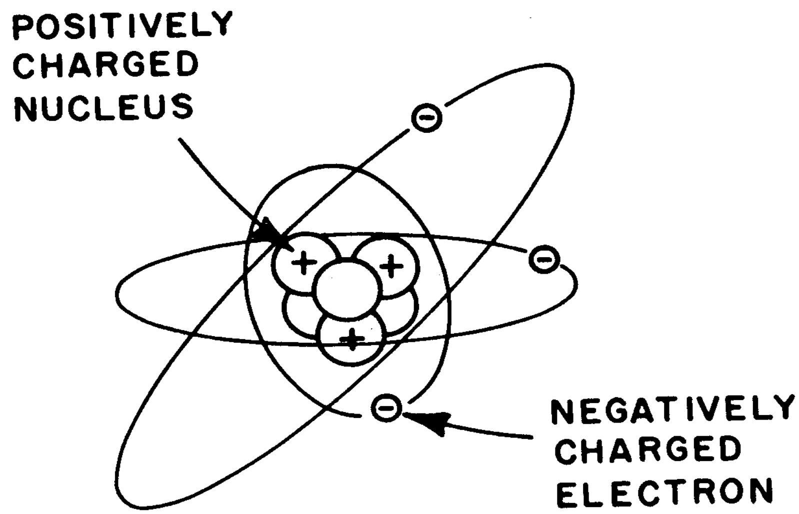
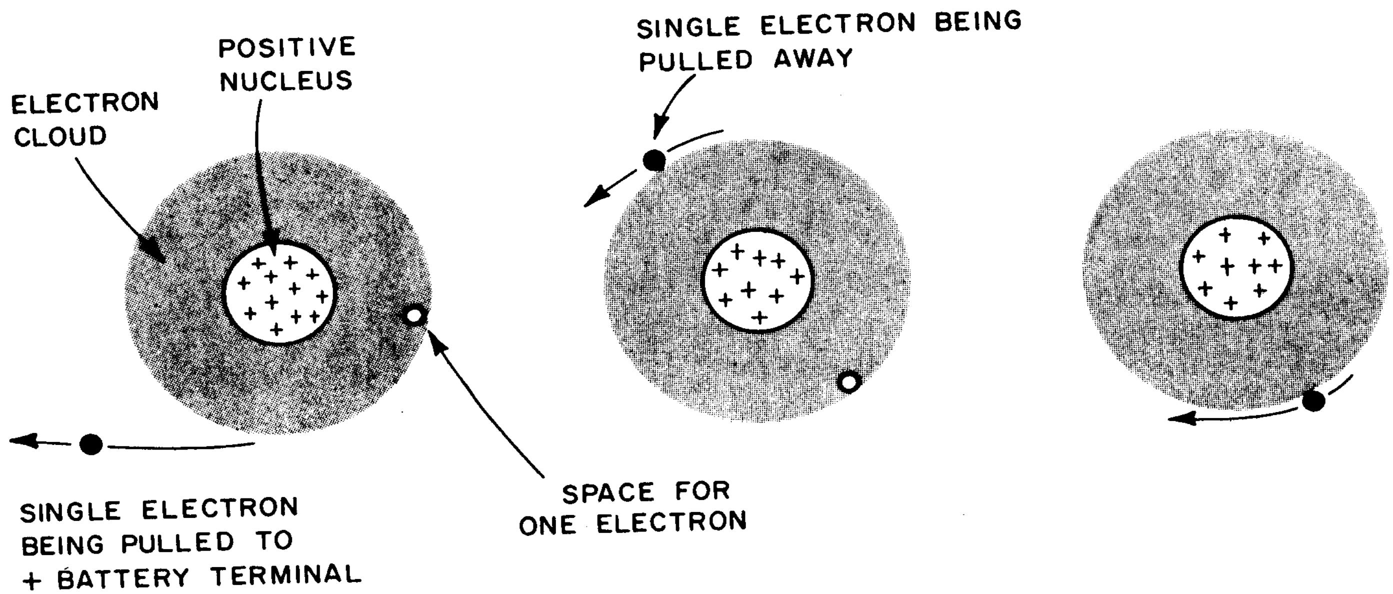
This booklet was compiled by John P. Cross AB5OX

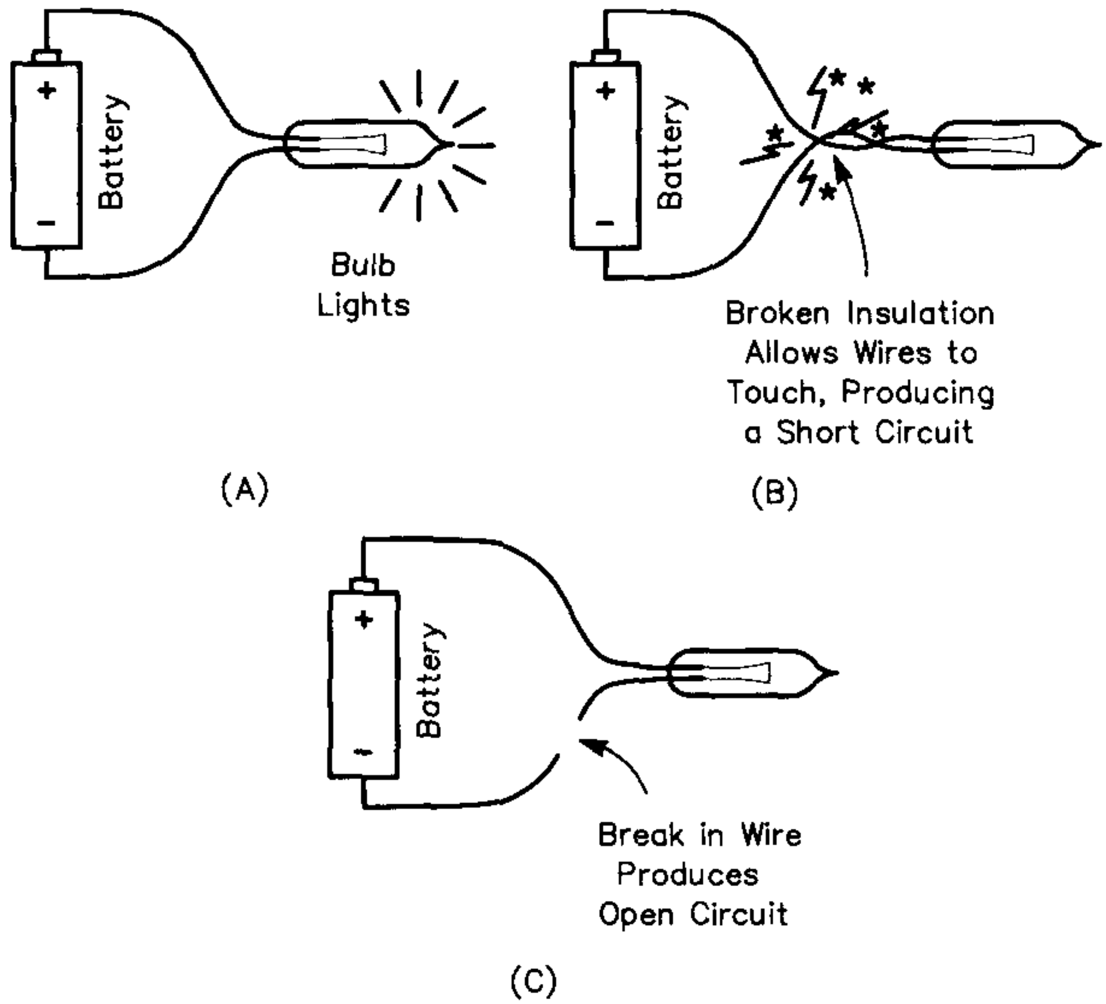
Basic Electrical Principles

- 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 similar to a 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. (convention – current sign is – to electron velocity)
- Resistance (ohms, Ω) is the ability to oppose an electrical current.


POSITIVELY
CHARGED
NUCLEUS
NEGATIVELY
CHARGED
ELECTRON

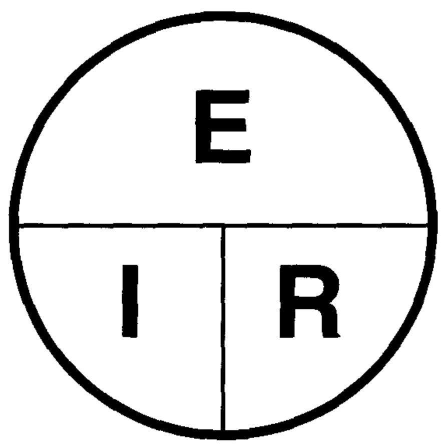

ELECTRON
CLOUD
POSITIVE
NUCLEUS
SINGLE ELECTRON BEING
PULLED AWAY
SINGLE ELECTRON
BEING PULLED TO
+ BATTERY TERMINAL
SPACE FOR
ONE ELECTRON

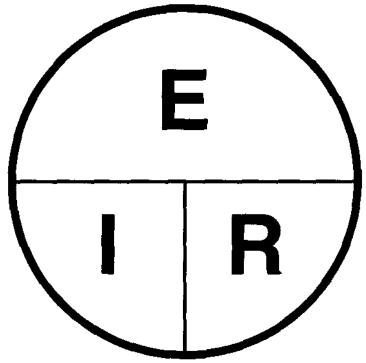
Circuit Definitions
A circuit must close to be complete!



