3. ELECTRICITY, COMPONENTS and CIRCUITS

Chapter 3 Part 2 of 3

Components and Units

Controlling flow of current

We use various **components** to control the flow of current

Resistors

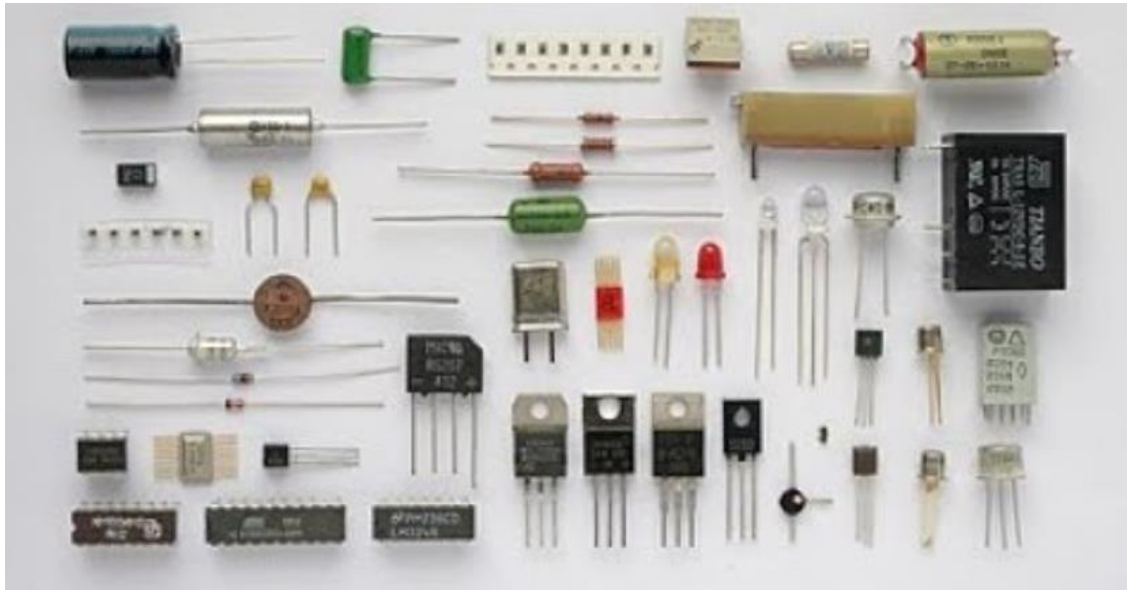
Capacitors

Inductors

Diodes

Transistors

Integrated circuits

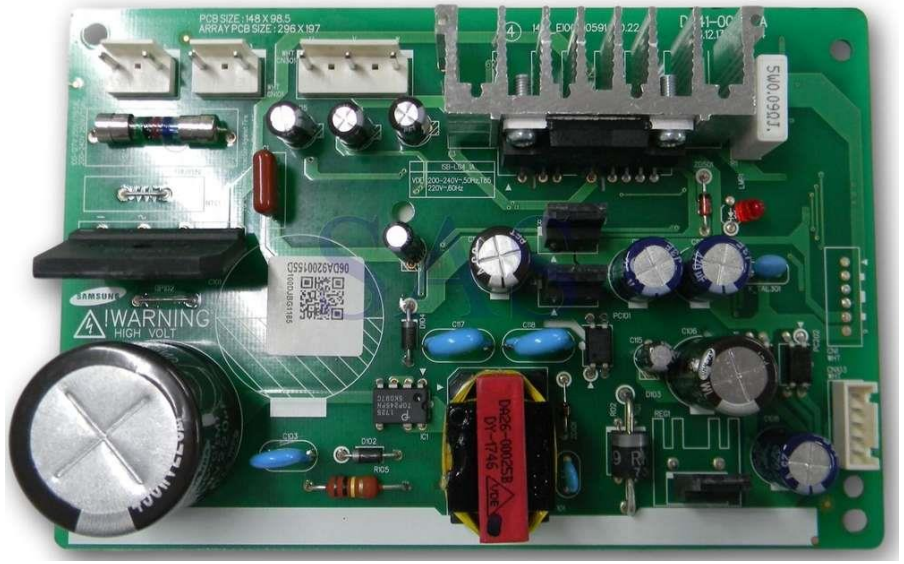


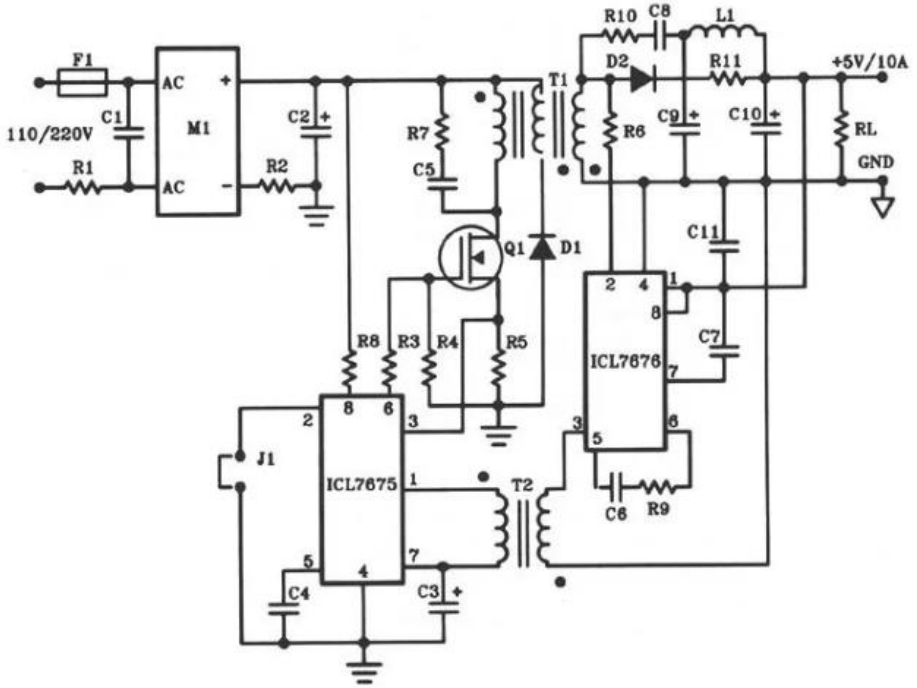
Switches, Relays, Transformers, LED's, Displays, Lightbulbs, Speakers, Fuses, Sensors, Connectors, Cables…..

Schematic diagram

A schematic diagram shows how the parts are connected,
