Active and passive components

An active component is an electronic component which supplies energy to a circuit. eg: Voltage source, Current source, Transistors , SCR, Integrated circuits etc

A passive component is an electronic component which can only receive energy, which it can either dissipate, absorb or store it in an electric field or a magnetic field. eg: Resistor, Inductor, Capacitor

Comparison between active and passive components

Active component	**Passive component**
Active components deliver power or energy to the circuit.	Passive elements utilizes power or energy from the circuit.
Devices which produce energy in the form of voltage or current.	Devices which stores energy in the form of voltage or current.
They are capable of providing power gain.	They are incapable of providing power gain.
Active components can control the flow of current.	Passive components cannot control the flow of the current.
They require an external source for the operations.	They do not require any external source for the operations.
Diodes, Transistors, SCR, Integrated circuits etc.	Resistor, Capacitor, Inductor etc.

Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements

Specifications of resistors

1. Resistance Value : It gives the value of resistor R in ohms. It's value is either printed or colour coded over the body depending upon the type of resistor. In general resistors from 1Ω to many MΩ are available.
2. Tolerance : It gives the variation of resistance value from the indicated value. It is generally expressed in percentage. It's typical values are ranging from ±1% to ±20%. Resistors with low tolerance values are preferred.
3. Power Rating : The power rating of a resistor is given by the maximum wattage. The resistor can dissipate without excessive heat. It is expressed in watts.
4. Temperature Coefficient of Resistance : It gives the variation of resistance with a change in temperature. It is usually measured with reference to resistance at 25°C.

5. Voltage Coefficient : It is measured as the change of resistance of a resistor with a change in the applied voltage.
6. Voltage rating: The maximum voltage that can be applied to a resistor without any damage
7.Stability:The change in resistance value that occurs under specified physical and electrical operating conditions.

Applications of resistors

In electronic circuits resistors are used to

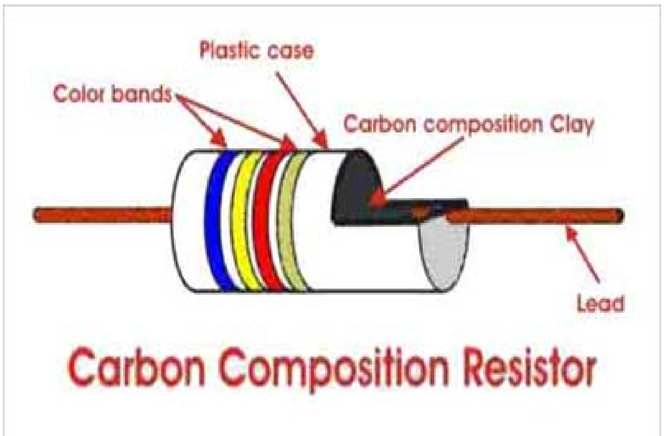
1) Reduce the current flow
2) Adjust signal levels
3) Divide voltages
4) Bias active elements
5) Terminate transmission lines
6) It is used in DC power supplies.
7) Resistors are used in filter circuit networks.
8) Resistor is used in voltage regulators.

Important types of resistors

Fixed resistor

The resistance value is fixed and cannot be adjusted. Symbol of a fixed resistors shown in figure. Examples of fixed resistors are carbon composition resistor and wire wound resistor

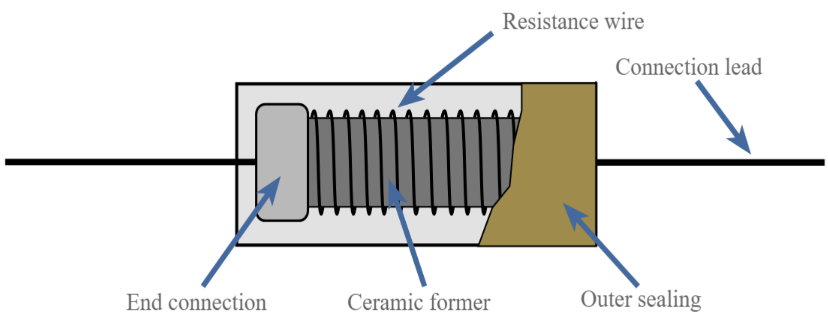
Carbon composition resistor



The resistive element in carbon composition resistors is made from a mixture of finely powdered carbon and an insulating material, usually ceramic. A resin holds the mixture together. The resistance is determined by the ratio of the fill material (the powdered ceramic)

to the carbon. Higher concentrations of carbon, which is a good conductor, result in lower resistances.
The leads are made of tinned copper. It is enclosed in a plastic or ceramic case to protect it from moisture and duct. It normally has diameters less than 10 mm. Colour coding is done to identify the resistance value.For higher power dissipation the size of the resistor should be increased. The shape of the resistor is of a cylindrical type.