Ohm's Law

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





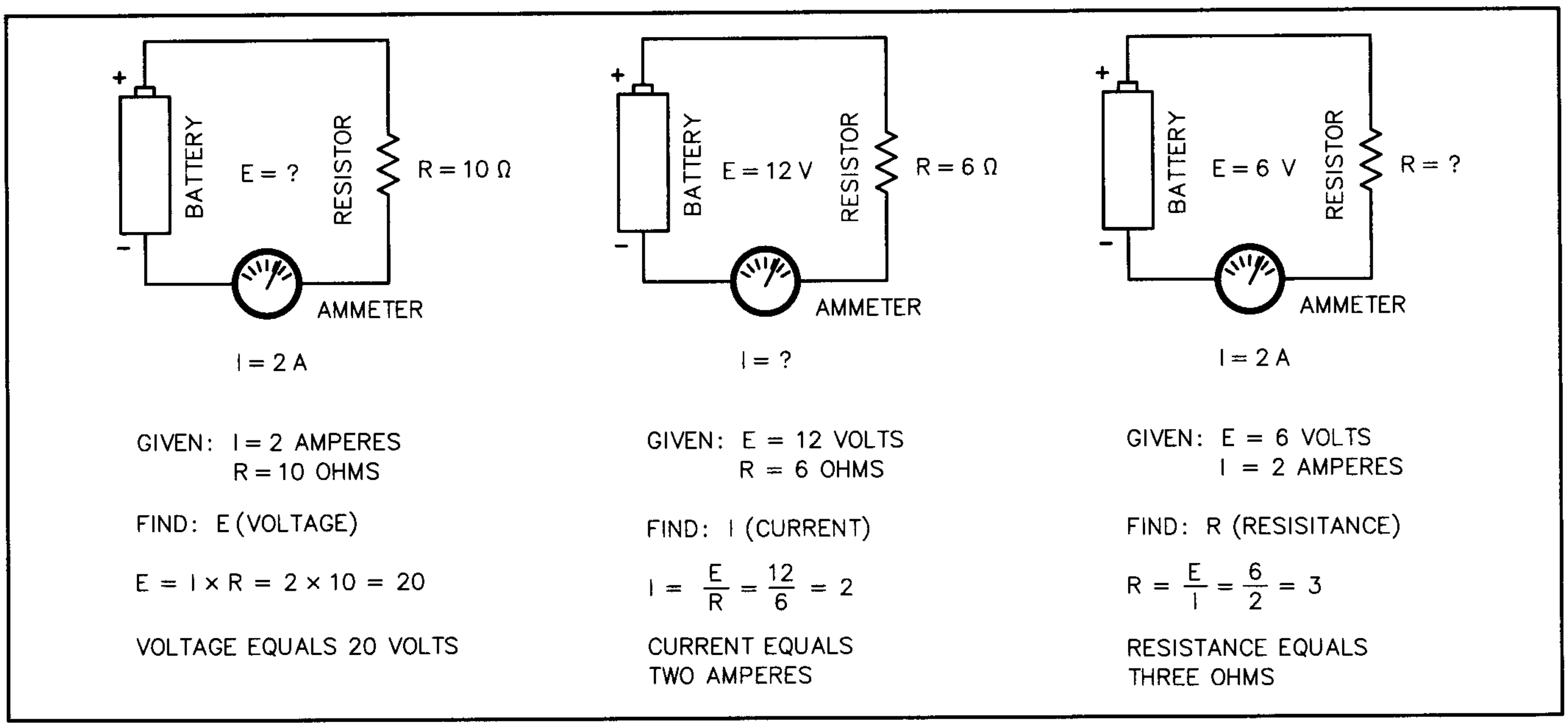


Figure 5-8—This drawing shows some Ohm's Law problems and solutions.

Resistors

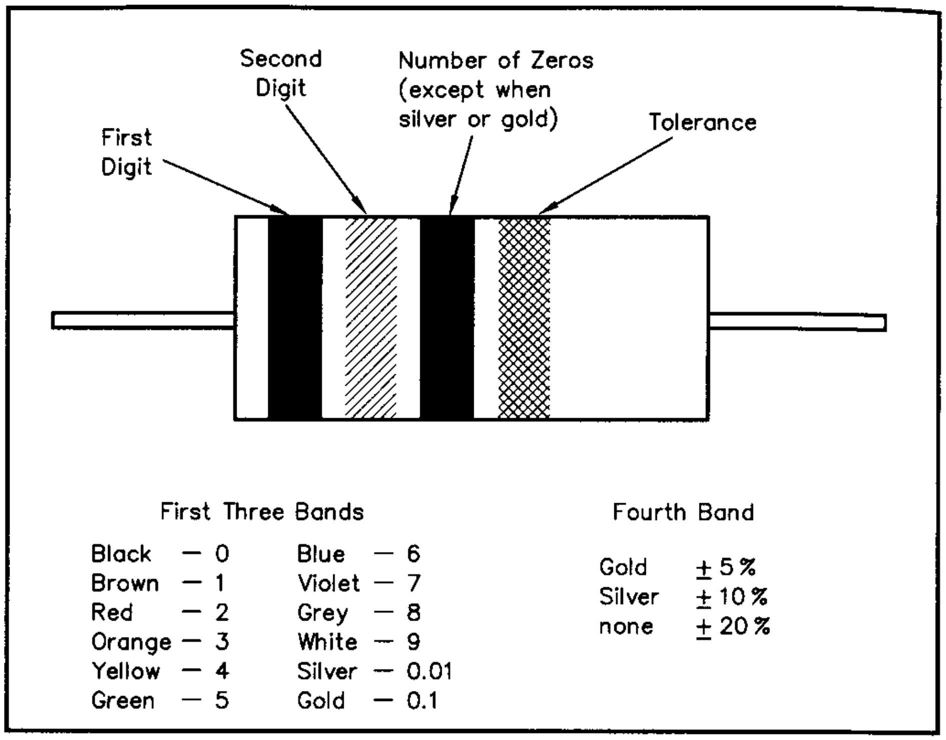
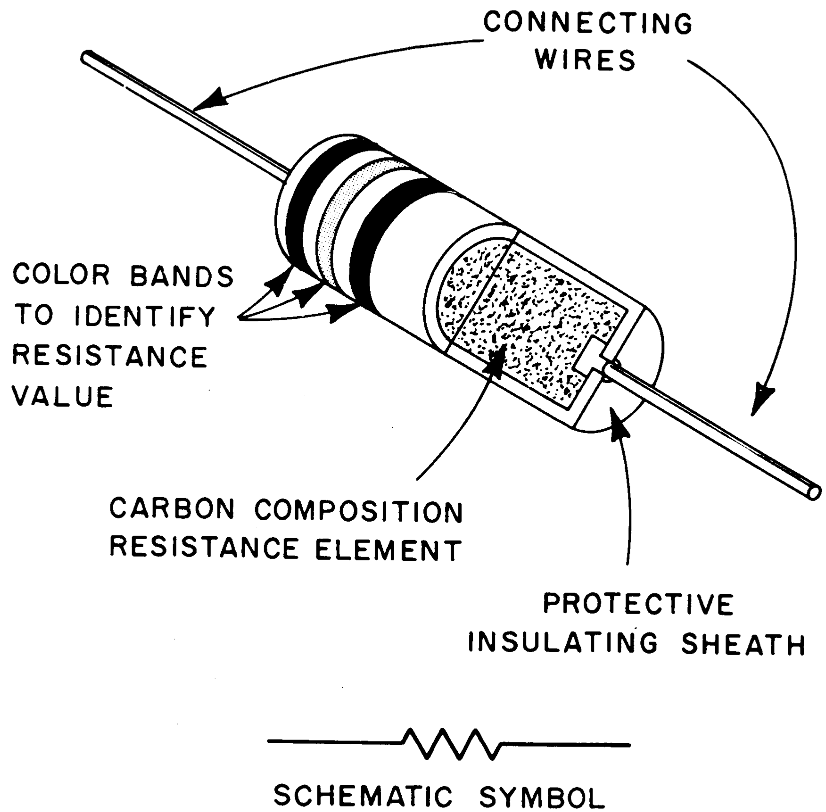
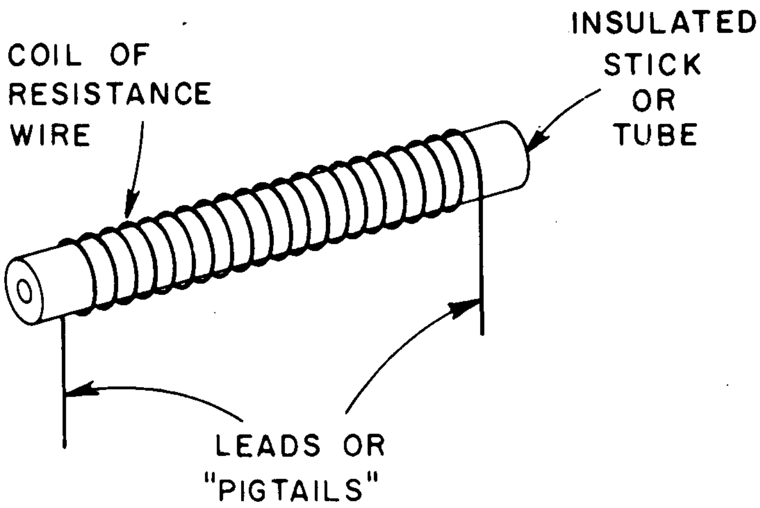


Figure 6-23 — Small resistors are labeled with a color code to show their value. For example, proceeding from left to right, a resistor with color bands of yellow/violet/brown/gold is a 470-Ω resistor with a 5% tolerance.

