



Technician License Course

Chapter 3

Electrical components and units



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Basic Components

All circuits contain three basic properties.

- Resistance: the conversion of electric energy to heat or light.
- Inductance: the energy stored in a magnetic field.
- Capacitance: the energy stored in an electric field.

Components are manufactured parts that are used to represent these properties.



The Resistor

The function of the resistor is to restrict (limit) the flow of current through it.

- Converts Electrical Energy to Heat.
- Current is same at both ends but voltage is changed.

Circuit Symbol



R1
100 Ω



Resistors

Unit of resistance is the Ohm – Ω .

milliOhms, KilOhms, MegOhms

Resistors are designed to dissipate heat. Their size and materials determine the wattage rating for safe operation. 1/8, 1/4 , 1/2, 1, 2, 5, ...

Material – metals or carbon

Size and shape – Wires, films, blocks.

Packaging – insulation, leads, and mounting



Resistors Power Ratings

Low power – 1/10 W, 1/8 W, 1/4 W, 1/2 W, 1 W

Carbon Composition – becoming obsolete.

Carbon Film – replacing composition. Widely available

Metal Film - High precision and accuracy to 0.1%

High Power – 2 Watts and higher

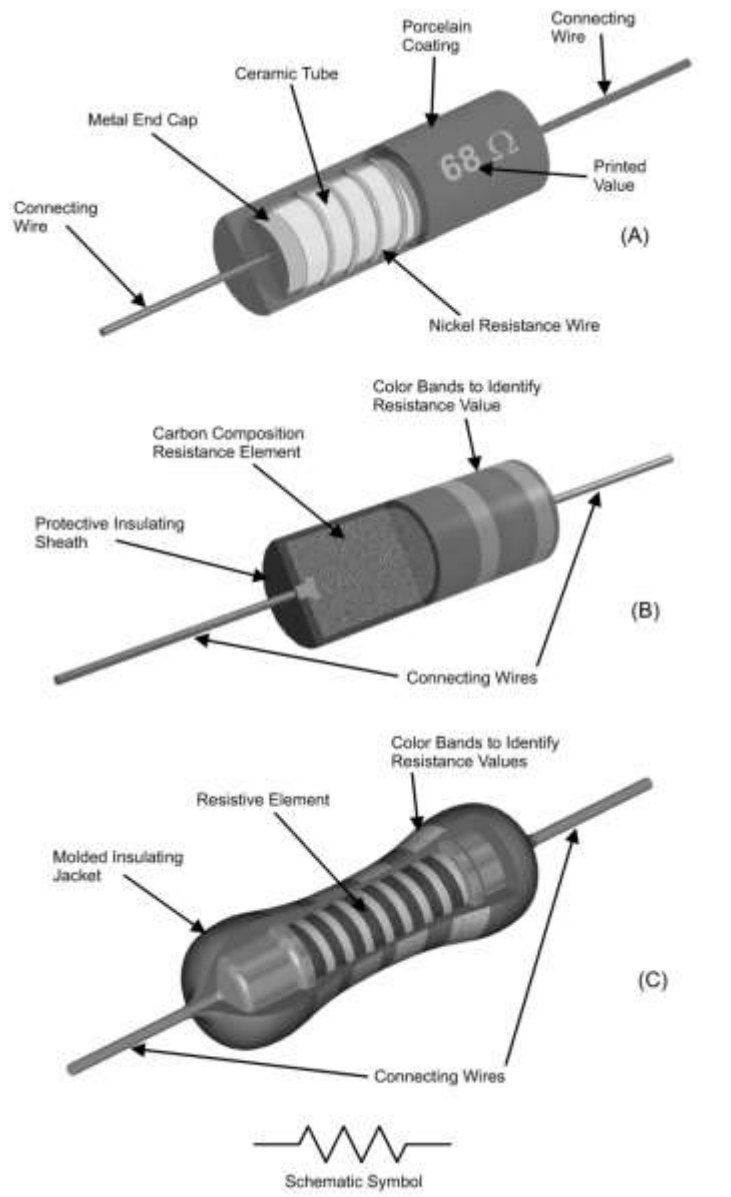
Wirewound (Sometimes very Inductive)

Ceramic – Smaller size than wirewound

Carborundum – Good for non-inductive.

Power is “I squared times R”. Use a rating of twice what the resistor will be dissipating.





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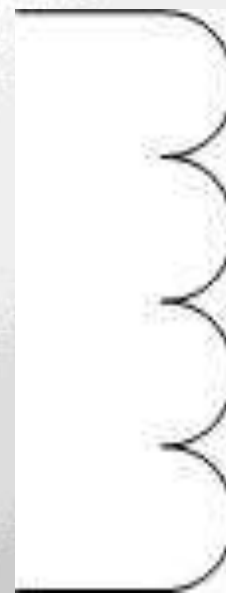


The Inductor

The function of the inductor is to oppose a change in current.