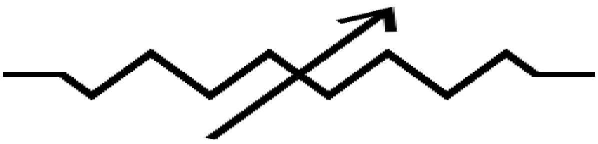
Wire wound resistor



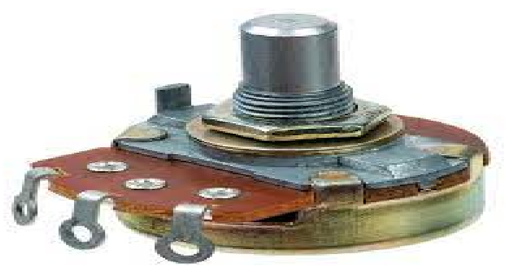
The resistor is constructed from resistance wire(Made up of nichrome or manganin) that is wound around a central core or former, that is usually made of ceramic.Once wound, end caps are pressed onto the core and the resistance wire is welded to them to make proper contact. Finally the assembly is encapsulated to protect it from moisture and physical damage.

Variable resistor

The variable resistor is an element that offers variable resistance to the circuit. By adjusting its internal configuration, we can obtain variable resistance at the load side. In the figure below, the symbolic representation of the variable resistor is shown. The arrow implies the value of the resistance can be varied.



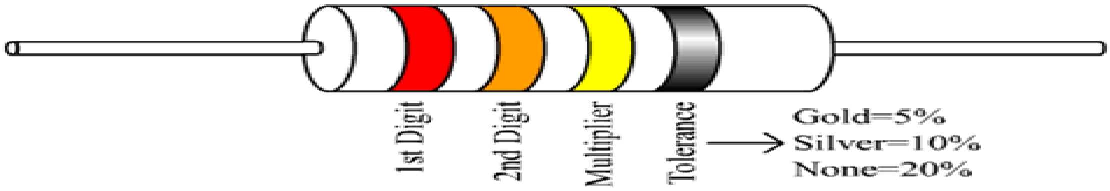
Examples of variable resistors are Potentiometers, Rheostat



Potentiometer

Rheostat

Colour coding of resistors



Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

B B ROY of **G**reat **B**ritain has a **V**ery **G**ood **W**ife

Four band colour coding system is shown in the above table. First two colour band represent digits in resistance value, third digit represents multiplier in resistance value and fourth band represents the tolerance.

- Colour code Brown Black Green Silver

  Resistanc value $10x10^5\ \Omega \pm 10\%$

  $1M\Omega \pm 10\%$

- Colour code Red Red Gold Gold

  $22x10^2\ \Omega \pm 5\%$

  $2.2k\Omega \pm 5\%$

- Value $1k\Omega \pm 10\%$

  Colour code

  brown,black,red,silver

- Value $47k\Omega \pm 5\%$

  Colour code

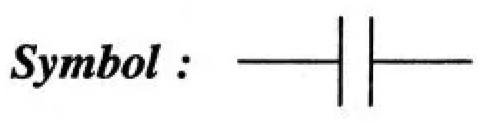
  Yellow,Violet,Orange,Gold

Capacitors

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.The effect of a capacitor is known as capacitance.

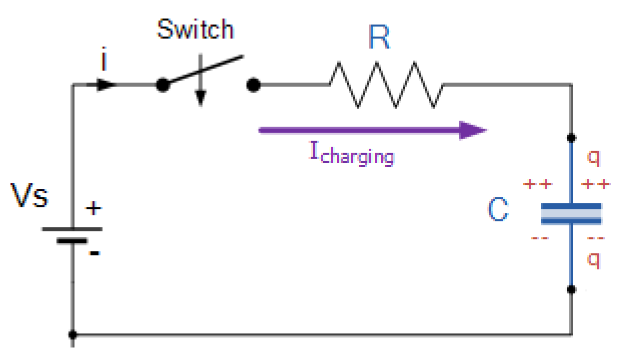
It holds the electric charge when we apply a voltage across it, and it gives up the stored charge to the circuit as when required.

Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium.



Charging and discharging of capacitor

Charging of capacitor



In the circuit above, let the capacitor having capacitance C have neutral charge in it initially . When we close the switch, the positive terminal of the battery attracts electrons from the top plate (this plate gets positive charge) and the negative terminal of the battery supplies electrons to the bottom plate(This plate gets negative charge). There will be an initial current flow through the external circuit in the direction shown (The direction of current flow is in the opposite direction of electron flow.).The charge gets accumulated on the plates of the capacitor and no current flows through the capacitor due to the presence of dielectric medium. Here the upper plate will get positive charge and lower plate will get negative charge.

