



Chapter 4 Basic Components

Resistors, Capacitors, Inductors
Diodes & Transistors
Switches and others



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R, L, and C

The basic three components present in all circuits.

– Resistors – R

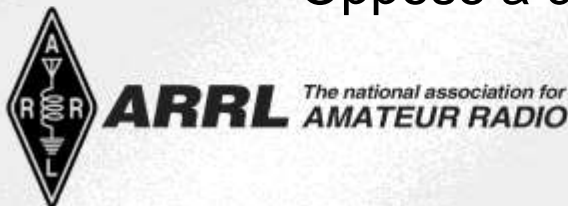
- Convert electric energy to heat
- Impede or reduce current
- Reduce voltage to rest of circuit

– Capacitors – C

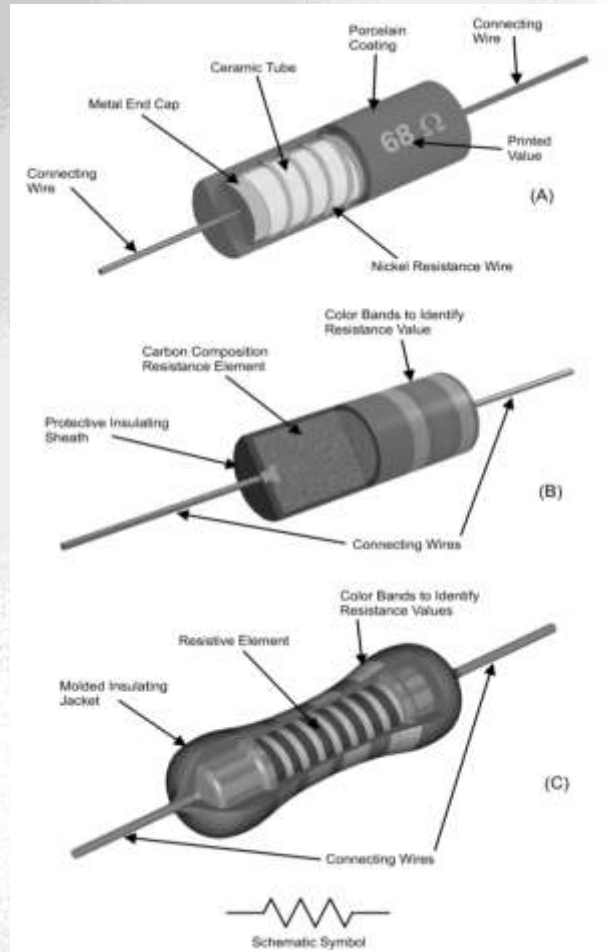
- Store energy in an electrostatic field
- Negative and positive charges separated by insulator
- Oppose a change in voltage.

– Inductors – L

- Store energy in a magnetic field.
- Oppose a change in current.



Resistors



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Resistors

Measured in Ohms. (Ω)

- One ohm, one volt, one amp.
- milliOhms 10^{-3}
- KiloOhms 10^3 ,
- MegOhms 10^6

Power rating

- Watts for safe operation. $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 5, ...
- Physical size and shape.
- Cooling – still air or moving air.



Resistors

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

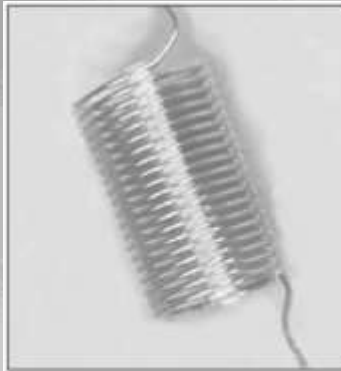
- Carbon Composition – once common but becoming obsolete.
- Carbon Film – replacing composition. Widely available
- Metal Film - High precision and accuracy to 0.1%

High Power – 2 Watts and higher

- Wirewound – Sometimes very Inductive
- Ceramic – Smaller size than wirewound
- Carborundum – Good for non-inductive.