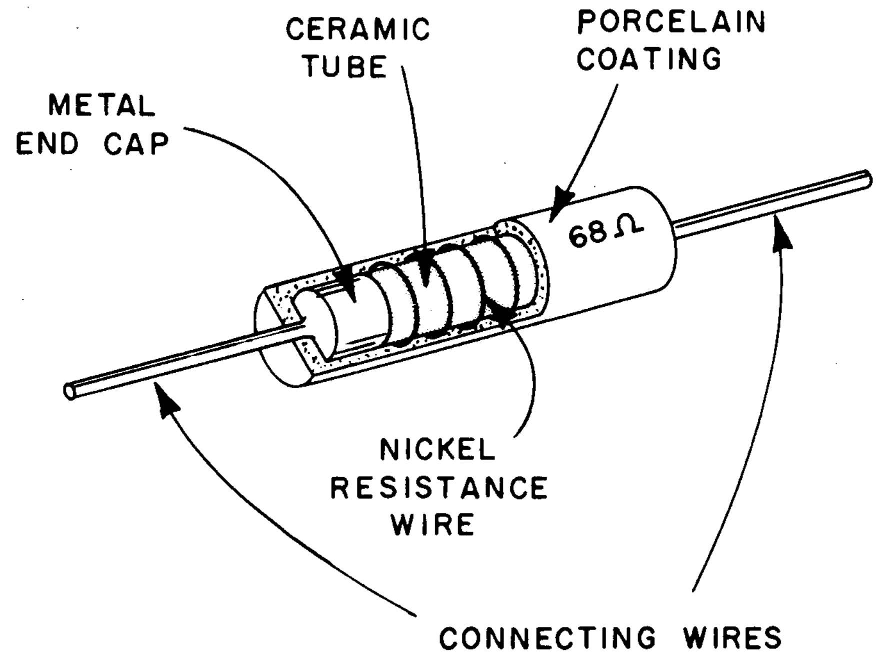


Mnemonic: "Black Bears Run On Young Grass By Violets Growing Wild"

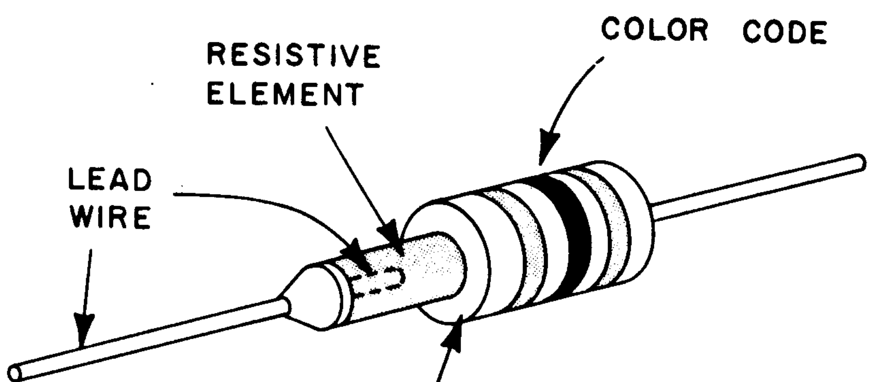
Resistor Types - Precision



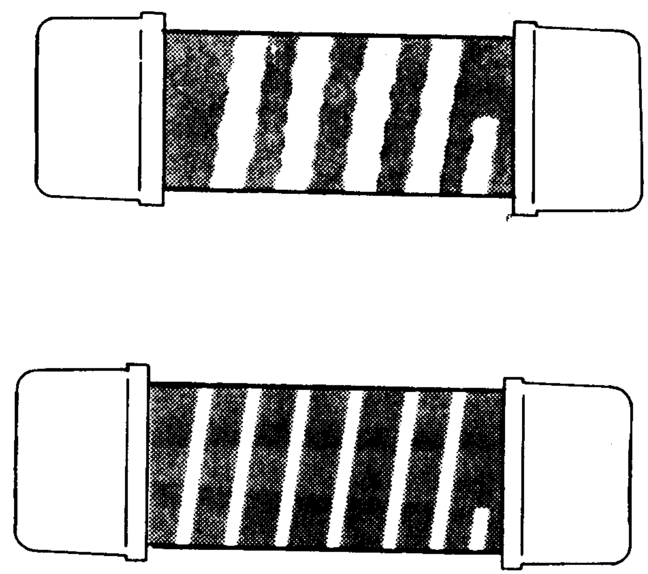
(A)



Resistors - Film Type

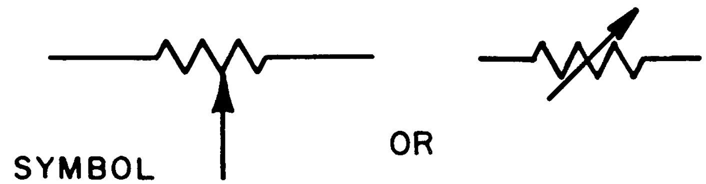


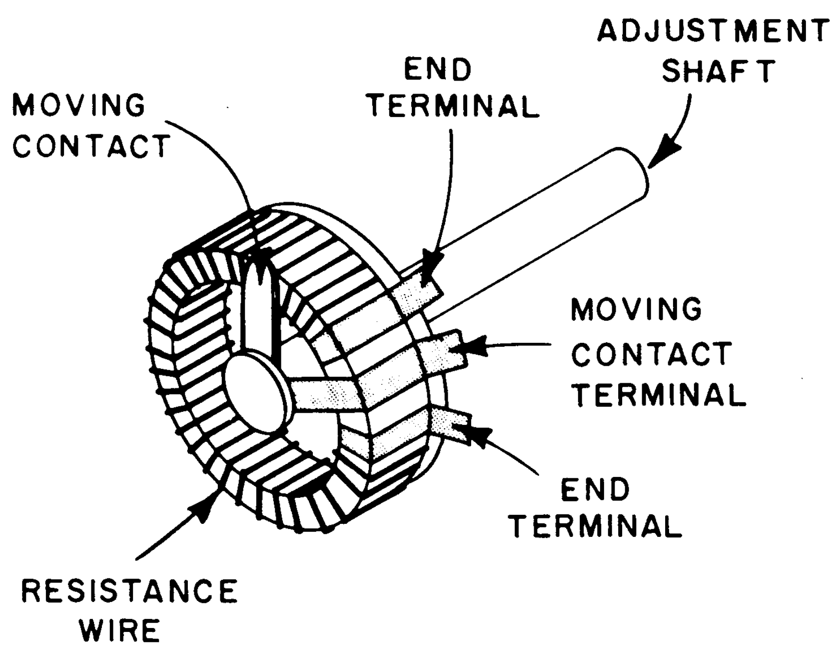
FILM TYPE RESISTOR



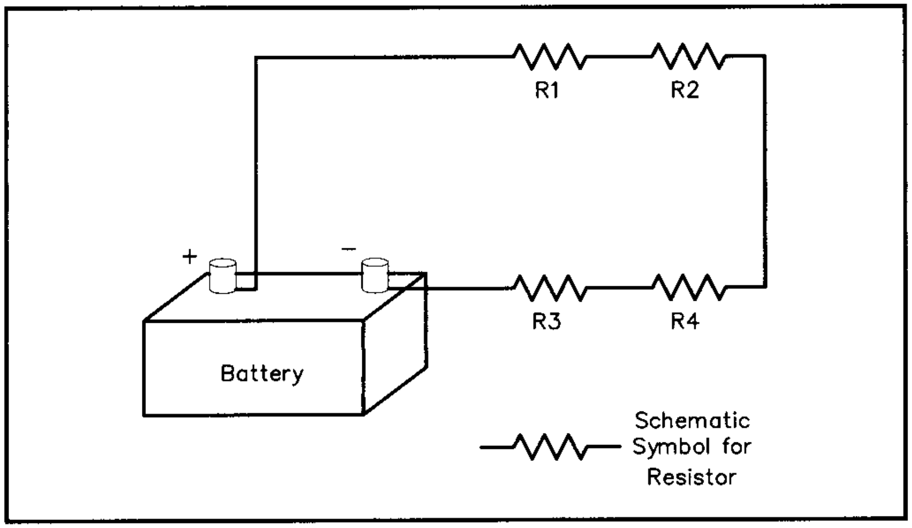
Resistors - Variable

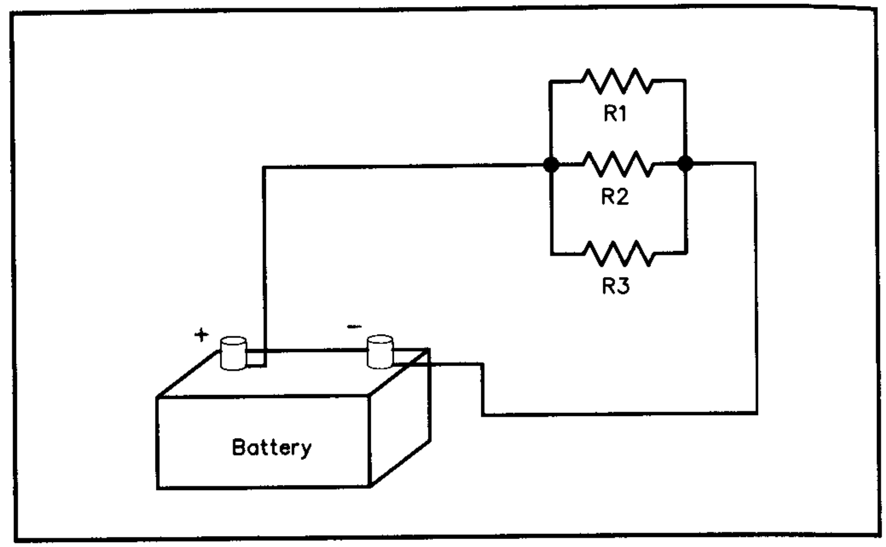
Potentiometers used for volume control





Calculating Resistance





- Series:

R=R1+R2+R3+R4
(the voltage adds up)