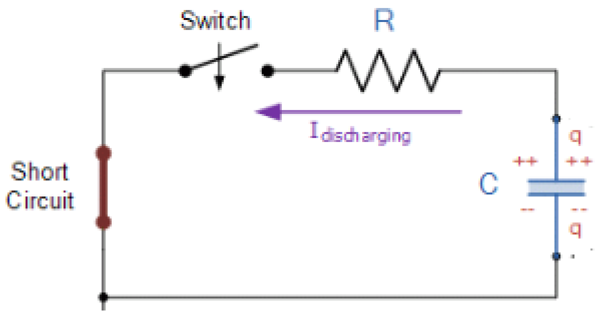
As charge gets accumulated in the plates of the capacitor, voltage builds up across the capacitor. The current flow in the external circuit slows down as the voltage builds up across the capacitor and stops when the voltage across the capacitor becomes equal to applied voltage and charging stops. The charge remains in the capacitor, with or without the applied voltage connected. The charge accumulated in the capacitor is directly proportional to the voltage developed across the capacitor. $q \alpha V$

$q=CV$

Here C is the constant of proportionality, and this is capacitance,

The capacitance is the charge that gets stored in a capacitor for developing 1 volt potential difference across it.

Discharging of capacitor



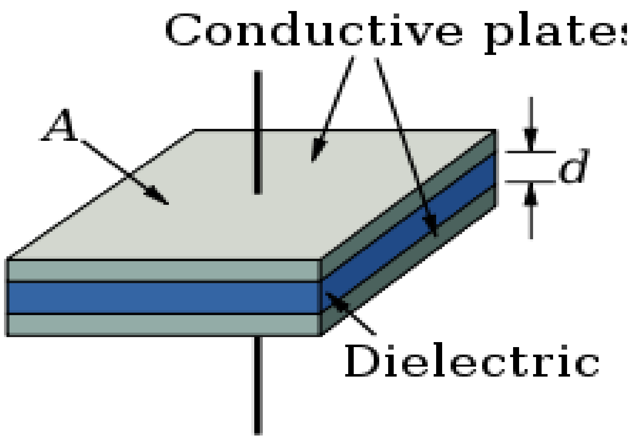
When the voltage source in the capacitor charging circuit is replaced by a short circuit, we now have a capacitor discharging circuit.

If we connect the charged capacitor to an external circuit as shown in the figure, the capacitor will act as a voltage source. When the switch is closed, The capacitor will discharge through the resistor. Current flows through the external circuit in the direction shown. The current decreases as the charge on the capacitor decreases and stops completely when the capacitor is fully discharged. Here energy stored in the electric field of the capacitor will be lost as heat loss in the resistor.

Specifications of a capacitor

- **Capacitance value:** The capacitance is the charge that gets stored in a capacitor for developing 1 volt potential difference across it**.** (The actual capacitance value units nF, μF etc SI unit is Farad)
- **Voltage rating**: Voltage rating is the operating voltage of the capacitor and it is measured in volts.
- **Tolerance**: Is the allowed percentage change in capacitance value
- **Temperature range**: The range of temperature in which the particular capacitance can operate
- **Temperature Co-efficient:** It gives the change in capacitance value with the change in temperature. It is expressed in ppm/°c.
- **Stability:** It is usually long or short term percentage variation of capacitance which occurs under specified physical and electrical operating conditions
- **Leakage current:** The current flowing in the dielectric when the rated dc voltage is applied at given temperature.
- **Frequency Range:** The frequency range is the maximum frequency up to which the capacitor can work safely.

Parallel plate capacitor value



A dielectric material is placed between two conducting plates (electrodes), each of area A, and with a separation d. The capacitance value of a parallel plate capacitor is given by the equation

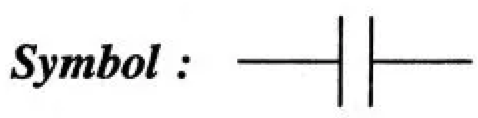
$$C = \varepsilon \cdot \frac{A}{d}$$

Where ε (Epsilon) is the permittivity of the dielectric.

Permittivity is a measure of how easily the dielectric will permit the establishment of flux lines within the dielectric.

Types of capacitors

Fixed capacitor



The capacitors whose capacitance value is fixed are known as fixed capacitors.Based on the dielectric material used fixed capacitors are further classified into:Mica Capacitors, Ceramic Capacitors, Paper Capacitors, Polyester Capacitors, Electrolytic Capacitors, Film capacitor

Paper capacitor

Constructed by rolling impregnated paper within metal foils.