Inductors



Air Core
Straight or Solenoid
Coil Form



(A)



Magnetic or Iron Core
Toroidal Coil Form



(B)



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Inductors (Coils)

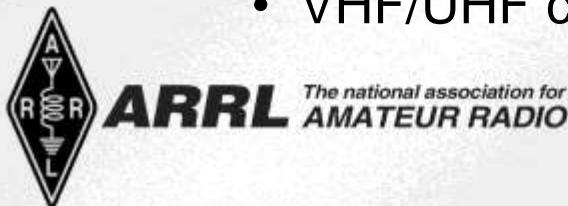
Coiling up a conductor increases its magnetic field and inductance. Inductance depends on:

- Diameter and length of the coil.
- Core material.
 - Air – Small inductance
 - Iron – Large inductance
 - Ferrite and Steel – Very Large inductance
- Number of turns.
 - Inductance is proportional to square of turns.

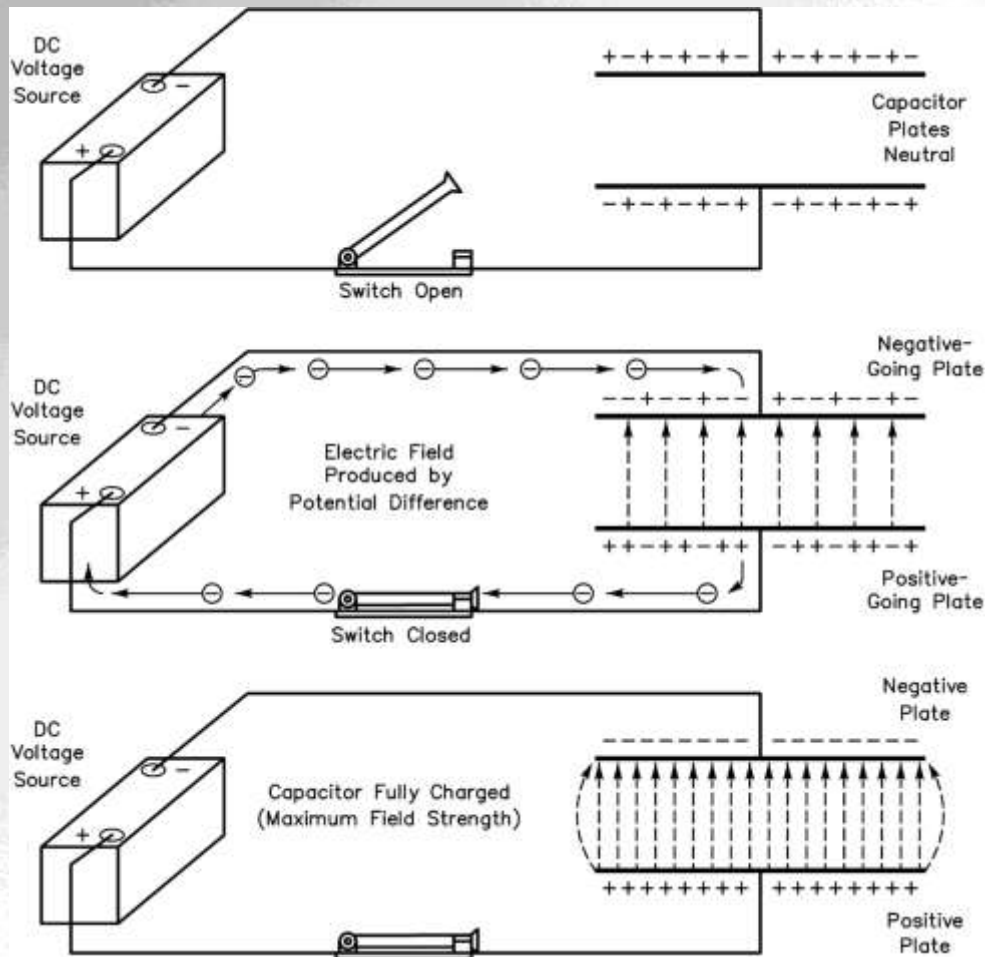
Inductors (Coils)

Unit of measure of inductance is the Henry – H.
Greater than 1 H is common in Power Supplies.