but not necessarily the location of the parts

This makes it easier to understand the function of the circuit





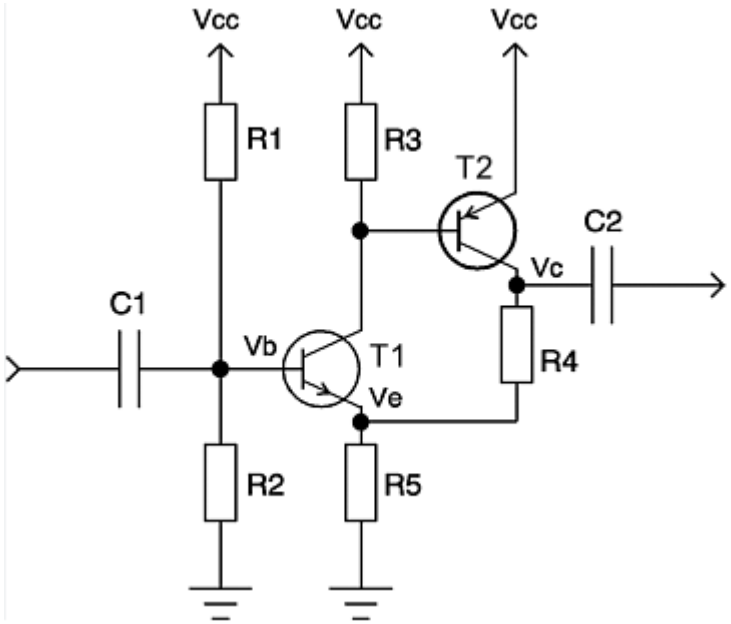
Schematic symbols

The lines and dots on the schematic represent connections between the components

The schematic uses standardized symbols for the various components

The parts are given designators, like ‘R3’ to denote what the component is, commonly:

- R : resistors
- C : capacitors
- L : inductors
- T : transistors
- D : diodes
- IC : integrated circuits
- J : jumpers / connectors