Mica capacitor

Consist of mica sheets separated by sheets of metal foil

Ceramic capacitor

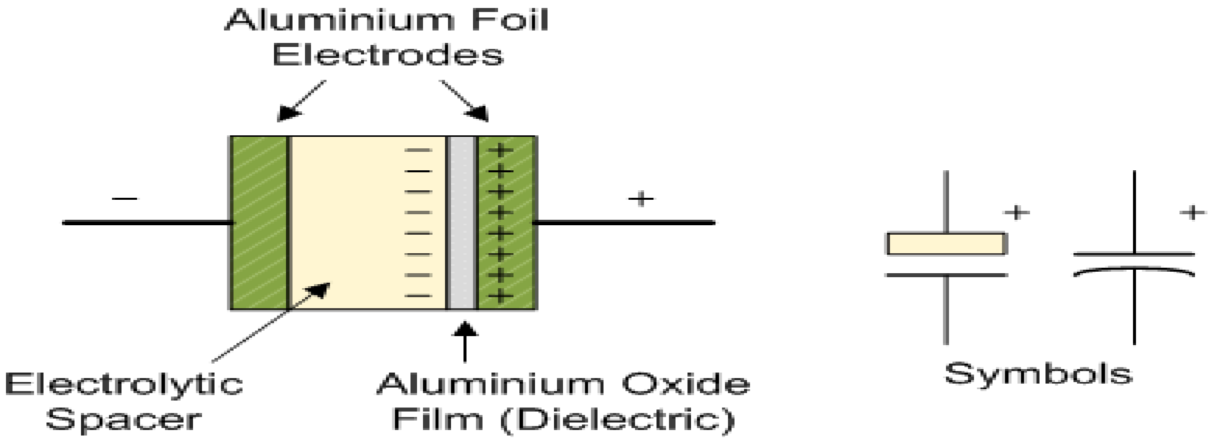
Consists of ceramic dielectric.

Polyester capacitor

Constructed using two metal foils separated by a strip of polyester material such as Mylar.

Electrolytic capacitor

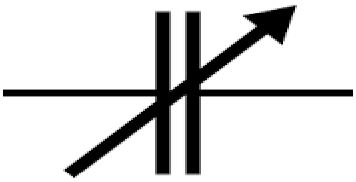
Electrolytic Capacitors are generally used when very large capacitance values are required.



A polarized aluminium electrolytic capacitor is shown in figure. Here positive electrode(Anode) is aluminium foil. The dielectric is a very thin layer of aluminium oxide which is grown electro-chemically ,the thickness of the film being less than ten microns. This insulating layer is so thin that it is possible to make capacitors with a large value of capacitance for a small physical size as the distance between the plates, (d is very small). The negative electrode (Cathode) is a semi-liquid electrolyte solution in the form of a jelly or paste. The electric contact from the negative electrode is taken with the help of aluminium foil.

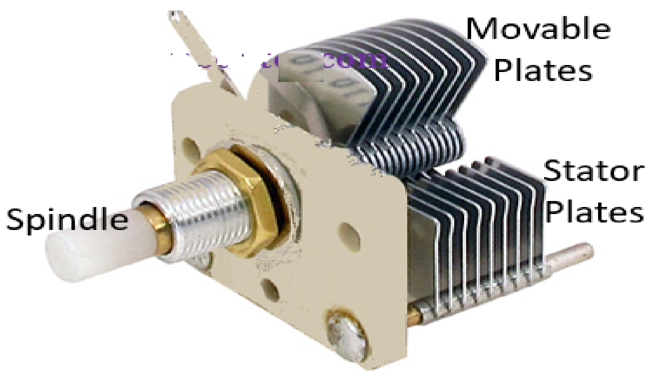
Variable capacitors .

Symbol



Variable capacitors are those for which the value of capacitance can be changed by adjusting some parameters.They are commonly used in circuits where exact value of capacitance cannot be calculated using normal design procedureThe capacitance value can be changed by varying three parameters. Distance between plates, dielectric and area of plates.Examples of variable capacitors are Gang capacitors, Trimmers and Padder capacitor.

Gang capacitor



It is a group of capacitors ganged together and the capacitance can be varied by means of a common shaf. It has two sets of metal plates, a movable plate called rotor and fixed plate called stator. Capacitance is varied by moving the rotor with the help of a rotating shaft and thereby changing the effective plate area. Availabe from 10pf to 365pf.