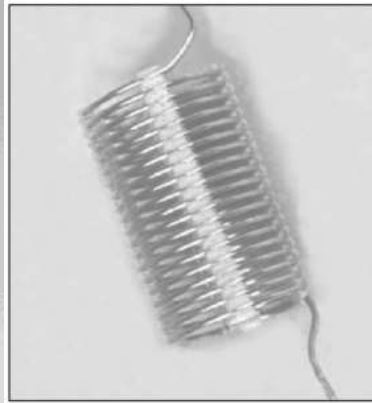
- Coiling a conductor increases the inductance.
- Stores energy in a magnetic field.

Circuit Symbol



L1
1 mH





Air Core
Straight or Solenoid
Coil Form



(A)



Magnetic or Iron Core
Toroidal Coil Form



(B)



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Inductors (Coils)

Unit of measure is the Henry.

- Greater than 1 Henry common in Power Supplies
 - Usually wound on iron core
- milliHenries (mH) – 10^{-3} H – used in RF filters (Chokes)
 - Air core with multiple layers
 - Powdered iron core
- microHenries (uH, μ H) – 10^{-6} H – used in Tuning circuits
 - Air core or Ferrite toroids
- nanoHenries (nH, η H) – 10^{-9} H – used in VHF/UHF circuits.
 - Sometimes are a printed circuit pattern



Inductors (Coils)

Inductance depends on:

- Diameter of the coil and Length of the winding.
 - Number of turns.
 - Spacing between turns.
- Core material.
 - Air – Low inductance
 - Iron – High inductance
 - Ferrite and Steel Very High inductance
 - Brass and Copper lower than air

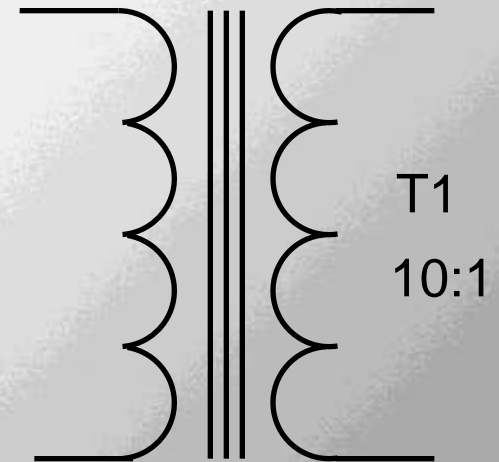


The Transformer

The function of the transformer is to couple circuits with a magnetic field.

- Is basically two coils in proximity.
- Energy is coupled by the magnetic field.
- Voltage may be increased or decreased by turns ratio.
- Core concentrates magnetic field for efficiency.

Circuit Symbol



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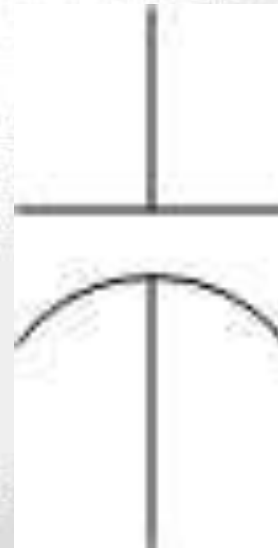


The Capacitor

The function of the capacitor is to oppose a change in voltage.