- milliHenries – mH –
 - 10^{-3} H
 - RF filters (Chokes)
- microHenries – μ H
 - 10^{-6} H
 - Tuning circuits
- nanoHenries – nH
 - 10^{-9} H
 - VHF/UHF circuits.



Capacitors



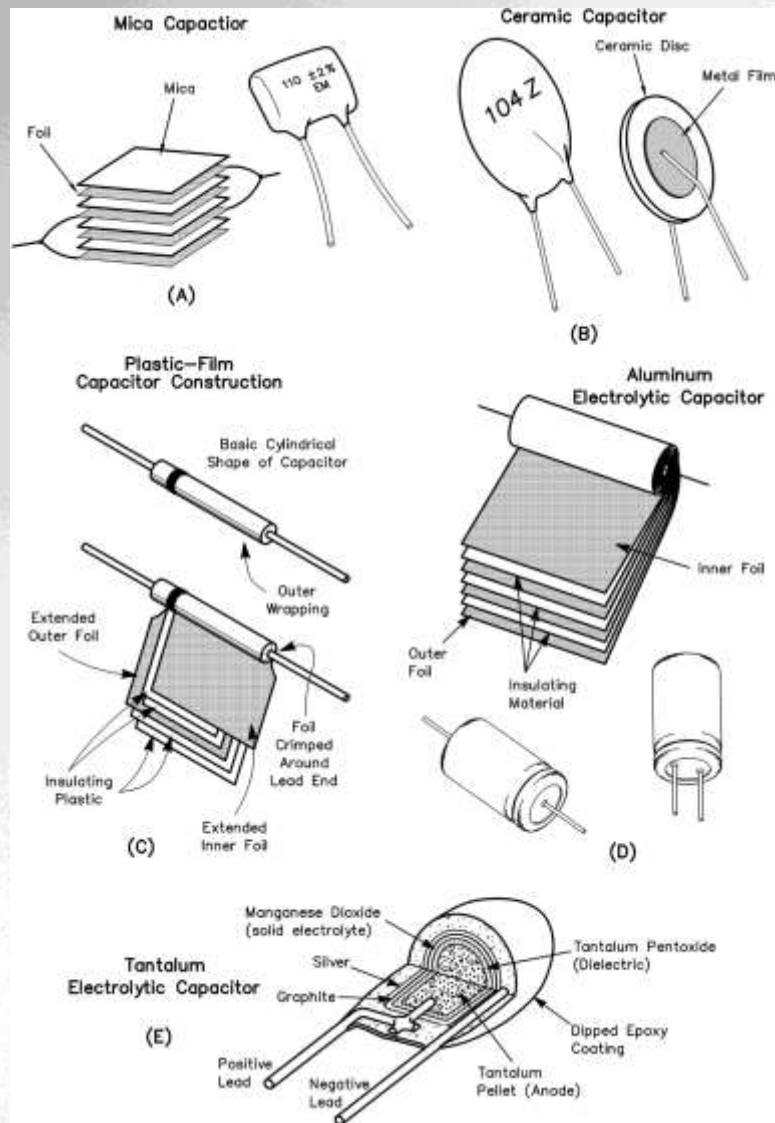
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Capacitors

Capacitors are conductors separated by insulators. Capacitance depends on:

- Area of conductors. Proportional to area.
- Insulator thickness. Inversely proportional.
- Type of Dielectric (material between plates).
 - Air – Lowest value of capacitance
 - Mica – Good RF qualities
 - Ceramic – Small size for larger values
 - Electrolytic – Very large values.