Trimmers

Trimmer capacitors are small variable units consisting of two metal plates usually separated by a thin piece of mica. The capacitance is varied by varying the distance between the plates by means of a small screw that forces the plate close together. Available with 3pf to 30pf and 4pf to 70pf

Padder capacitor

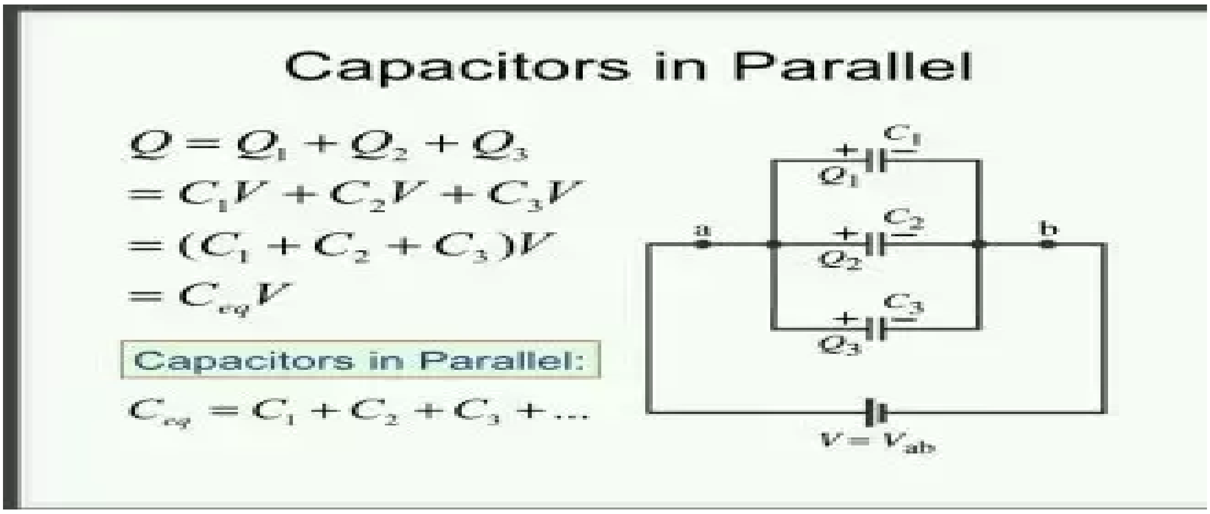
Similar to trimmer in appearance and no change in construction.But padder capacitor is somewhat bigger in size and higher in capacitance value. Usually available values of padder are 400 pf, 600pf,750pf,1000pf

Applications of capacitor

1) The capacitor used for storage of energy.
2) It is used in filter circuits to minimise the ripple voltage.
3) Capacitors are used to run the motor.
4) Bypass the high frequency signals.
5) Used in tank circuits in electronic oscillators.
6) Used in snubber circuit to suppress radio frequency interference.
7) It is used in the timing circuit to select the time.
8) It is used in single phase motors.
9) Capacitors are used in both AC and DC application.
10) Capacitors are widely used in radio and telecommunications.
11) It is generally used in filter circuits and tuning circuits.

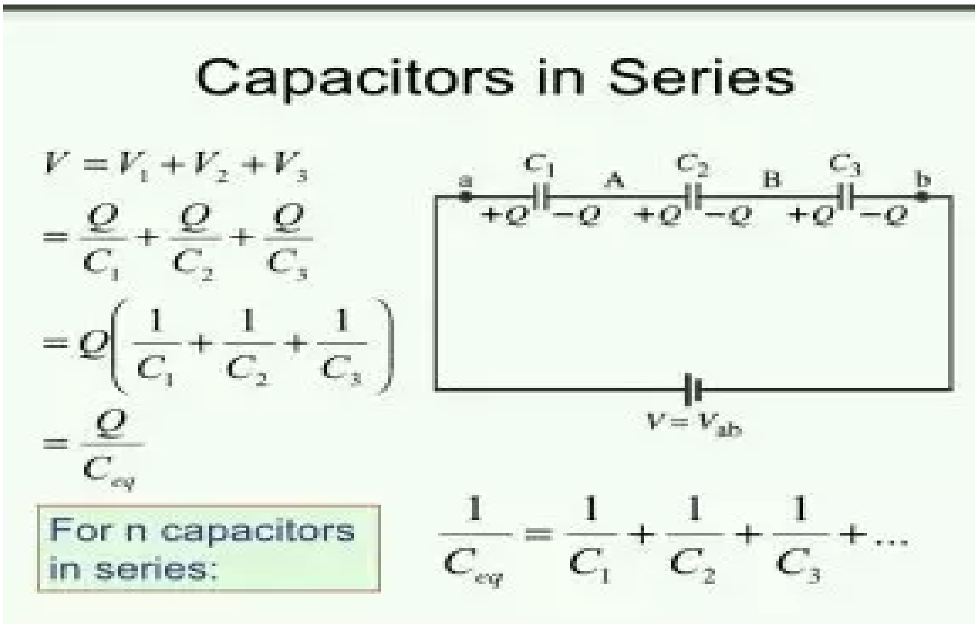
Combination of capacitors (Parallel)

Consider three capacitors connected in parallel. The voltage across each individual capacitor is same. The total charge is the sum of charge across each individual capacitor.