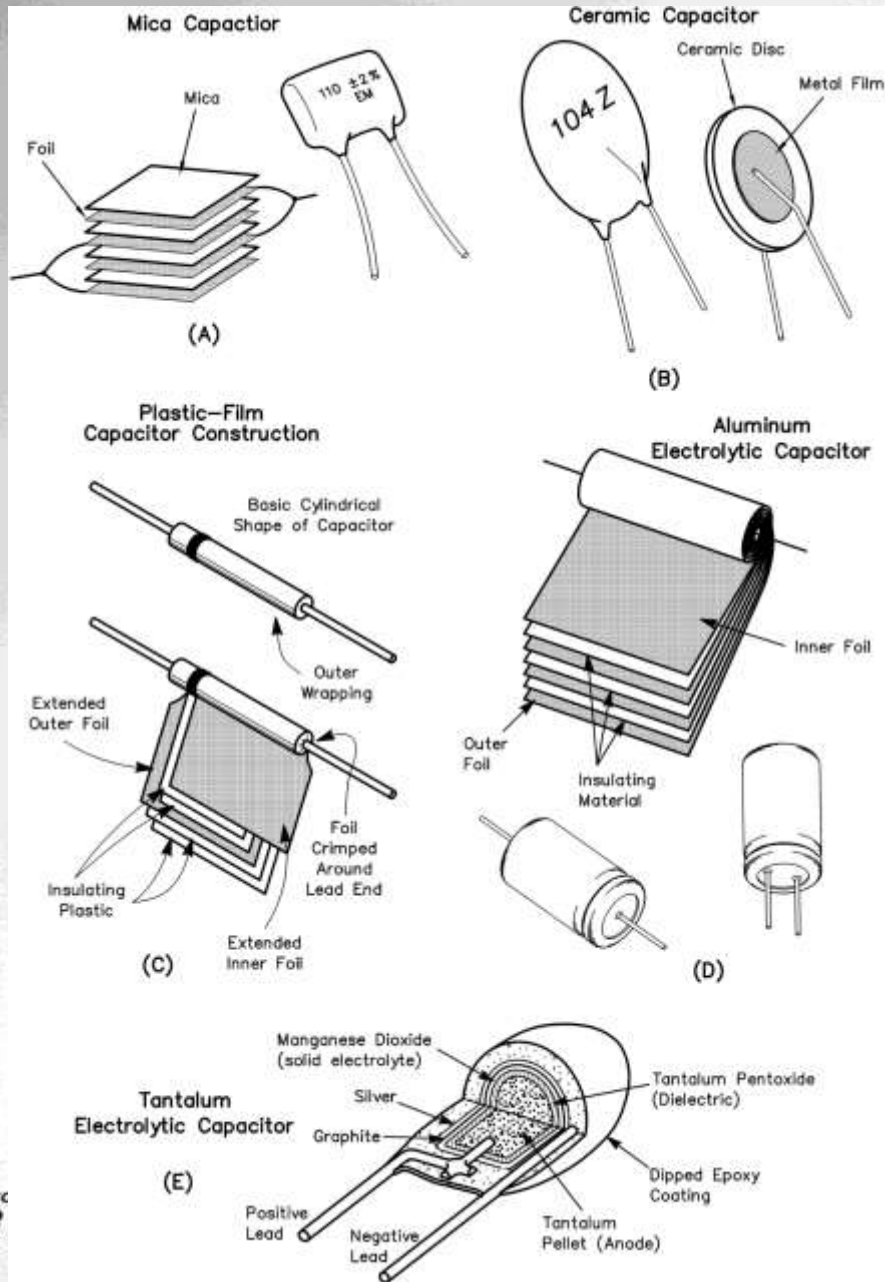
- Stores energy in an electric field.
- Like a very temporary storage battery.
- Voltage indicates amount of charge.

Circuit Symbol



C1
100nF





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Capacitors

Unit of capacitance is the Farad.

- One Farad used to be physically very large, but now available as “SuperCaps”.
- microFarads – μF
 - 10^{-6} F – Filtering and de-coupling
- nanoFarads – nF
 - 10^{-9} F – Coupling and by-passing
- picoFarads – pF (mmF – micro-micro Farad)
 - 10^{-12} F – Tuned circuits and timing.



Capacitors

Capacitance depends on Surface area of conductive plates and Space between plates.

- Dielectric (insulating material between plates).
 - Air – Lowest value of capacitance
 - Mica – Good RF qualities
 - Ceramic – Small size for larger values
 - Electrolytic – Very large values.



Capacitors and Stored Energy

When voltage source is applied to a capacitor:

Electric field is set up in the dielectric as current starts.

Electrons leave the positive plate.

Electrons accumulate on the negative plate.

Current stops when capacitor has same voltage as source.

When voltage source is removed:

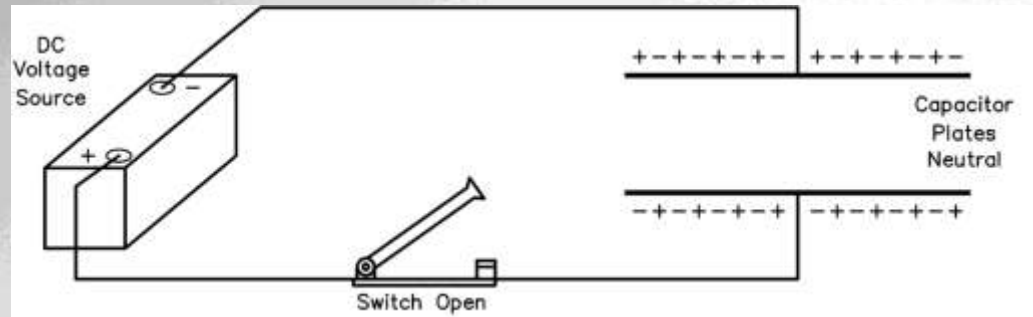
Electric field remains in the dielectric.

Field will remain until charges can move from one plate to the other via an external conductor.