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Capacitors

Unit of measure is the Farad. (F) One Farad can be physically very large, but available as “SuperCaps”.

– microFarads – μF

- 10^{-6} F – Filtering and de-coupling

– nanoFarads – nF

- 10^{-9} F – Coupling and by-passing

– picoFarads – pF

- 10^{-12} F – Tuned circuits and timing.



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Variable Components

Circuits sometimes need adjustments provided by adjusting the size of components. 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.

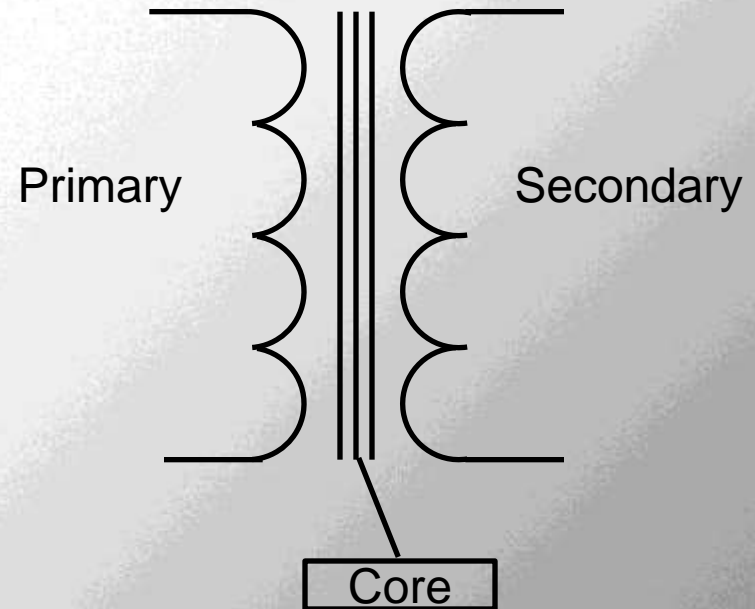


Transformers

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 of the core.
- Used to increase or decrease Voltage .

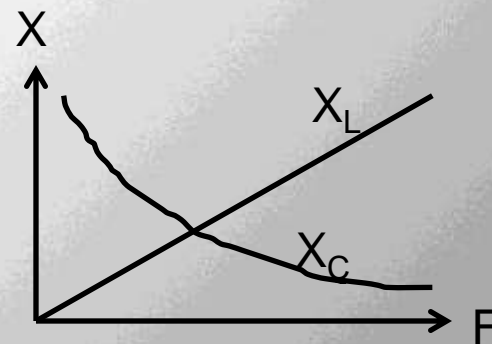
Circuit Symbol – T



Reactance

Because they store energy in fields, capacitors and inductors react differently to AC than to DC. Their opposition to AC is called REACTANCE.

- Reactance is measured in Ohms.
- Reactance in a diagram is shown by a resistor symbol with the letter X with a subscript L or C – “X sub L” or “X sub C”.
- Capacitive reactance X_C behaves the opposite of inductive reactance X_L .
- X_L increases with frequency.
- X_C decreases with frequency.



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Resonance

Because capacitors and inductors store energy in different ways, their stored energies can actually cancel each other at one frequency when connected together in series or parallel.

- Cancellation results in no Reactance, leaving just resistance.
- This cancellation is called RESONANCE and the frequency is the Resonant Frequency.
- A circuit with a capacitor and an inductor will be resonant to at least one frequency.



Antennas – Resistance and Reactance

Antennas act like a series circuit of capacitance, inductance and resistance.

- The resistance is due to energy lost or radiated.
- 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 for a minimum opposition to current.
- Minimum opposition to the radio frequency current flowing in the antenna means maximum current
- Maximum current produces a stronger radio wave into space.