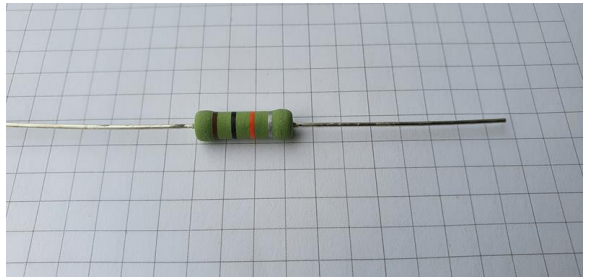


Resistor

Resistors restrict the flow of current

It has a value measured in **Ohm (Ω)**, called **resistance**

Schematic symbol:



Variable Resistor, Potentiometer

Used to adjust the resistance

For example, a volume control

Schematic symbol:

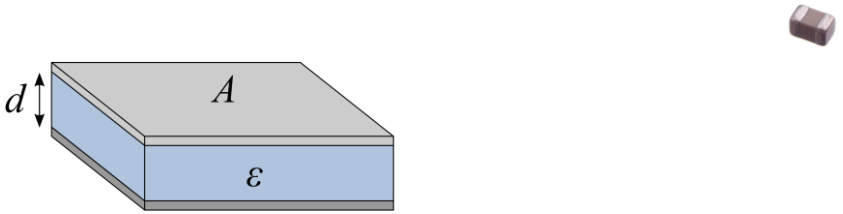
Capacitor

Capacitors store electric energy in an **electric** field

It has a value measured in **Farad (F)**,
called **capacitance**

Schematic symbol:

Also variable:



Inductor

Inductors store electric energy in a **magnetic** field

It has a value measured in **Henry (H)**,
called **inductance**

Schematic symbol: 

Also variable/core: 

Unit recap

Passive component's values covers wide ranges

Resistors: Ω (Ohm, resistance)	0 Ω – 10,000,000 Ω
Capacitors: F (Farad, capacitance)	0.000,000,000,001 F – 0.01 F
Inductors: H (Henry, inductance)	0.000,000,000,1 H – 0.1 H

Prefixes makes handling wide ranges of numbers much easier

Prefixes

Prefix	Symbol	Multiplier		Common name
Tera	**T**	× 10^{12}	× 1 000 000 000 000	trillion
Giga	**G**	× 10^{9}	× 1 000 000 000	billion
Mega	**M**	× 10^{6}	× 1 000 000	million
Kilo	**k**	× 10^{3}	× 1 000	thousand
Deci	**d**	× 10^{-1}	× 0.1	tenth
Centi	**c**	× 10^{-2}	× 0.01	hundredth
Milli	**m**	× 10^{-3}	× 0.001	thousandth
Micro	**μ**	× 10^{-6}	× 0.000 001	millionth
Nano	**n**	× 10^{-9}	× 0.000 000 001	billionth
Pico	**p**	× 10^{-12}	× 0.000 000 000 001	trillionth

Reactance

Resistors oppose the flow of electrons (current)

- Independent of direction and frequency

Capacitors and Inductors store energy and also oppose the current, but behaves different depending on frequency

Capacitors create **capacitive reactance (X_C)**

- Decreases with increasing frequency

Inductors create **inductive reactance (X_L)**

- Increases with increasing frequency

Reactance is measured in Ohm (Ω)

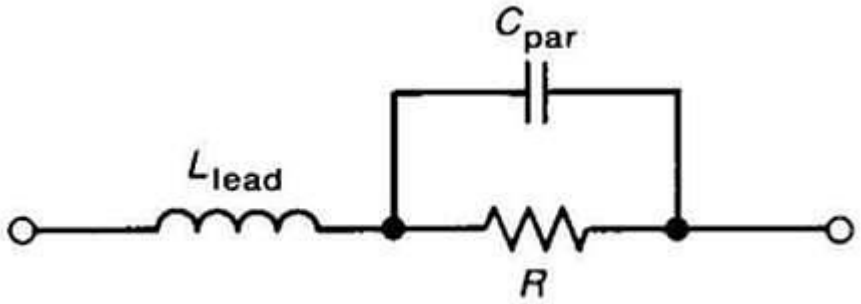
Impedance

Any real component has ALL of:

- Resistance
- Capacitance
- Inductance

The combination of these is called **Impedance** (Z).