Combination of capacitors (series)

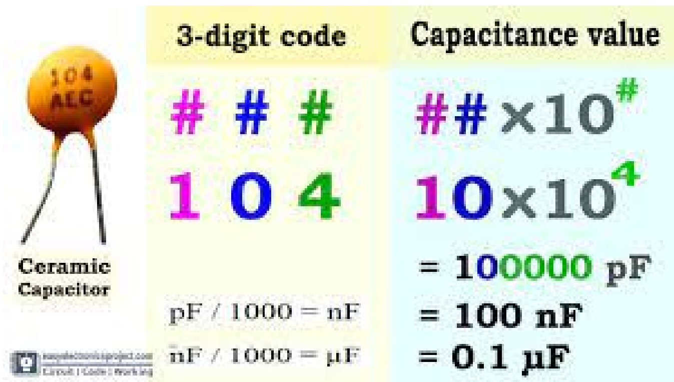
Consider three capacitors connected in series. The charge in each individual capacitor is same . The total voltage is the sum of voltage across each individual capacitor.



Problems

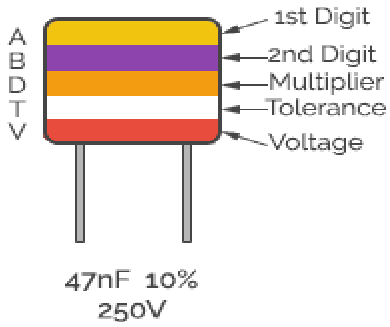
Numerical coding of capacitors

Small value ceramic and polyester type capacitors have their values stamped on their bodies as numerical code. In this coding system, three digit coding system is used to represent capacitance value. First two digit represent the two significant digits and the third digit represents the decimal multiplier (Value obtained in picofarads , if required, the value can be converted to picofarads moving six decimal places to left.)



Capacitor colour coding

Older capacitors were using colour coding,but today most of the capacitors are using alphanumeric values A simple five colour band system is shown in figure



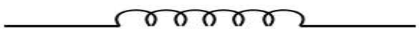
Colour	1 st and 2nd band	3rd band	4th band	5th band
Black	0	10^0	±20%	
Brown	1	10^1		100
Red	2	10^2		250
Orange	3	10^3		
Yellow	4	10^4		400
Green	5	10^5	±20%	
Blue	6	10^6		
Violet	7	10^7		
Gray	8	10^8		
White	9	10^9	±20%	

Inductors

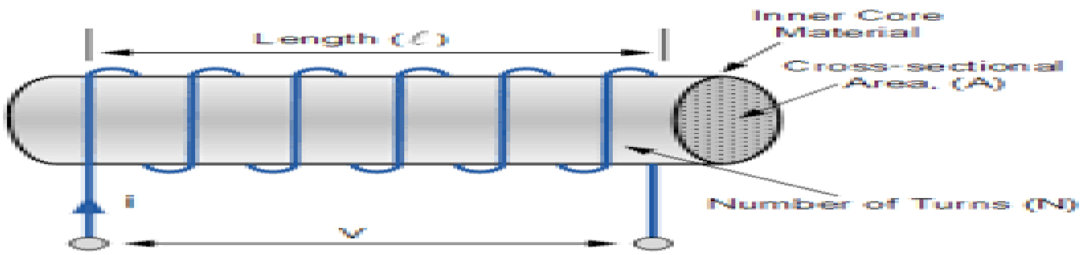
An inductor, also called a coil, choke, or reactor, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it. An inductor typically consists of an insulated wire wound into a coil. Many inductors have a magnetic core made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance.

When the current flowing through the coil changes, the time-varying magnetic field induces an electromotive force (e.m.f.) (voltage) in the conductor, described by Faraday's law of induction. According to Lenz's law, the induced voltage has a polarity (direction) which opposes the change in current that created it. As a result, inductors oppose any changes in current through them.

Symbol



The equation for inductance of a coil



$$L = \frac{\mu N^2 A}{l}$$

Where:

L = Inductance in henries (H)

μ = permeability (Wb/A · m)

N = number of turns in coil

A = area encircled by coil (m^2)

l = lenth of coil (m)

Permeability (μ) is a measure of how easily magnetic flux lines can be established in a material

Reluctance: It is the property of a material by which it opposes the creation of magnetic flux in it, it is analogous to resistance in electric circuit.

Inductance (L) is a property of an inductor that opposes any change in magnitude or direction of current flowing through it. The larger an inductor’s inductance, the greater the capacity to store electrical energy in the form of the magnetic field.