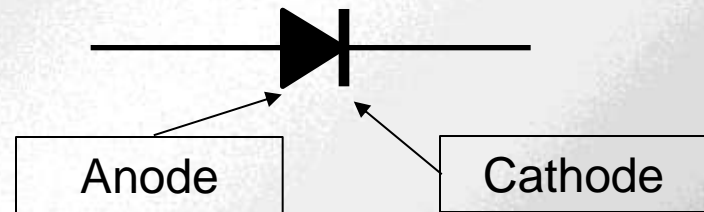
The Diode

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

A Two Lead device:

- Anode
- Cathode
- Electrons move from Cathode to Anode.

Circuit Symbol



Typical Diode



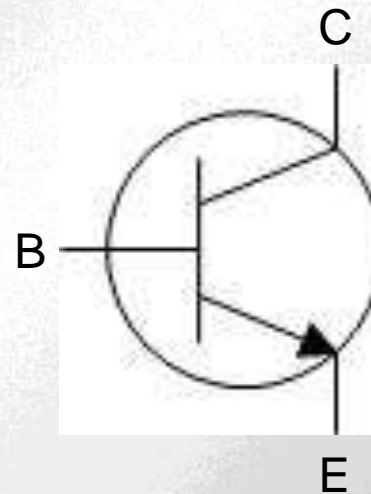
The Transistor

The function of the transistor is to variably control the flow of current.

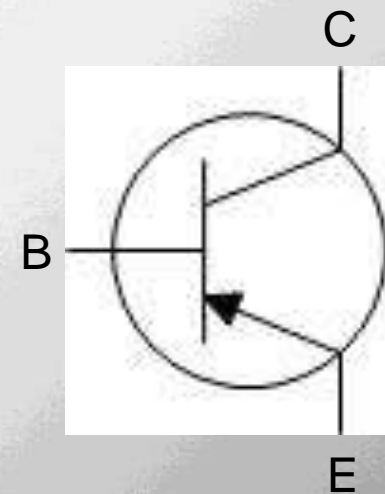
- A large Collector current is controlled by a small Base current
- Much like an electronically controlled valve.
- An analogy, a water faucet or a light dimmer

Circuit Symbol

NPN



PNP



C – Collector

B – Base

E – Emitter



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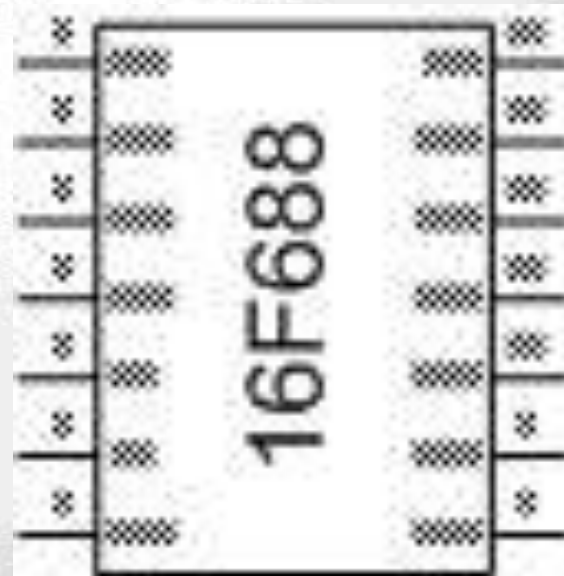


The Integrated Circuit

The integrated circuit is a collection of components contained in one device that accomplishes a specific task.

- Digital or Linear
- Gates, Flip-Flops
- Memory or Processors
- Programmable or general purpose.

Circuit Symbol of a Microcontroller



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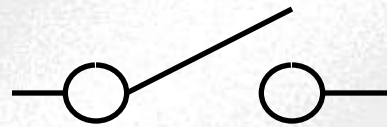


Controlling current – Switches

Switches block current or change its direction. Some terms used to describe switches:

- P – Poles; Moving Contact. Single, Double, Triple, Etc.
- T – Throw; Single, Double, Triple, Etc.
- N.O. – Normal Open
- N.C. – Normal Closed

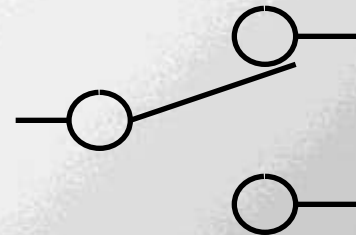
Circuit Symbols:



SPST – N. O.