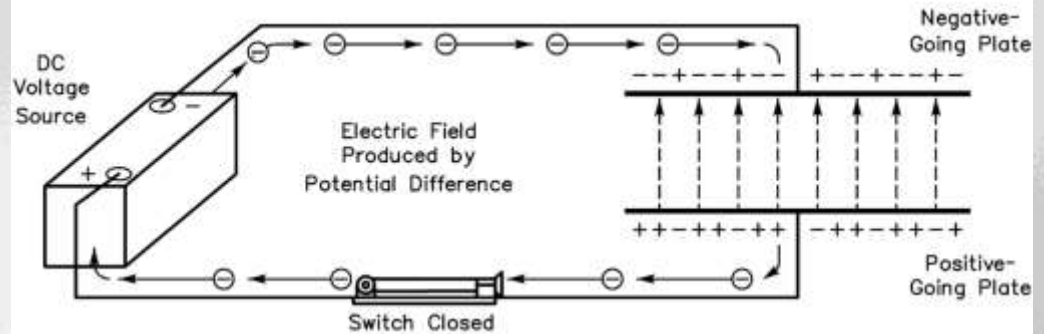
Energy has been stored and can provide current if a circuit is connected to the capacitor. **DANGER!**



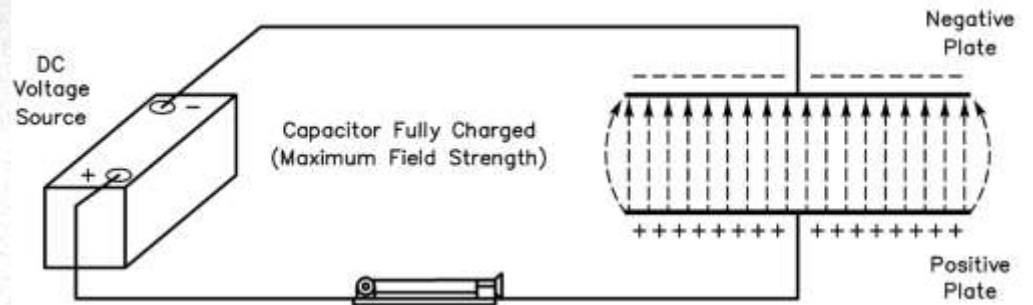
Switch Open –
Capacitor has no charge.



Switch Closes –
Electrons move to the negative plate and away from the positive plate.



Capacitor voltage equals the source voltage. Current stops.



If the switch is now opened, the capacitor remains charged.



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Variable Components

Circuits sometimes need adjustments.

- Adjustable components are usually indicated by an arrow through the symbol.
- Variable tapped resistors, called **potentiometers**, are used for Audio Volume Controls.
- Variable capacitors and inductors are used for Frequency Tuning.



Resistance and Reactance

Resistors have the same opposition to DC or AC but inductors and capacitors oppose DC and AC differently.

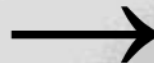
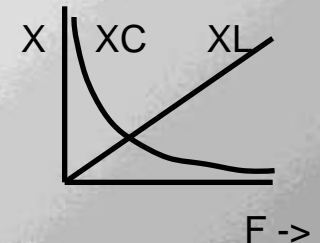
The opposition of inductors and capacitors to AC is called **REACTANCE**. Reactance (X) is measured in Ohms.

Inductors:

- Very low opposition to DC.
- Oppose a change in current through the inductor.
- Reactance increases as frequency increases.

Capacitors:

- Very high opposition to DC.
- Oppose a change in voltage across the capacitor.
- Reactance decreases as frequency increases.



Resonance

Because capacitors and inductors store energy in different ways, their reactances in a circuit can actually cancel each other at one frequency as energy moves back and forth between the inductor and capacitor.

Cancellation results in no REACTANCE, leaving just resistance.

RESONANCE is the condition when Reactance is zero.

A circuit with a capacitor and an inductor will be resonant to at least one frequency.

Resonant circuits are used for tuning and filtering.



Antenna: Capacitor + Inductor + Resistor

Antennas have characteristics of a circuit with capacitance, inductance and resistance.

The values of resistance, inductance, and capacitance of an antenna depend on:

- Frequency applied to the antenna
- Length and Diameter of the antenna
- Height of the antenna
- The measurement point



Resonant Antenna

An antenna is usually designed so that the capacitive reactance cancels the inductive reactance at the operating frequency.

- The resulting reactance is zero leaving only resistance
- Minimum opposition to the radio frequency current flowing in the antenna means maximum current
- Usually makes the signal stronger.