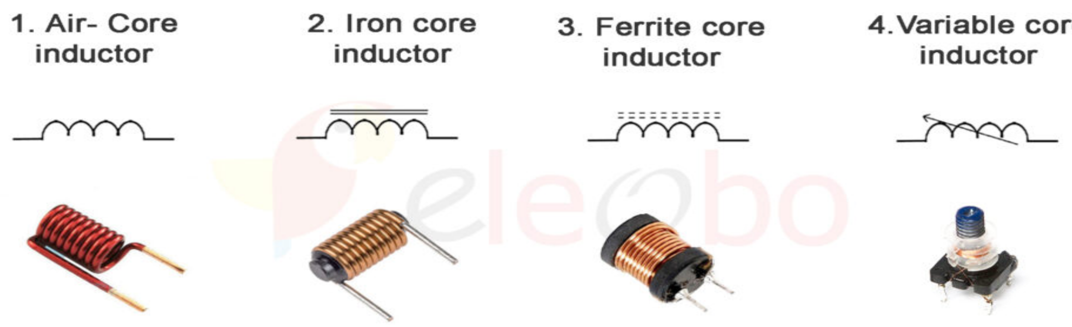
Self inductance

Self inductance is the property of a single isolated coil to induce emf in accordance with the change in magnetic flux linked with it.

Mutual inductance

Mutual inductance of a pair coils is the ability of one coil to produce an induced emf in nearby coil when the magnetic flux linked with it.

Types of inductors



1. Air- Core inductor

This type of inductor that does not use a magnetic core. They are used to obtain small value of inductance.

2. Iron core inductor

The iron core inductor is the fixed value inductors. However, which have an iron core placed inside the coiled. By using iron core the inductance value of an inductor can be increased.

3. Ferrite core inductor

Ferrite is used to provide an increase in the permeability of the medium around the coil to increase the inductance of the inductor. moreover, Ferrites are widely used inductor.

4. Variable core inductor

Variable inductor allows the inductance to be easily varied by changing the position of the ferrite core in a threaded structure.

Specifications of inductor

1)Value of inductance: The specified inductance value is expressed in H(Henry),mH, μH,nH

2) Current rating: It is the maximum current which can be continuously applied to the inductor under a specified set of conditions,

3) Tolerance: Maximum permissible percentage change from the marked value

4) Temperature coefficient: It is a measure of change in inductance value wrt temperature. Expressed in ppp/oC

5)DC resistance(ideally zero): It is a measure of resistance offered by the coil when direct current flows through it

6)Q factor quality factor: Depend upon the value of inductance and losses of the inductor

7) Frequency range: Upper and lower working frequency range

8) Stability: Long or short term percentage variation of inductance which occurs under specified physical and electrical operating conditions

Inductor Applications

1. Store energy in a device: Since the electric current produces a strong magnetic field around the coil, this field is like energy storage, which represents the effective motion of electrons through the flux coil.

2. Inductors are used as relay coil: A relay coil is just a coil of wire, which is completely an inductor too. So, a relay coil has some inductance, which means that it is an energy storage device.

3. Transformers: Transformer is a device made of two or more inductors, the powered inductor in a transformer is called the primary winding. The unpowered inductor in a transformer is called the secondary winding.

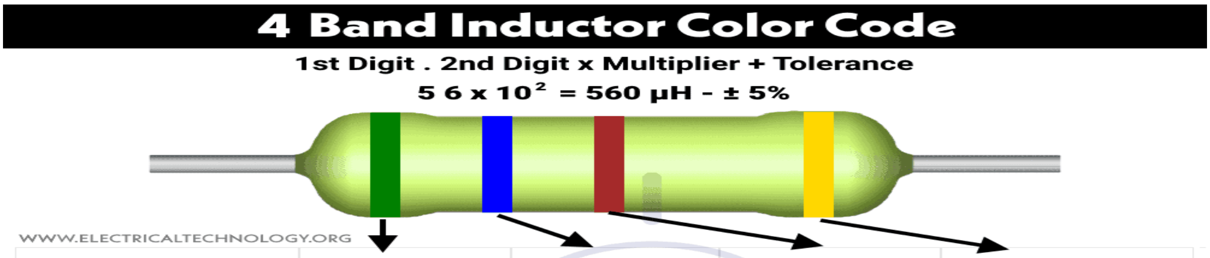
4. Tuning circuits: Inductors are used in tuning circuits which are used to select the desired frequency (The rate per second of a vibration constituting a wave) In a tuned circuit, we have capacitor connected beside with the inductor, either in parallel or series.

5. Filters: The role of inductor in filter is circuit can be constructed by the combination of components like resistors, capacitors and inductors. Inductor is used here for allows only dc components to pass and blocks ac signals.

6. These are used as sensors: The inductive proximity sensors are very reliable in operation and is a contactless sensor. Inductance is the main principle behind it in which the magnetic field in the coil will oppose the flow of electric current. The proximity sensors mechanism is used in traffic lights to detect traffic density.