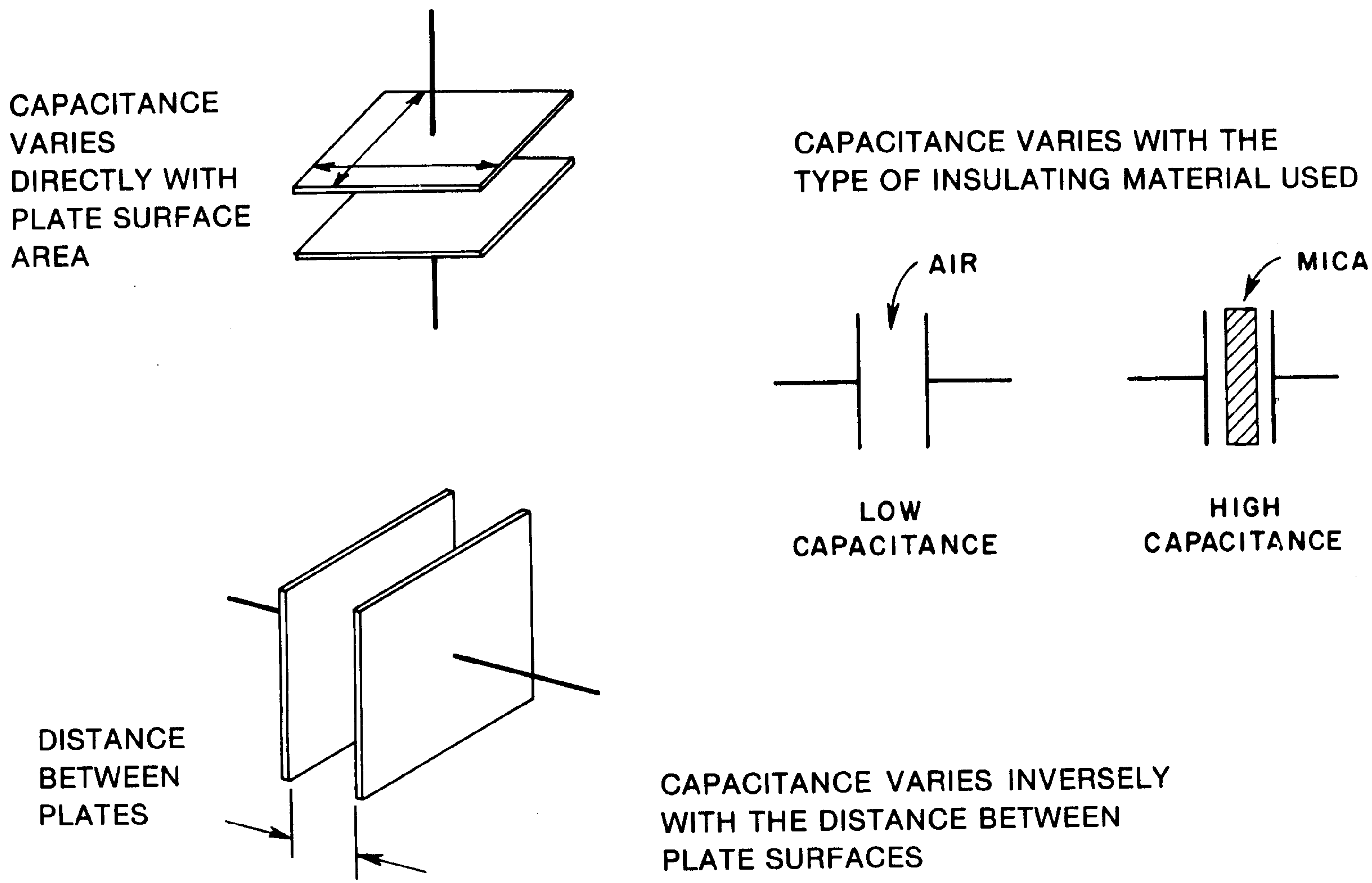
- Parallel:

1/R=1/R1+1/R2+1/R3
(the current adds up)

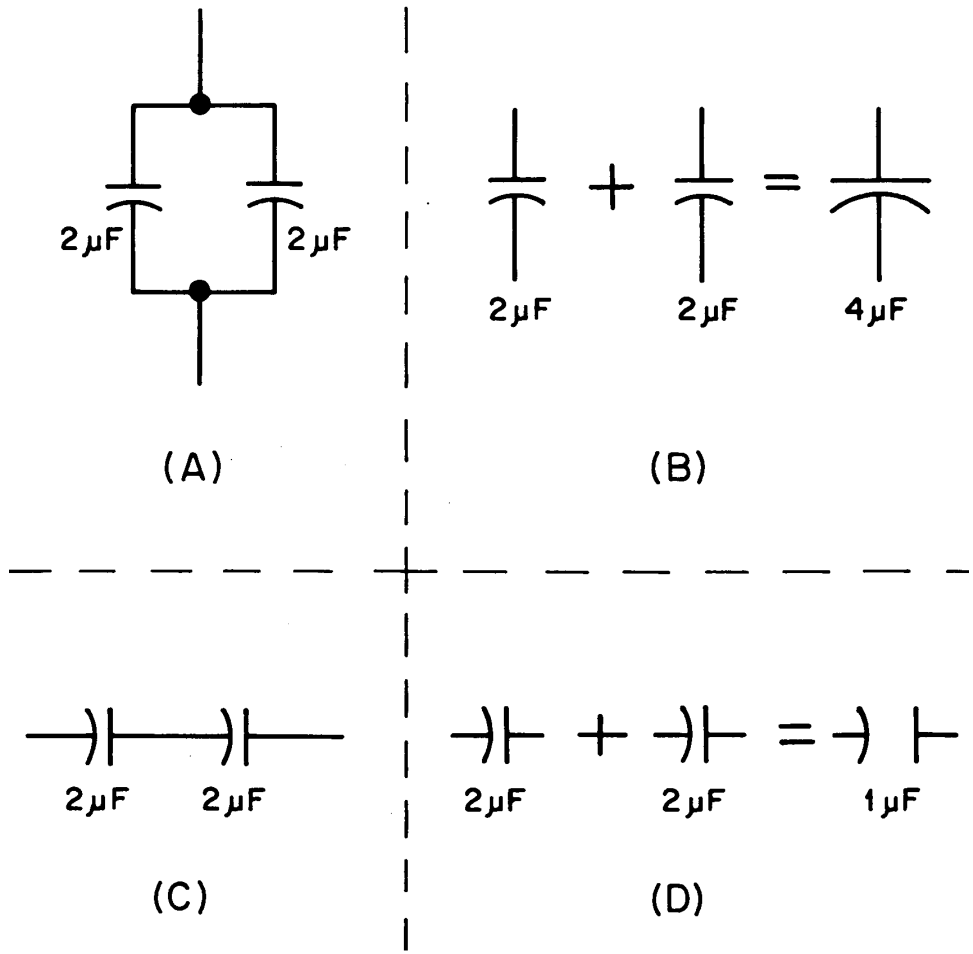
Capacitors

- 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: $C=C1+C2+C3$
- (opposite to resistance)
- Capacitance is determined by 3 factors:
  - plate surface area
  - plate spacing
  - insulating material (dielectric)

