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DEPARTMENTOF PHYSICS

E-NOTES

Paper:6c(Applications of Electricity and Electronics)

UNIT-I

INTRODUCTION TO PASSIVE ELEMENTS

PASSIVE AND ACTIVE ELEMENTS:

An element circuit is comprised of two different types of components known as Passive components and active components.

PASSIVE COMPONENTS: The components which are not capable of amplifying or processing an electrical signal are called passive components

EX: Resistors,Inductors and Capacitors.

ACTIVE COMPONENTS : The components which provide amplification or switching are called active components.

EX: Diodes, Transistors and ICs.

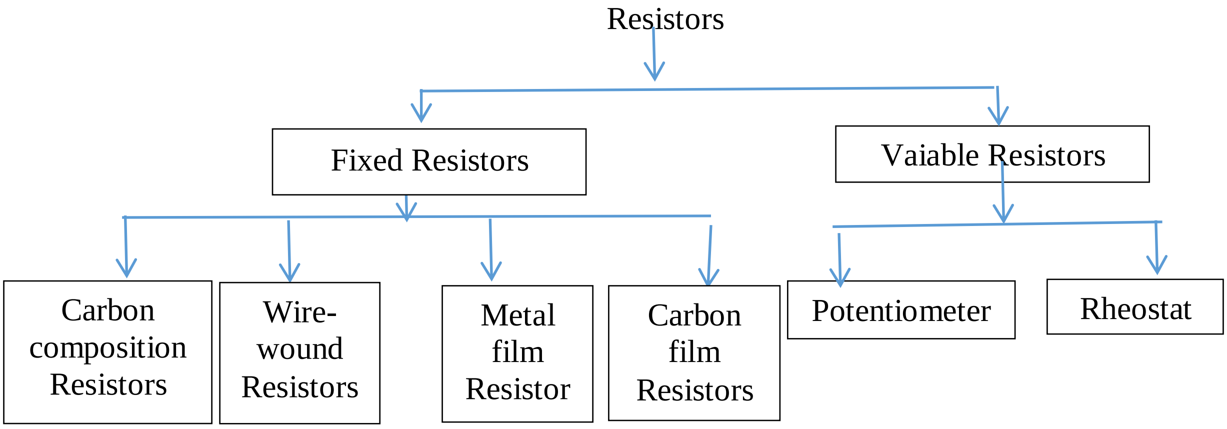
RESISTORS: An electronic circuit for controlling the current and/or voltage in the circuit. They oppose the flow of current through it, The property of the substance which opposes the flow of an electric current through it is called resistance.

The main characteristics are

(i) Resistance resistance value in ohm and

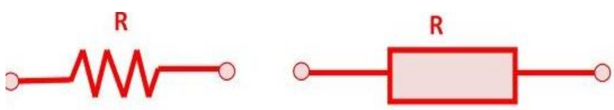
(ii) Power dissipating capacity in watt.

TYPES OF RESISTORS



Fixed Resistors: The main purpose of a fixed resistor is to control or limit the flow of electrical current in a electrical circuit.

The symbol for fixed resistor used in electronic circuit is

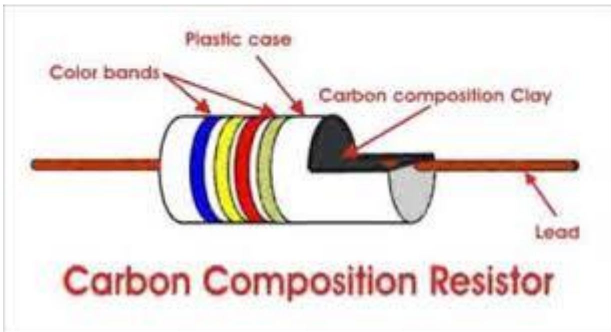


Fixed Resistors

They are classified into four types . They are
1. Carbon composition Resistors.
2. Wire wound Resistors.
3. Metal film Resistors.
4. Carbon film Resistors.

- **Carbon Composition Resistors:**

The resistor is common type of low wattage resistor. They are made of graphite of finely ground carbon mixed with a powdered insulating material (filler material) in suitable proportion.



Graphite is a moderately good conductor . The lesser the graphite amount, the higher is the resistance. The ratio of graphite to insulating material determines the final value of resistance. The mixture is compressed in the form of a cylindrical rod. The ends of this rod are joined to silver plated end caps with leads of tinned copper wires for soldering its connection into circuit. The whole resistor is moulded in a plastic case with coloured bands for specifying its resistance.

Advantages:

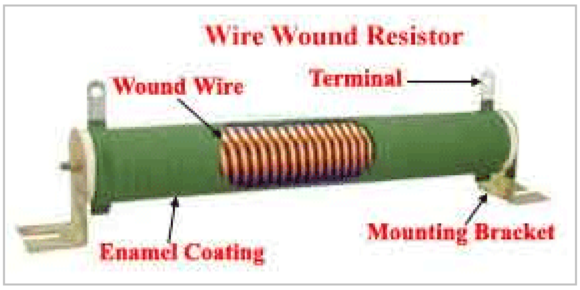
1. The resistors are available in values ranging from a few ohms to about 20 MΩ.
2. These resistors have the advantages of being cheap and reliable.
3. Their stability is very high during their life times.