SPST – N.C.



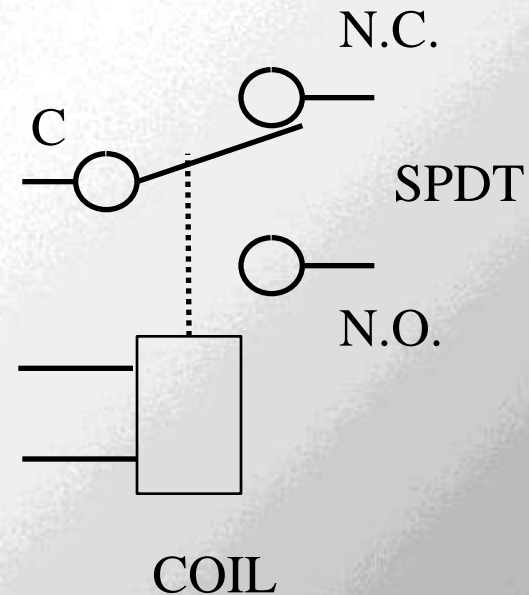
SPDT

Controlling current – Relays

Relays are like switches but actuated by a magnetic field.

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

Circuit Symbols:

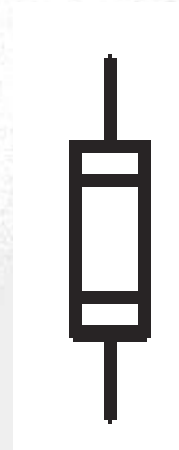


Protective Components

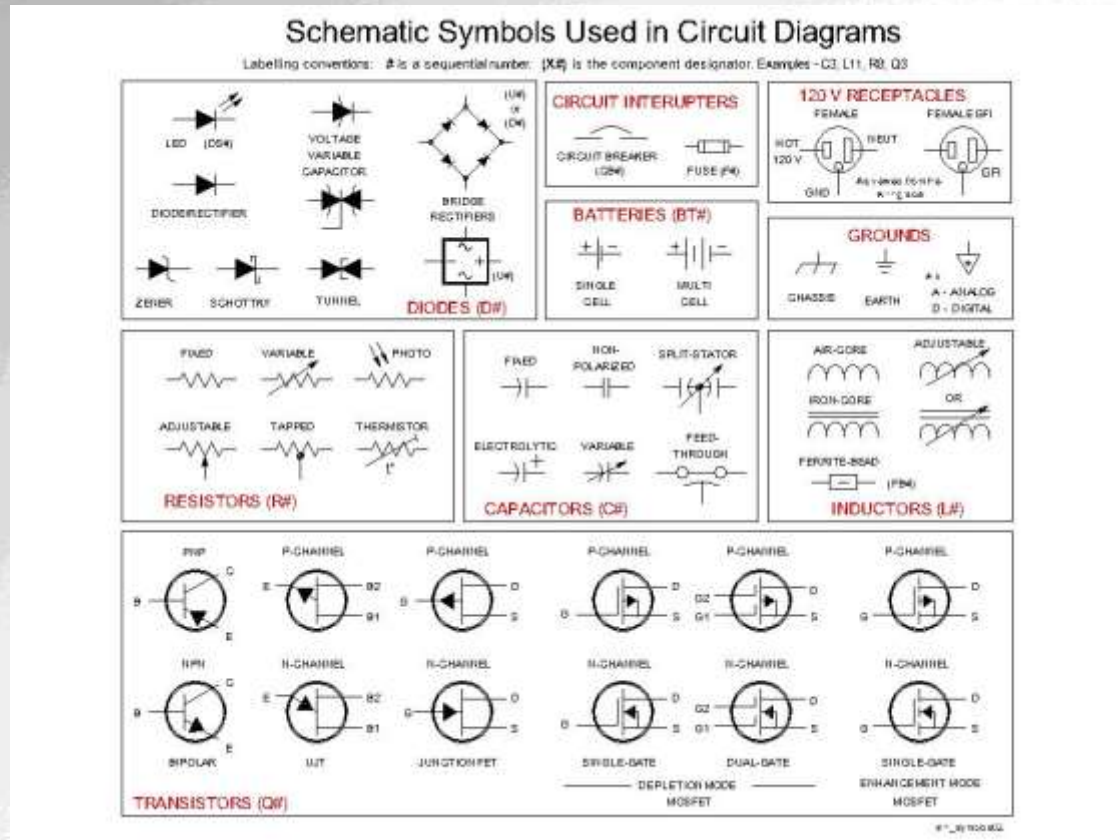
Fuses and circuit breakers are designed to interrupt the flow of current if the current becomes uncontrolled.