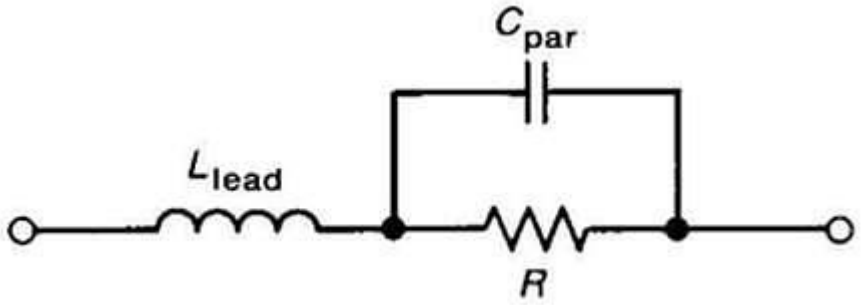
..and is also measured in Ohm (Ω)

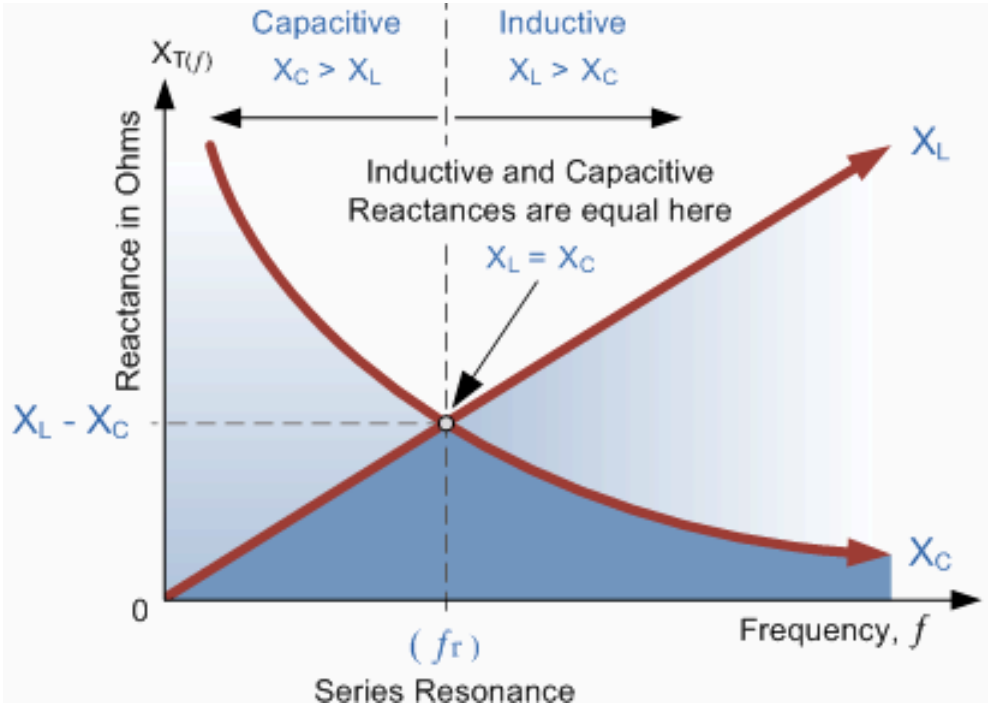


Resonance

This circuit has both capacitive and inductive reactance

This is called a **tuned circuit**





X_C decrease as the frequency increase

X_L increase as the frequency increase

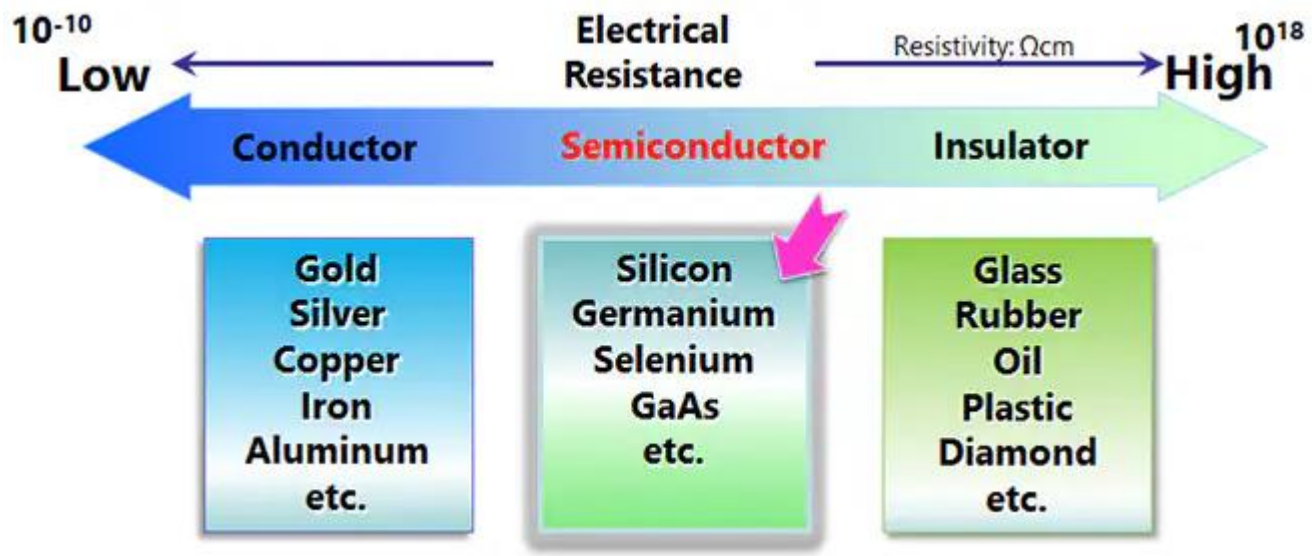
The point where **$X_C = X_L$** is called **resonance**

More components : Semiconductors

Most commonly made of **silicon** or **germanium**

By adding “impurities”, current flow can be controlled

‘P’ and ‘N’ material has more or less electrons than usual



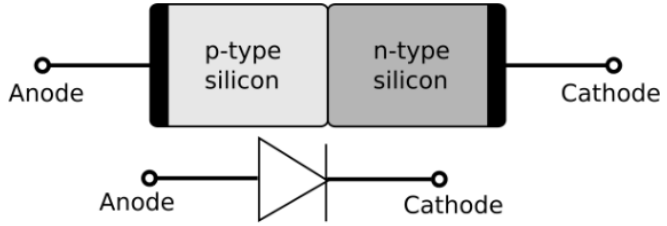
Diode

Only conducts in one direction*