The Diode

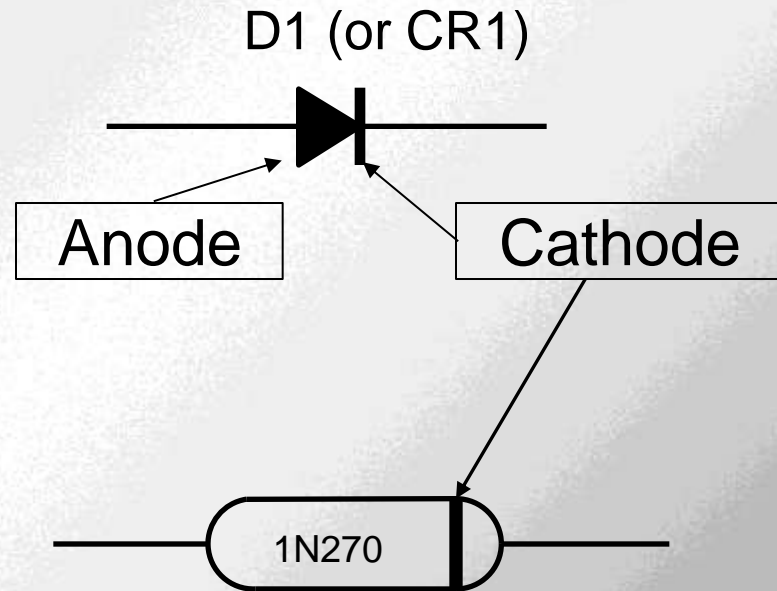
The function of the Diode is to pass Current in only one direction.

Metallic junctions exhibit rectification

A Two Lead device:

- Anode
- Cathode

Current from cathode to anode only when anode is more positive than cathode.



Light Emitting Diodes emit light.



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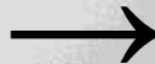
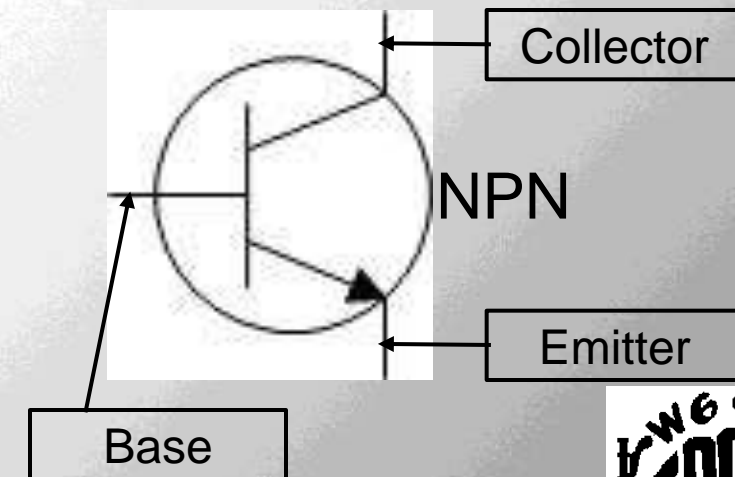
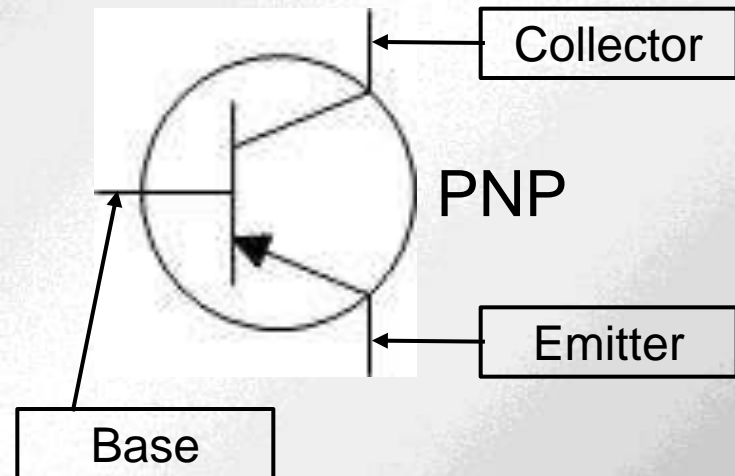


The Junction Transistor

Small input current to the **Base** controls a larger output current in the **Collector**

- Input current from Emitter to Base
- Output current from Emitter to Collector
- A current gain

Made from Germanium or Silicon.



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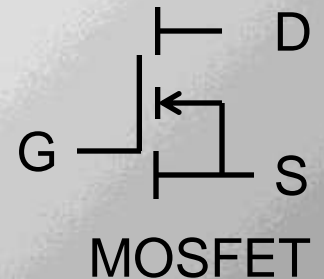
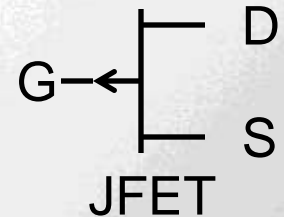
The Field Effect Transistor – FET

Input is an insulated contact called a Gate. Output current flows in a Channel.