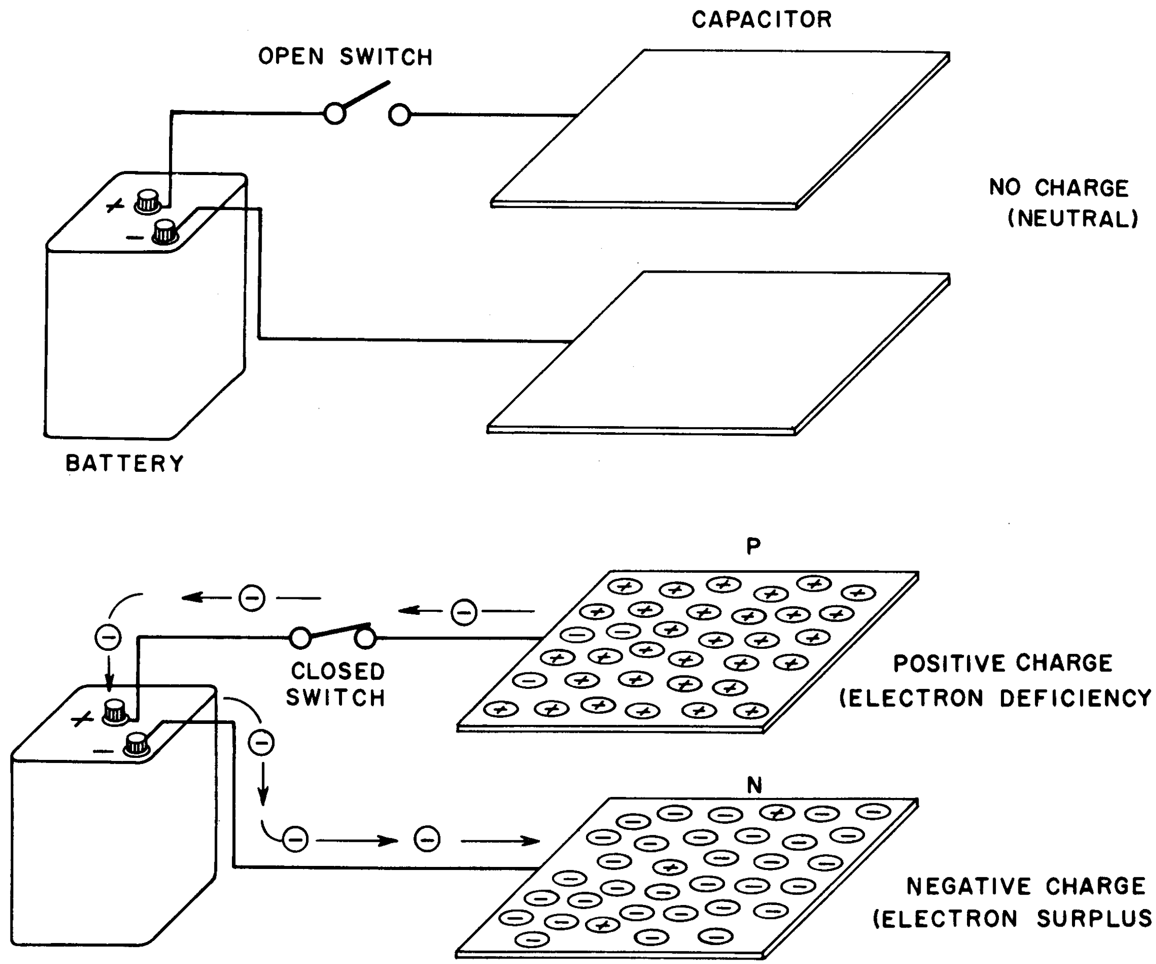
Variables Determining Capacitance



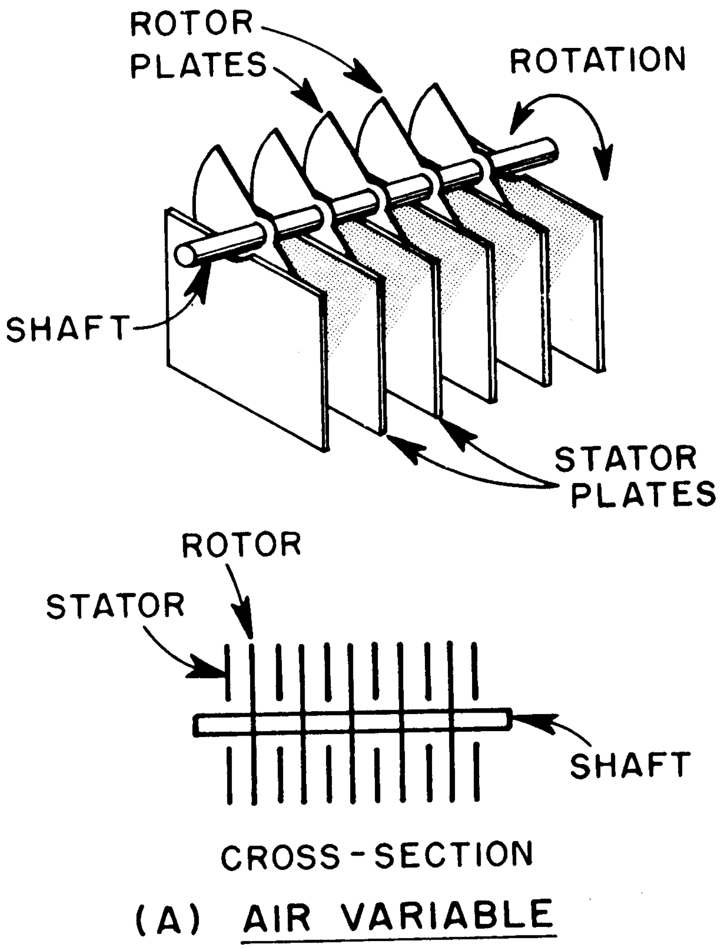
Parallel Capacitors Increase Plate Area; increase charge so C

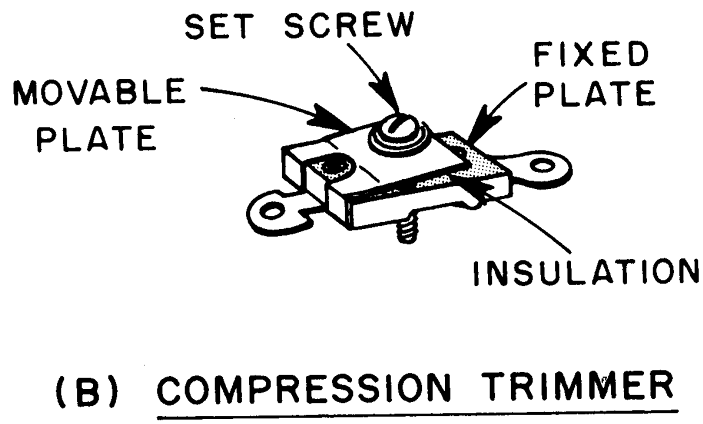


Capacitors Store Energy in Electric Field



Variable Capacitors

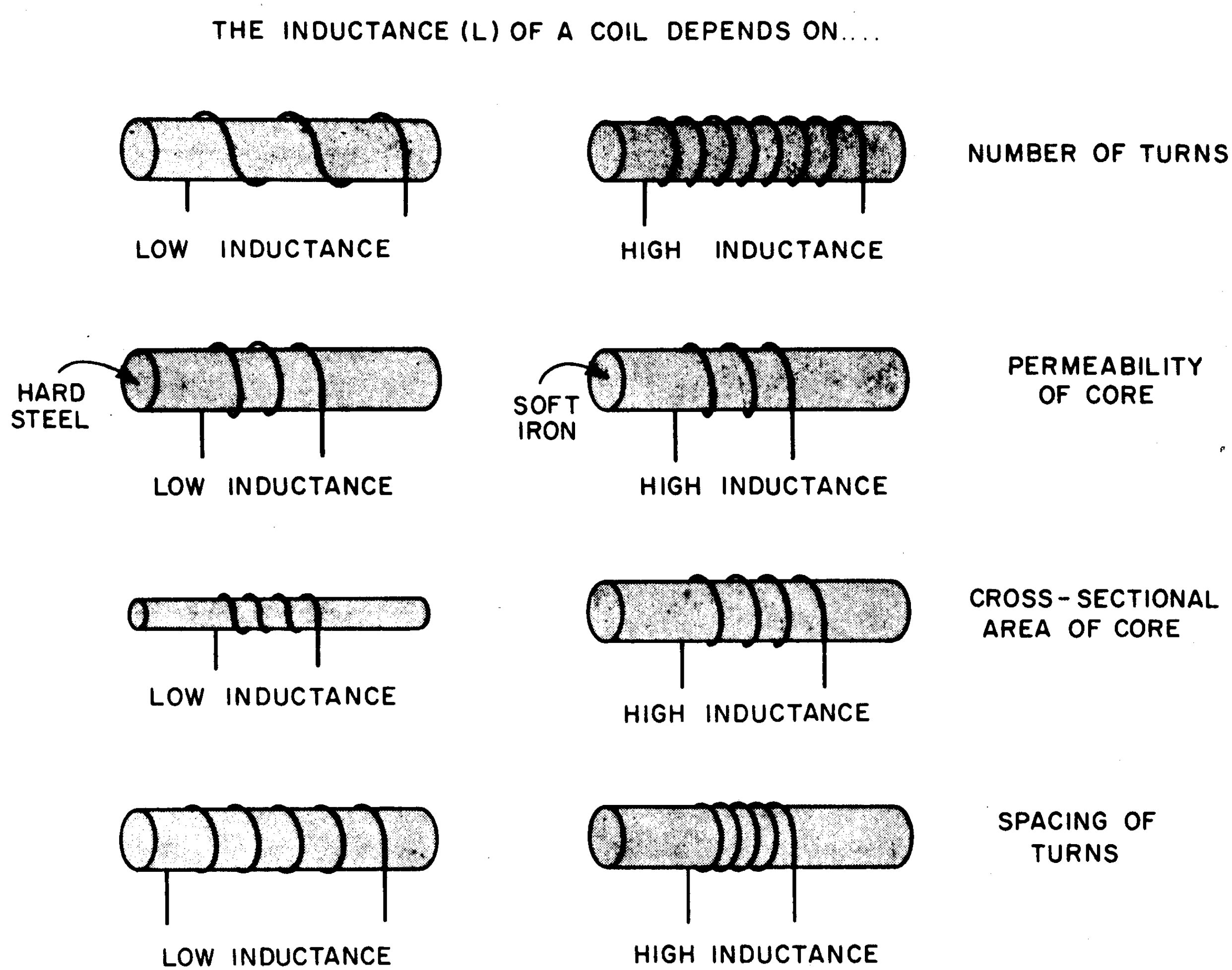




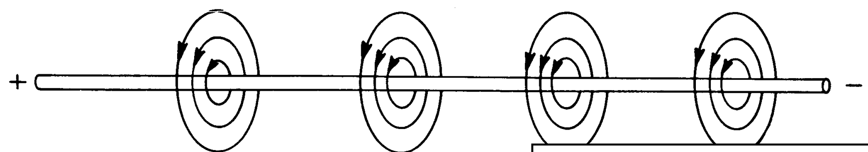
Inductors

- 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: $L=L1+L2+L3$
  (like resistors)
- 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

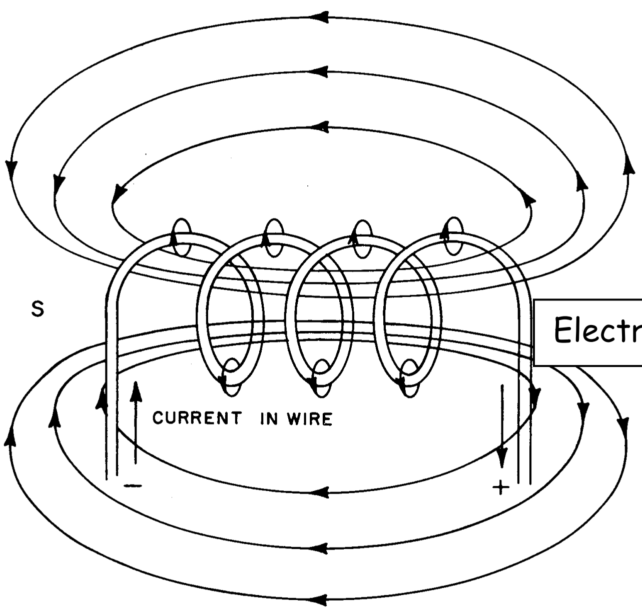


Inductors Store Energy in Magnetic Field



(A)