7. Inductors are used in power electronic converters

Colour coding of inductor



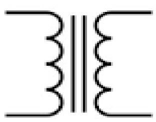
Band Color	1st Digit	2nd Digit	Multiplier	Tolerance (%)
BLACK	0	0	1	± 20%
BROWN	1	1	10	± 1%
RED	2	2	100	± 2%
ORANGE	3	3	1,000	± 3%
YELLOW	4	4	10,000	± 4%
GREEN	5	5	100,000	–
BLUE	6	6	1,000,000	–
VIOLET	7	7	–	–
GREY	8	8	–	–
WHITE	9	9	–	–
GOLD	–	–	0.1	± 5%
SILVER	–	–	0.01	± 10%

- 4 band system is shown
- First band and second band indicate first and second digit respectively
- Third band indicate the multiplier
- Fourth band indicate the tolerance
- The result is in µH

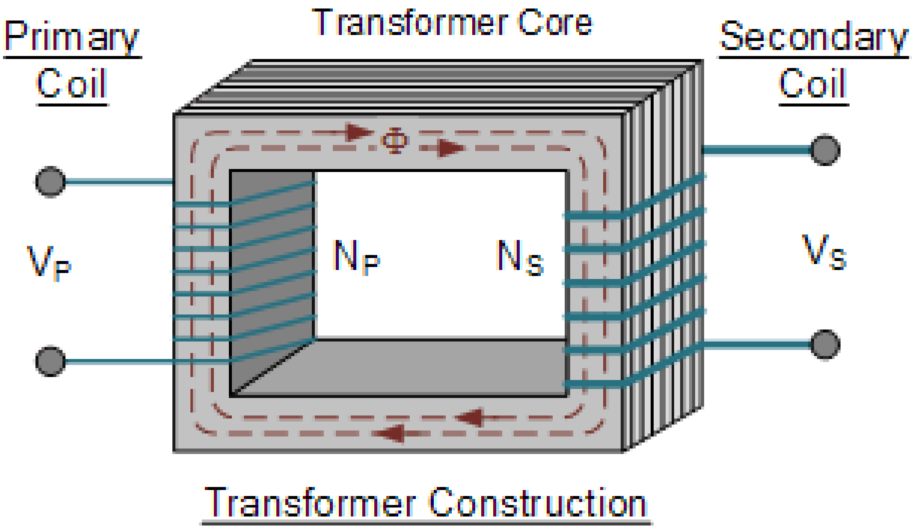
Transformer

Transformer is a device consisting of two or more coils used to transfer electrical energy from one circuit to another circuit at different voltages without change in frequency. Transformer operate based on the principle of mutual induction

Symbol



Working principle



Mutual inductance is a phenomenon by which a change in the current flowing through a coil will induce an emf in another coil, if the two coils are placed in close to each other (Coupled).When two coils are placed in close, the flux lines from one coil cut the turns of the other coil and a voltage will be induced in the second coil.

Transformer consists of two insulated coils wound on a core. An alternating voltage applied in one coil will produce a changing flux in it, which links with the neighbouring coil and induces varying emf in it. The magnitude of induced emf induced in the coil mainly depends upon the rate of change of flux linkage with it and also on the number of turns. The coil across which the rated voltage is applied is called primary and the coil in which the emf is induced is known as secondary of the transformer. Transformer may be step up or step down. In step up transformer the number of turns in the secondary is more than number of turns in primary hence voltage induced in secondary is greater than that of primary applied voltage. In step down transformer the number of turns in the secondary is less than number of turns in primary hence voltage induced in secondary is lesser than that of primary applied voltage.

Overall, a transformer carries the below operations:

1)Transfer of electrical energy from circuit to another

2) Transfer of electrical power through electromagnetic induction

3) Electric power transfer without any change in frequency

4)Two circuits are linked with mutual induction

Specification

1) Voltage ratings
2) Current rating
3) Power rating
4) Frequency range
5) Regulation

Transformer turns ratio

The transformer turns ratio is the ratio number of turns of the primary winding to the number of turns of the secondary coil.

Turns ratio=Np/Ns

Where Np is the number of turns in primary winding and Ns is the number of turns in secondary winding.

Turns ratio is also the ratio of primary voltage to secondary voltage.Turns ratio is also the ratio of secondary current to primary current

Turns ratio=Np/Ns=Vp/Vs=Is/Ip

Where Vp and Ip are the primary voltage and current and Vs and Is are secondary voltage and current.

Applications of transformer

1) To rise or lower voltage or current
2) Audio transformers
3) Impedance matching or impedance transfer device
4) As input transformer, inter stage transformer and output transformer
5) Used in rectifier circuits
6) To isolate two circuits electrically
7) Used in voltage regulators and stabilisers
8) For construction of electrical measuring device such as ammeter, voltmeter, relay etc
9) Transformers are used in radio and TV