Source at input end of channel.

Drain at output end of channel

- Gate voltage controls channel current. Called Transconductance
- High input impedance.
- JFET, Junction FET – Amplifiers
- MOSFET, Metallic Oxide Semiconductor FET – Switches



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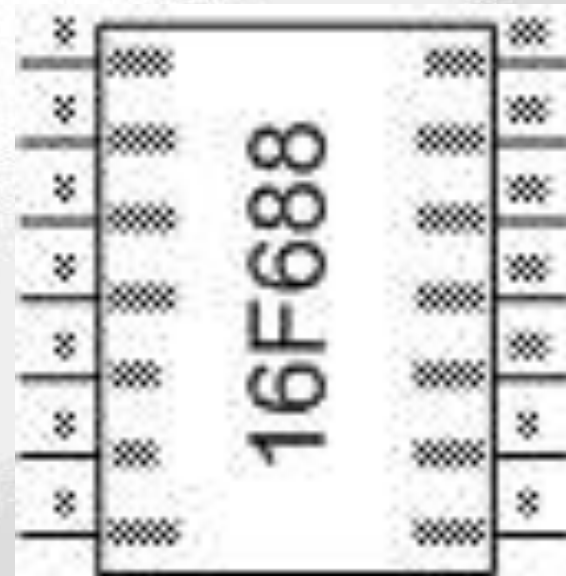


The Integrated Circuit

The integrated circuit is a collection of transistors, resistors, diodes, and FETs in one device connected to accomplish a specific task.

- Digital Logic
- Analog Functions
- MicroControllers

Circuit Symbol



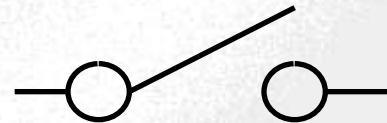
Controlling current – Switches

Switches stop or change the direction of current.

Switch terminology:

- Single Pole – SP
- Double Pole – DP
- Single Throw – ST
- Double Throw – DT
- N.O. – Normal Open
- N.C. – Normal Closed

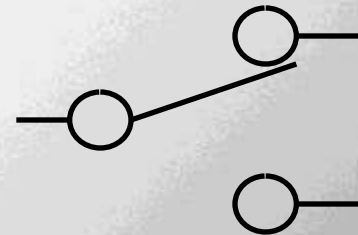
Circuit Symbols:



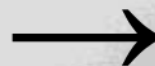
SPST – N. O.



SPST – N.C.



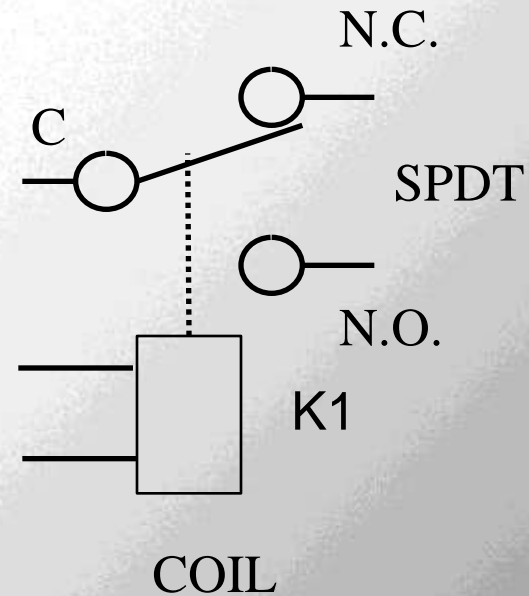
SPDT



Controlling current – Relays

Relays are like switches but are actuated by a magnetic field.

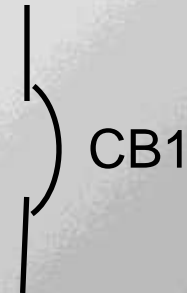
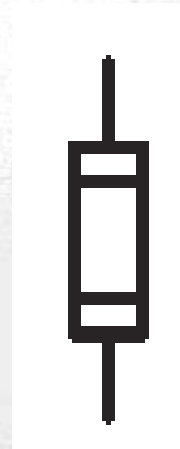
- C - Common; Moving Contact.
- N.O. – Normal Open
- N.C. – Normal Closed
- Coil requires voltage, may be DC or AC.



Protective Components – Intentional Open Circuits

Fuses and circuit breakers are designed to interrupt the flow of current if the current becomes uncontrolled.