Current flows from the Anode to the Cathode, but not in the other direction

Used to **rectify** AC into DC

When current flows, there's a small voltage over the diode, called **forward voltage drop**.
Usually 1V or less depending on the diode and current.



*) **Zener diodes** conduct in reverse direction, with a very specified voltage drop

Light Emitting Diodes

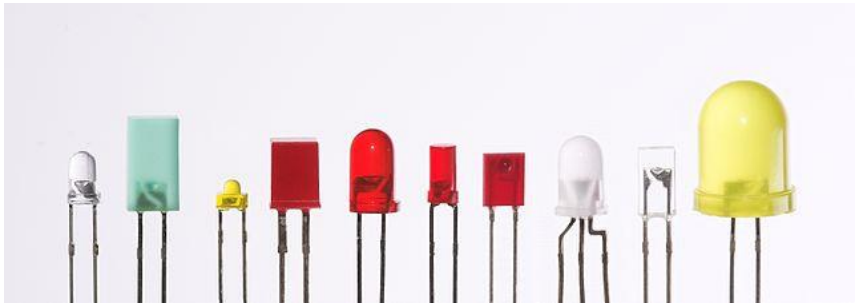
Forward current cause electrons to jump between layers

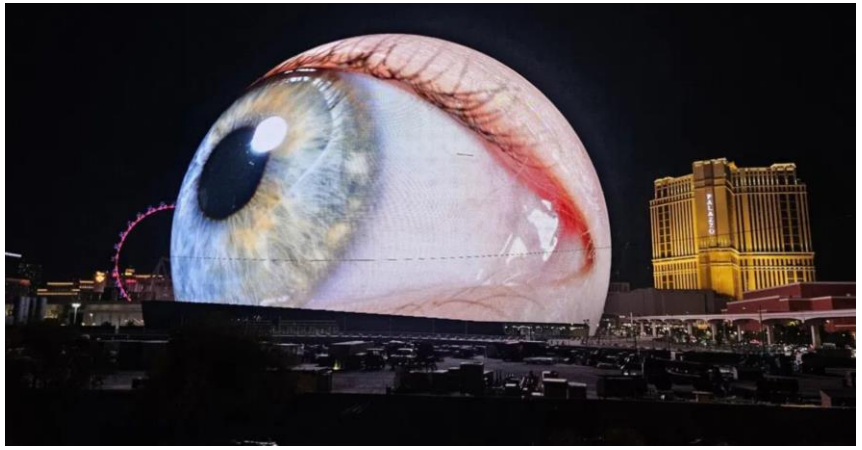
The jump emits photons

Color depends on material

Used for indication and illumination

Small, efficient, fast, cheap





Transistors

Controls a larger signal with a smaller signal.