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

Circuit Symbol



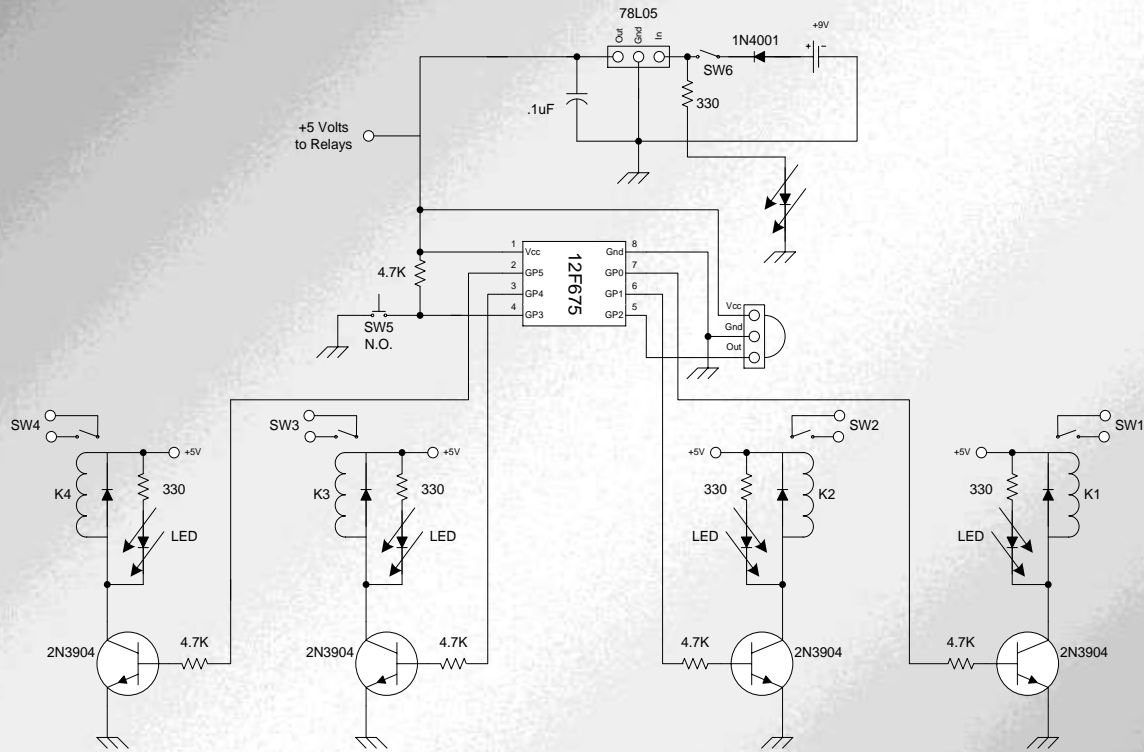
Some Other Circuit Symbols



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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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