Current flow-->

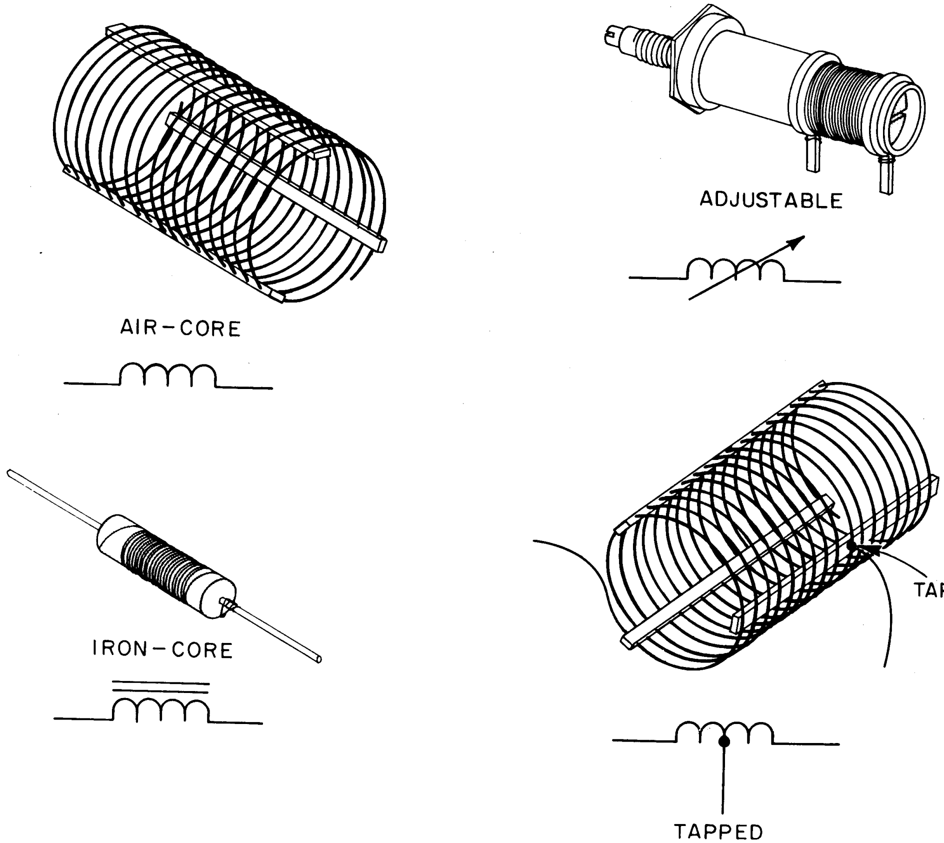


Electron flow-->

(B)

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

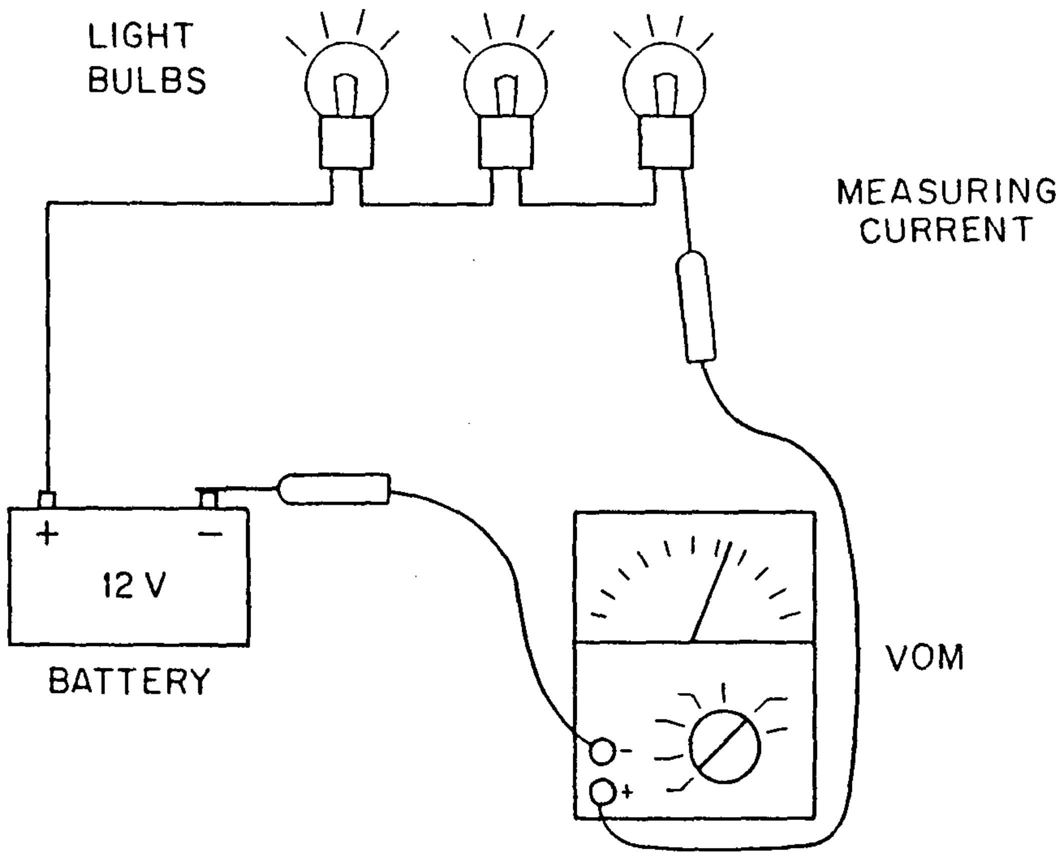
Types of Inductors



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:
  - » $P = E^2 / R$

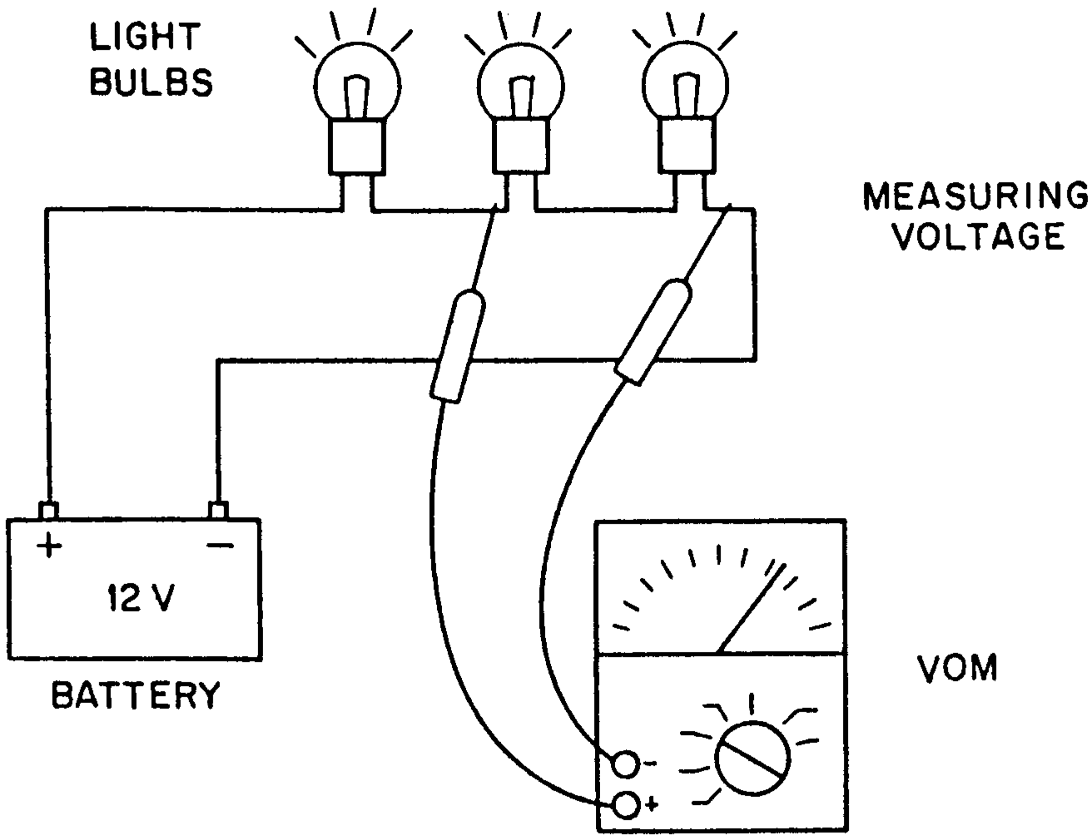
Meters - Measuring Current



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

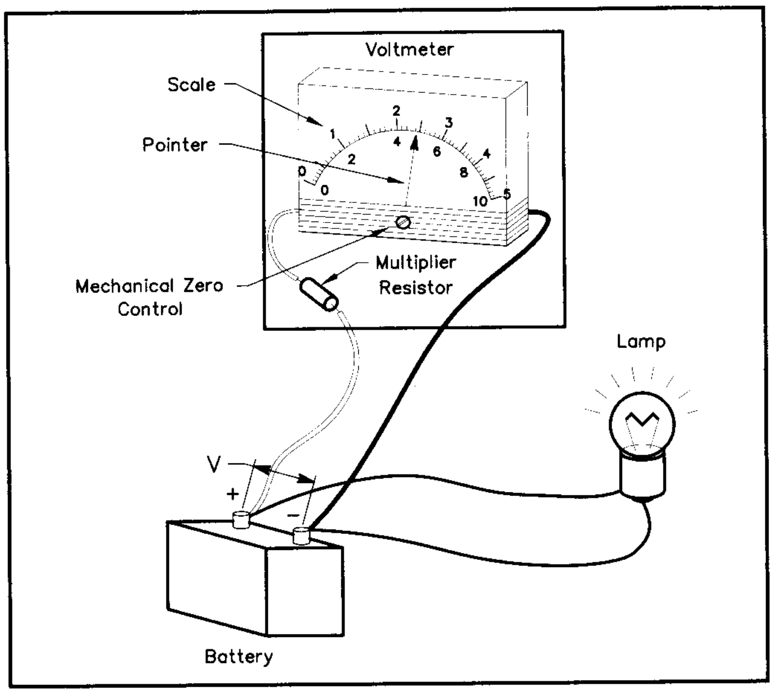


Figure 4-12—When you use a voltmeter to measure voltage, the meter must be connected in parallel with the voltage you want to measure.