Can be used as an **amplifier** or as a **switch**

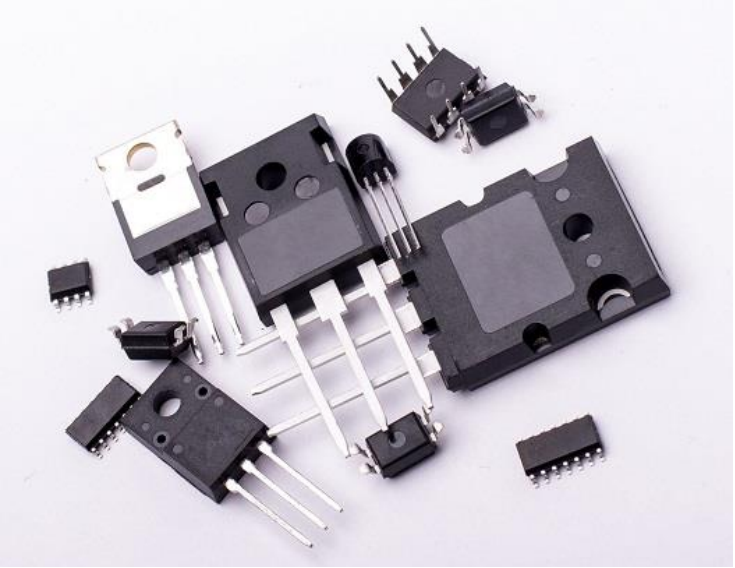
The amount of amplification is called **gain**

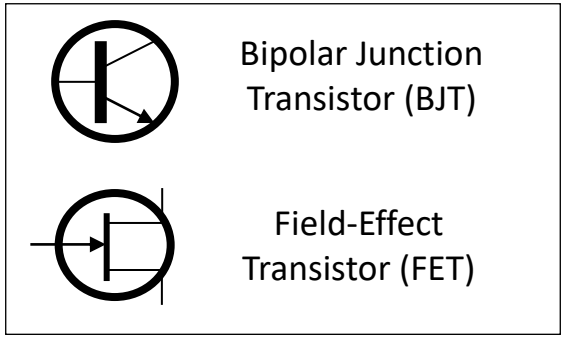
BJT's

- **Three** layers: N-P-N or P-N-P
- **Collector, Base, Emitter**
- Controlled by current