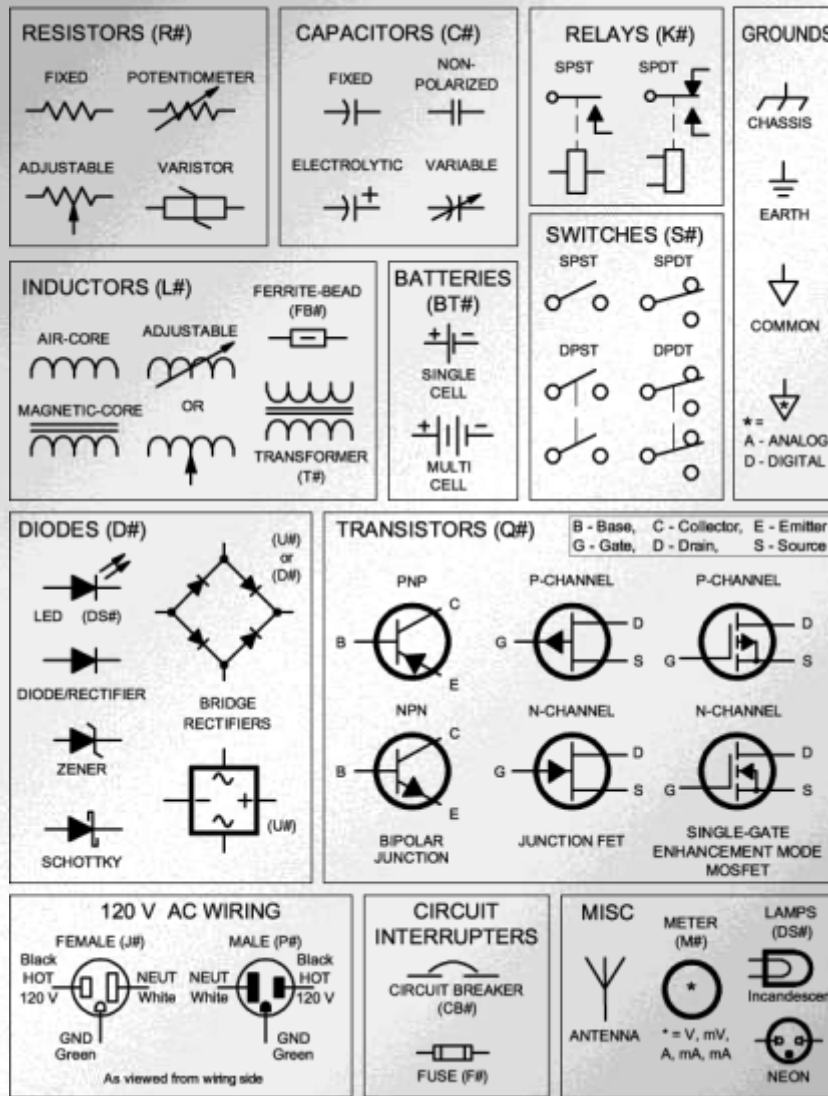
- Fuses blow – one time protection.
- Circuit breakers trip – can be reset and reused.



Schematic Symbols Used in Circuit Diagrams

Labeling conventions:

is a sequential number. (X#) is the component designator. Examples - C3, L11, R8, Q3