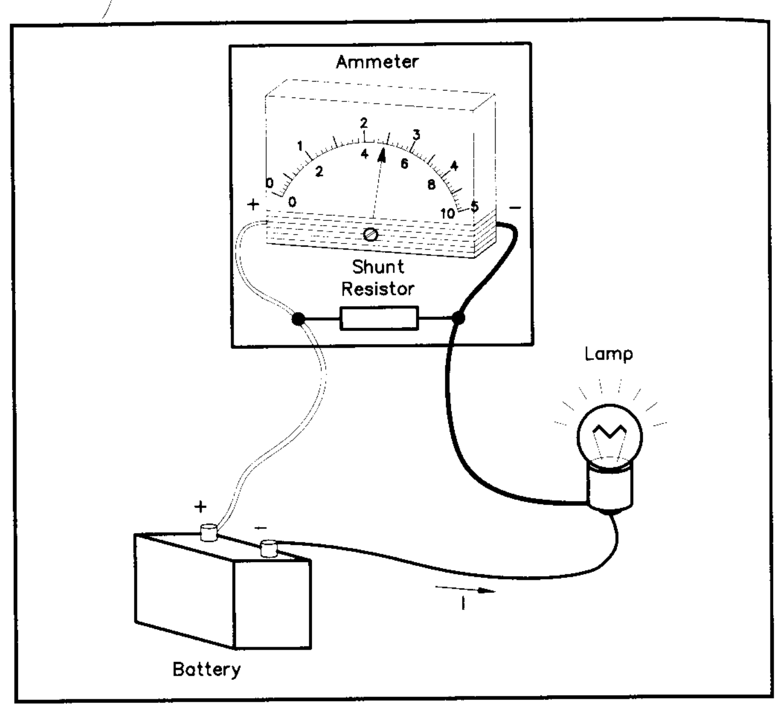
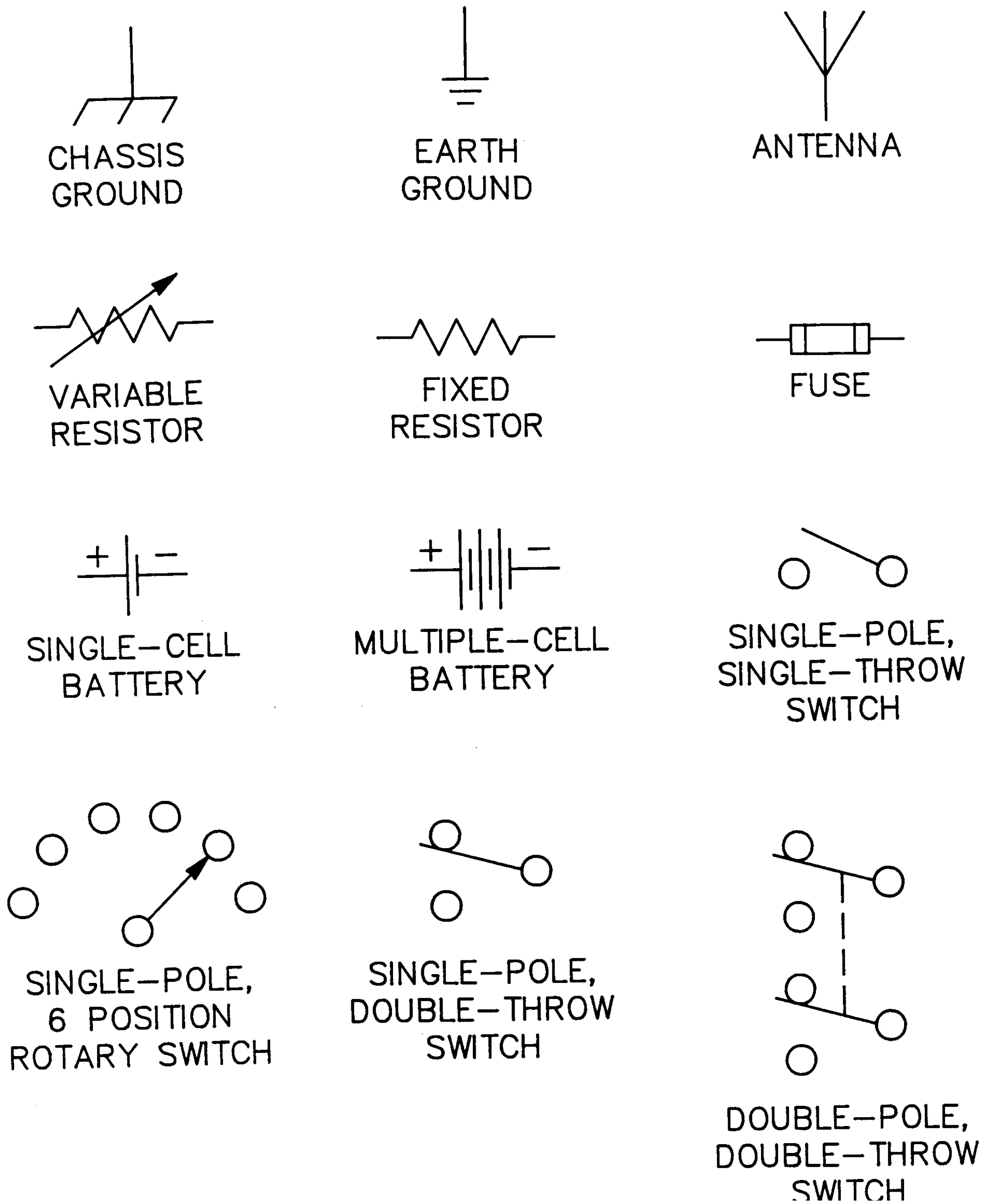
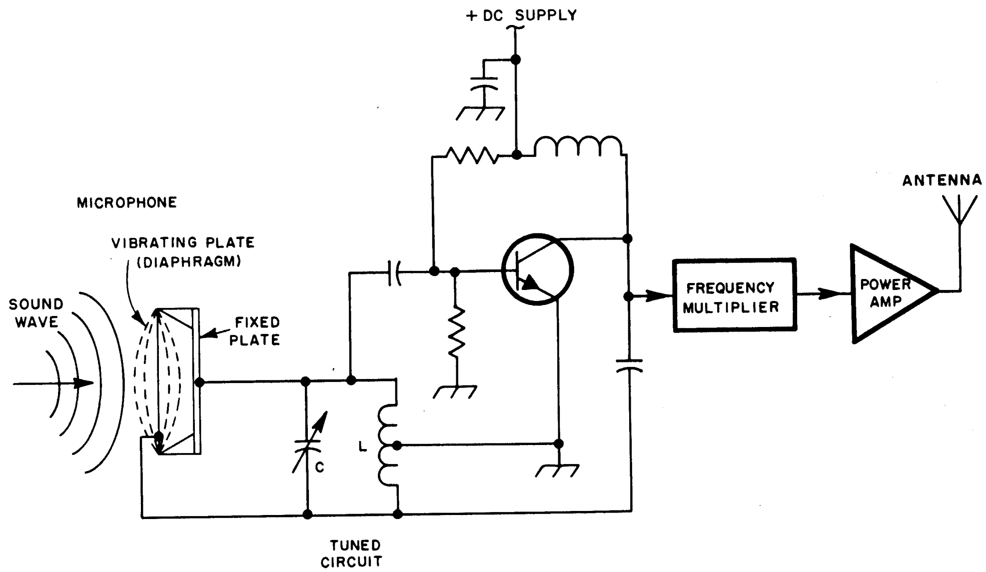


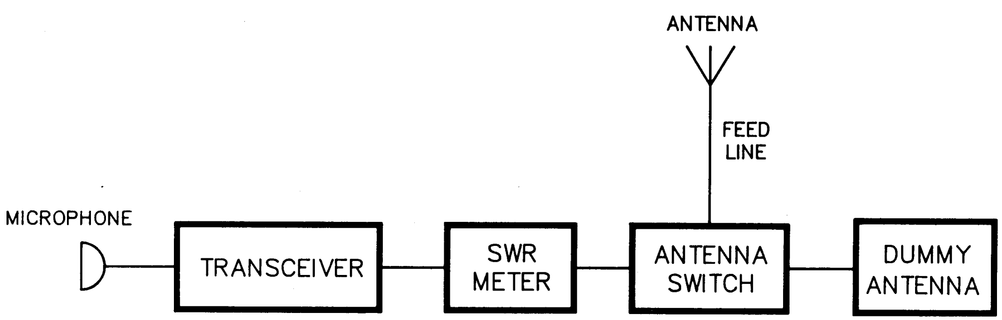
Figure 4-13—To measure current you must break the current at some point and connect the meter in series at the break. A shunt resistor expands the scale of the meter to measure higher currents than it could normally handle.

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

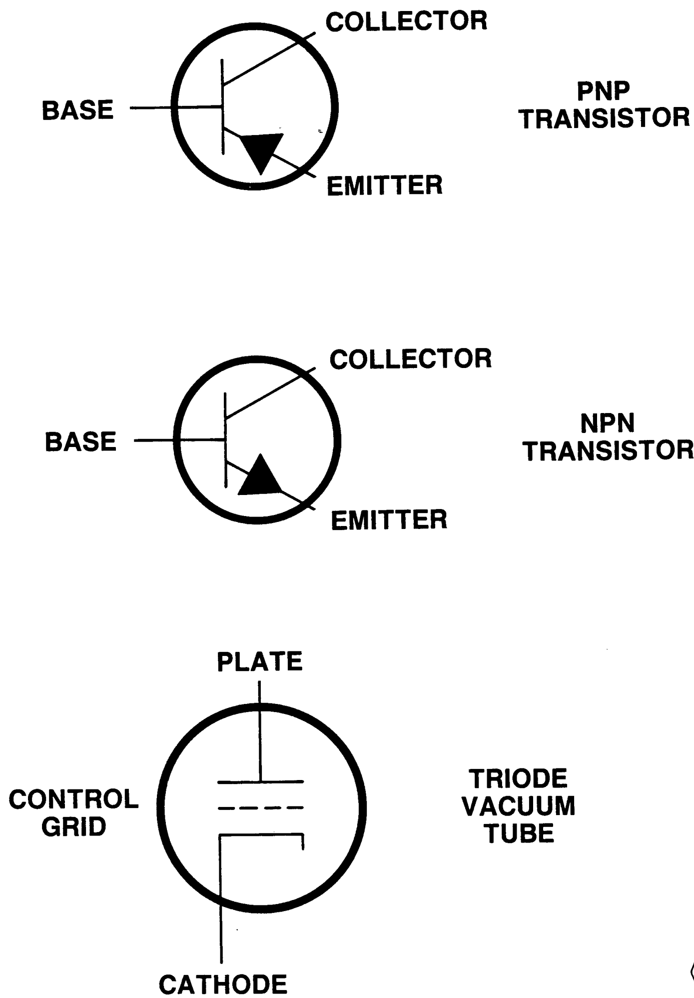
Use these problems to practice converting between various units in the metric system. The following chart will help you decide which direction and how far to move the decimal point. Remember to move the decimal point to the right when the final unit you want is to the right of the beginning unit. Move 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)