FET's

- Path of N or P material
- **Source, Gate, Drain**
- Controlled by voltage



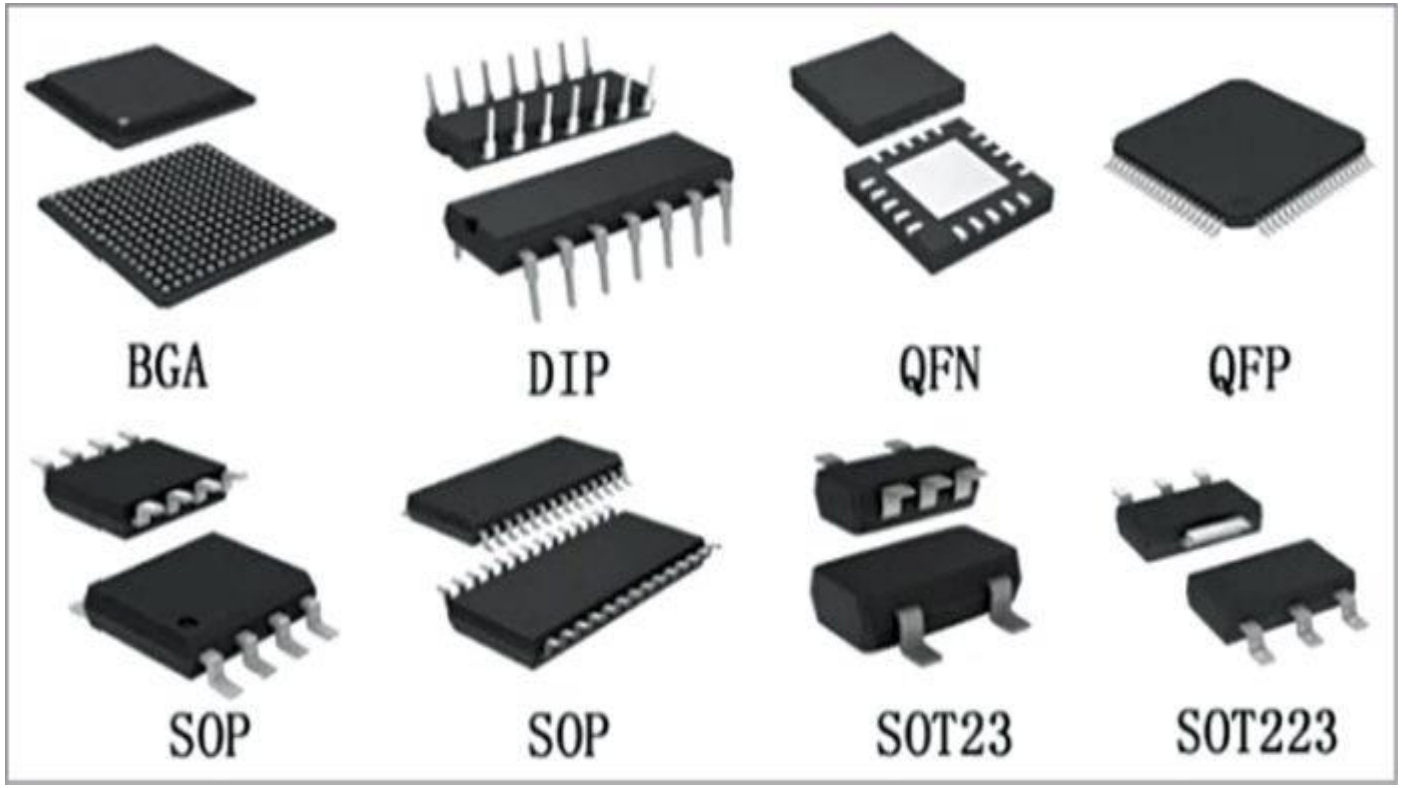


Integrated circuits

Multiple components on a very small silicon plate

Wires bonded out to pins or pads

Can have both analog and digital functions



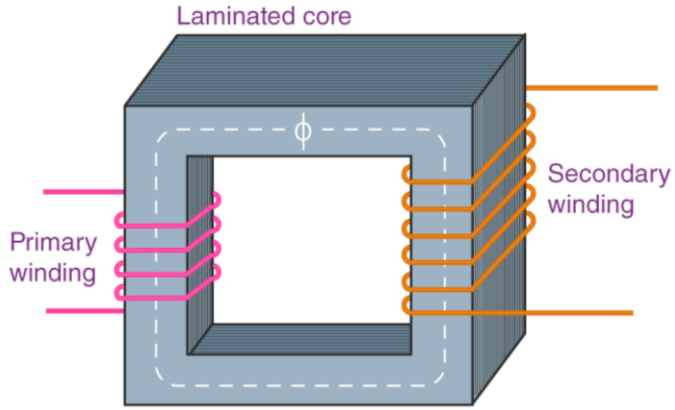
Transformers

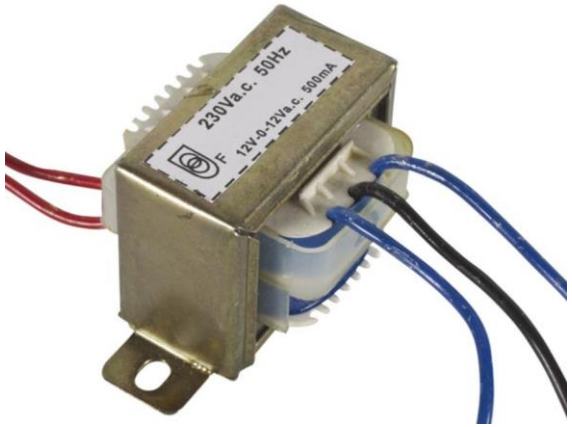
Two (or more) inductors

Sharing a core – so sharing the magnetic field

Allows transfer of energy (constant power)