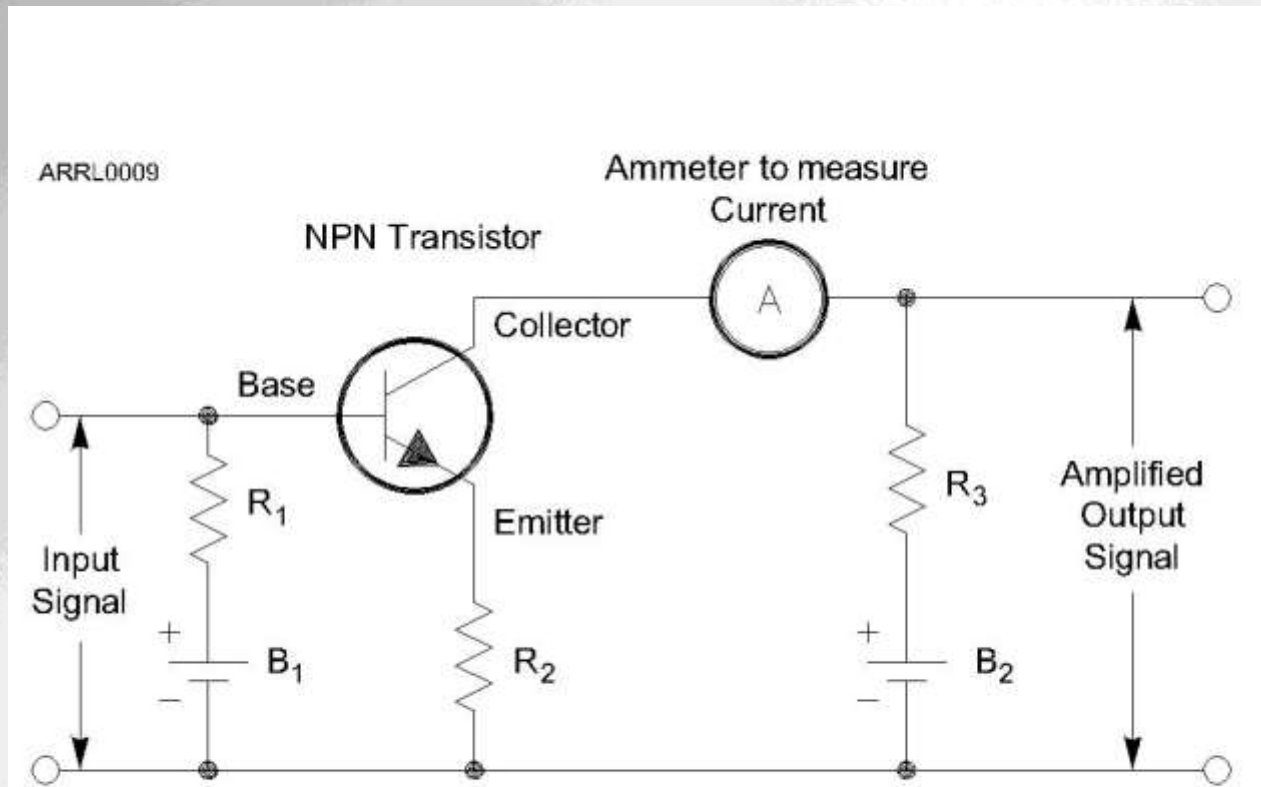
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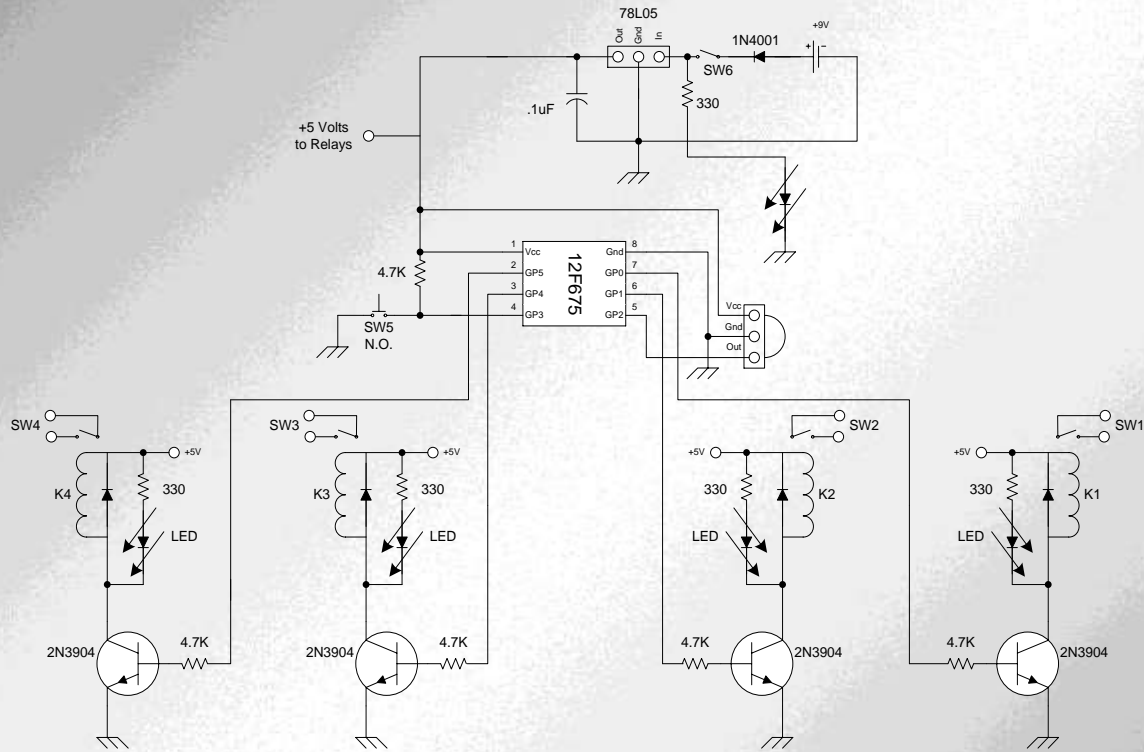
Circuit Schematic Diagram



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Project T.V. Remote Decoder Circuit



Note:

- ┌ Internal pull-up resistors are used on 12F265 pins GP0, GP1, GP2, GP4, GP5
- ┌ External pull-up resistor required on GP3
- ┌ Protection diodes are internal to K1 - K4
- ┌ Switchs SW1 - SW4 are internal to K1 - K4



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