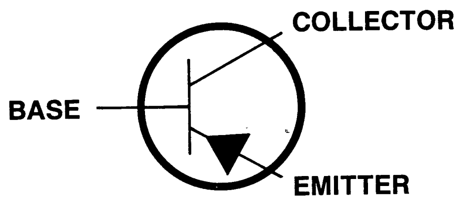
- **Decibels** – logarithmic power scale (questions T5B09, 10, 11)
- 10 decibels = factor of ten in power
- = 10 * log (Power 2/ Power 1)
- 3 dB is factor of 2
- 6 dB is 4 (2*2); 9 dB is 8 (2*2*2)
- 5 dB is factor of pi (since pi*pi is almost 10)

Amplifiers

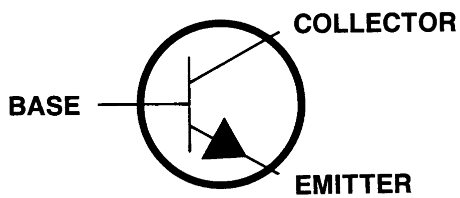


- Tubes and transistors amplify signals applied to base or control grid. The amount of amplification is called **GAIN**.
- Transistors have advantages:
  - size
  - power consumption
  - cooling
  - robustness
- Tubes have advantages:
  - high power

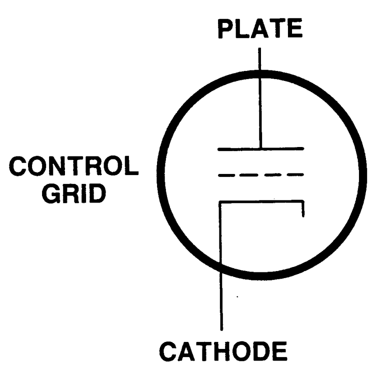
Amplifiers



PNP TRANSISTOR



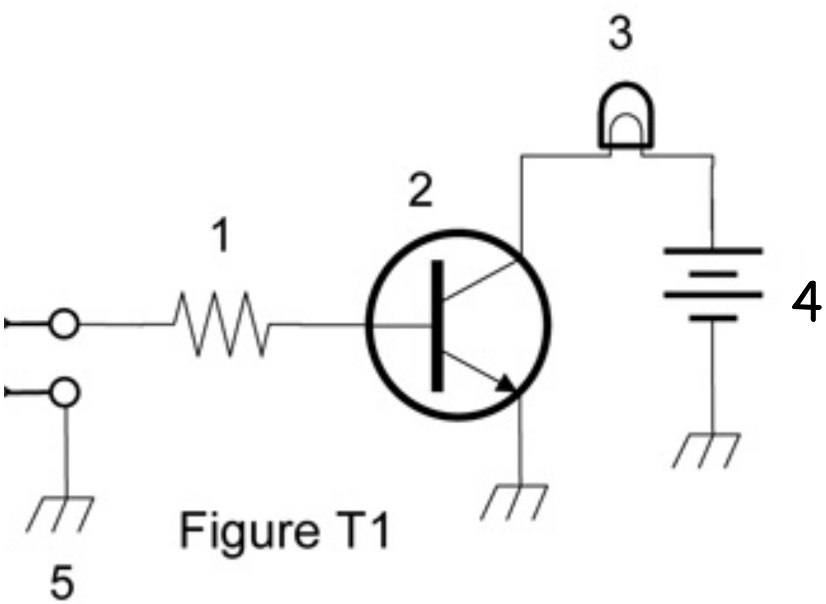
NPN TRANSISTOR



TRIODE VACUUM TUBE

- FET is **Field Effect Transistor, and has a "gate" electrode.**
- The component with an emitter electrode is **a bipolar transistor.**
- ***An integrated circuit*** is a device that combines several components into one package (generally including transistors)

Typical Circuit Diagrams



- 1 is a resistor
- 2 is a transistor (NPN)
- 3 is a lamp
- 4 is a battery
- 5 is chassis ground

Typical Circuit Diagrams

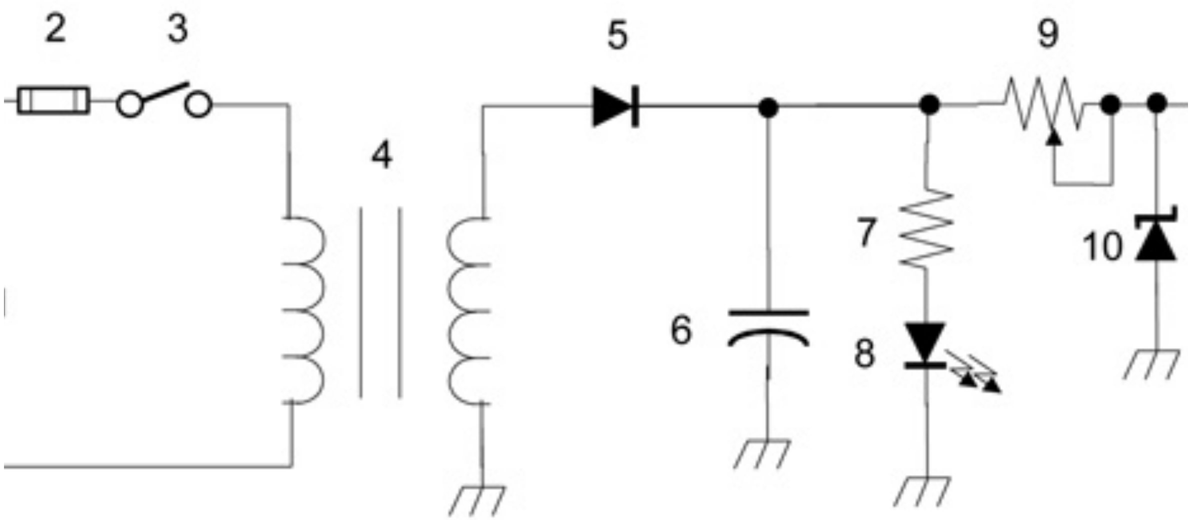
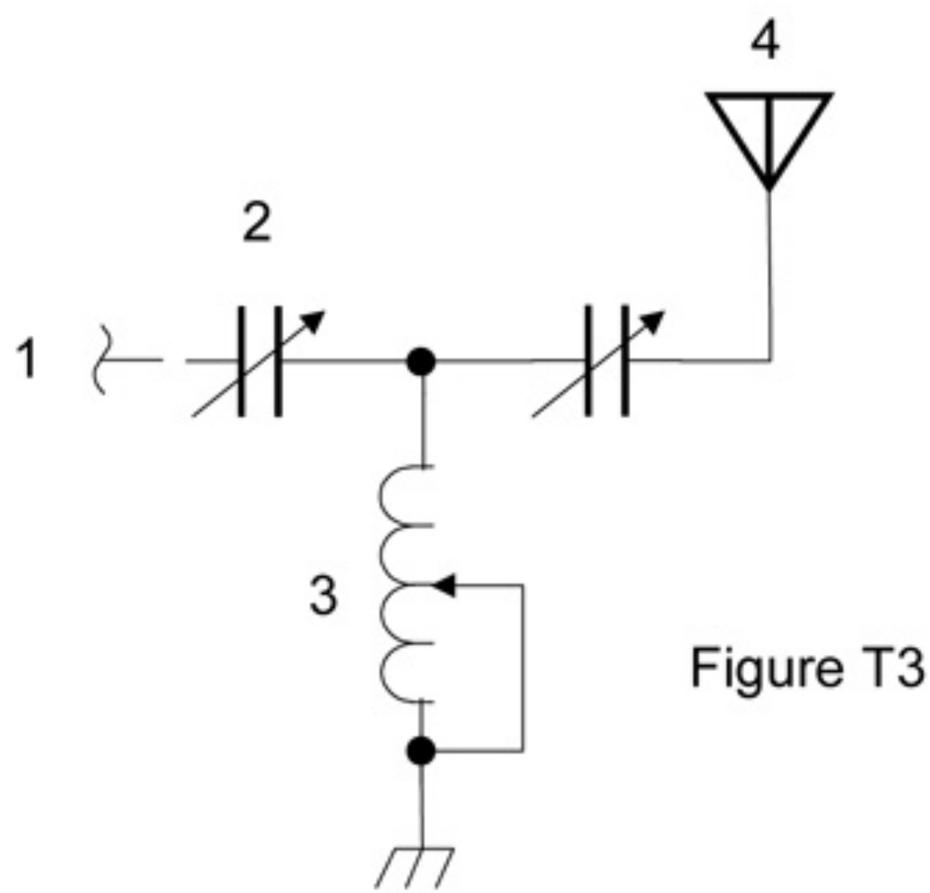


Figure T2

- 3 is a switch (single-pole, single throw)
- 4 is a transformer
- 5 is a diode
- 6 is a capacitor
- 7 s a resistor
- 8 is a light-emitting diode (LED)
- 9 is a variable resistor
- 10 is a diode

Typical Circuit Diagrams



- 1 is an AC current
- 2 and 4 is a variable capacitor
- 3 is a variable inductor
- 4 is an antenna
- Note: diagrams do not represent true wire lengths

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.