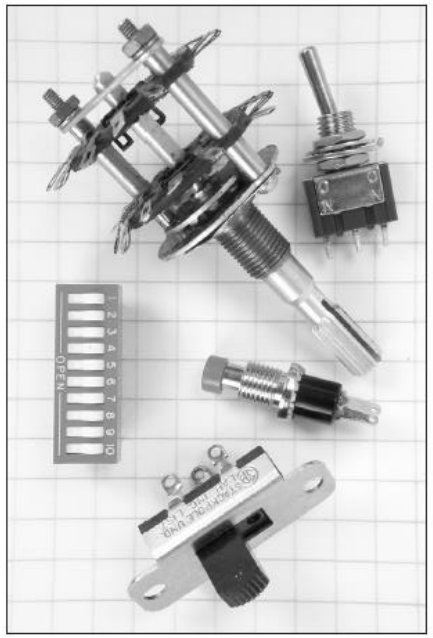
Schematic symbol:

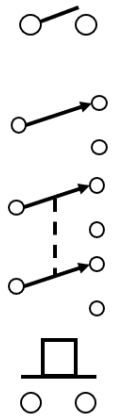




Electromechanics

Switches





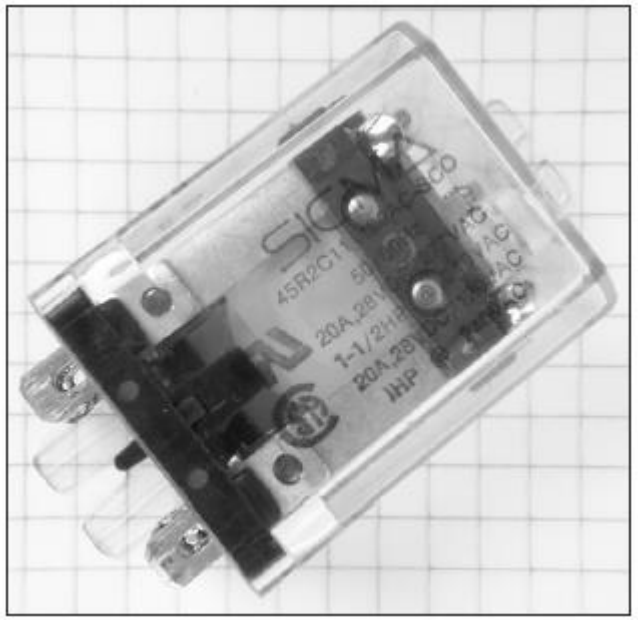
SPST

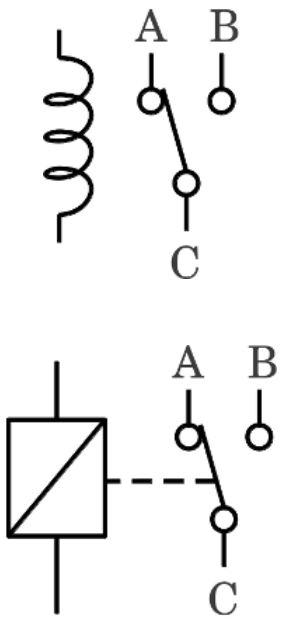
SPDT

DPDT

Pushbutton

Relays

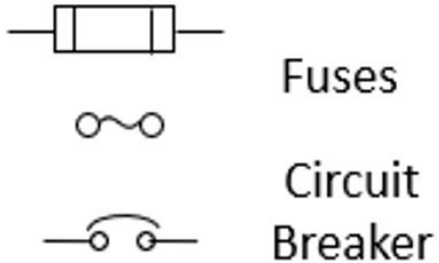


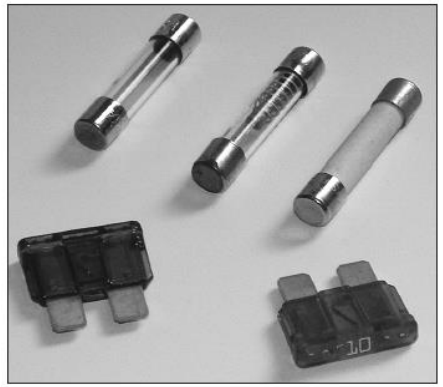


Protective components

Fuses

- Blow : one time protection





Circuit breakers

- Trip : can be reset and reused

Protects a circuit from overload (too much current)

Replacing a fuse/breaker with one with a higher current rating may allow a fault to permanently damage the circuit or cause a hazard/fire.

Questions!