Dis advantages:

1. The resistors are electrically noise.
2. They are low stability in life time.

- **Wire wound Resistors:**

The wire resistor are manufactured by winding a resistance wire around an insulating hollow cylindrical core.The materials are made up 60% copper, 40% nickel and hollow cylindrical core. The materials have high resistivites and low temperature coefficients. The length and resistivity of the resistance wire determines the resistance value. The completed wire wound resistor is coated with an insulting material.

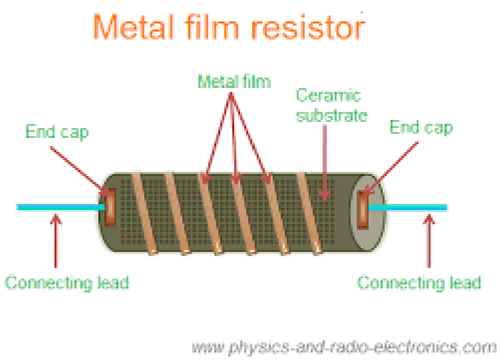


Advantages:
1. The range of resistance values of wire wound resistors varies from 1Ω to 1MΩ.
2. The power rating of resistors are from 5W to several hundred Watts.
3. These Resistors are controlled in resistivity and size by adjusting the length of wire.
4. These resistors are more accurate.

Dis advantages:
1. These resistors have inductance which arises due to winding. Like coil like structure.
2. These resistors are unsuitable for high frequencies due to high inductance. These can be avoided by using double thread winding.

- ## Metal Film Resistors:

The metal film resistors are also called as thin film resistors. They are constructed by deposing a thin metal coating on an insulating (glass, ceramic or other insulating material) substance.

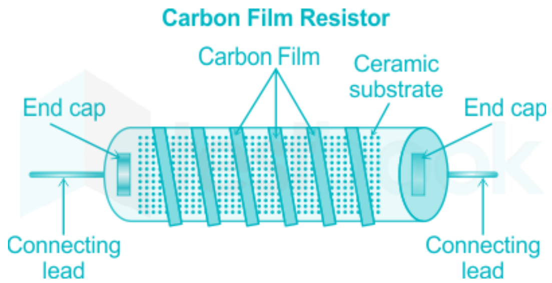


Advantages:
1. The metal film resistors can range in values up to 10,000 MΩ.
2. High Accuracy and low temperature coefficient.
3. Very low noise and excellent tolerance.
4. They are very suitable for numerous high grade applications.
5. The main advantage is the problems of inductance and wire size in case of wire wound resistors is overcome.

Dis advantages:
1. They are smaller in size than wire wound resistors.

- ## Carbon Film Resistors :

The Carbon film resistors are constructed by depositing a thin film of carbon on ceramic rod or core. Desired values of resistances are obtained by trimming the layer thickness or by cutting helical grooves of suitable pitch along its length. Contact caps are fitted at both ends. The lead wires made of tinned copper are then soldered on both ends.



Advantages:

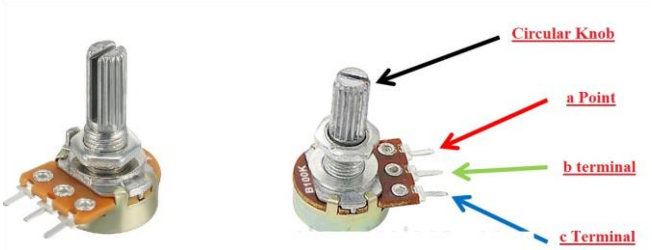
1. These resistors have mildly negative temperature coefficient which is useful in certain electronic circuits.

Dis advantages:

1. These resistors are smaller values of resistance and low tolerance to metal film resistors.

- ## Variable Resistors:

These are the resistors whose resistance can be changed between zero and a certain maximum value. They are used in electronic circuits to adjust the values of voltage and currents.



A variable wire wound resistor is made of a resistance wire wound on ceramic core which is covered with insulating coating . The strip is bent round a cylindrical surface. An adjustable sliding arm rotates along the wire and make electric contact with the wire. The terminals T_1 and T_2 are the end points of wire and terminal T_3 is adjustable point.

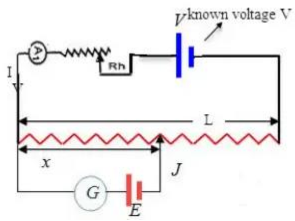
If the rotating shaft moves towards the terminal T_2 then the resistance between terminals T_1 and T_3 increases. If the rotating shaft is moved towards T_1 then the resistance between terminals T_1 and T_3 decreases. By moving the rotating shaft, the different resistances can be obtained. Because of their inductive and capacitive properties the wire wound resistors are not suitable for high frequency applications.

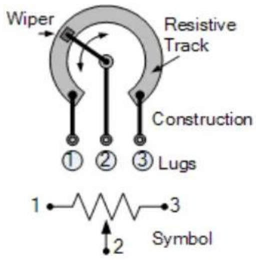
They are preset at a given value. They are available at range 1Ω to 150 kΩ. It is commonly used as a gain control element in an amplifier and as brightness and contrast controls in TV receivers.

Carbon variable resistors with resistance values range from 1kΩ to 5 kΩ are avaialble. Controls are combined with an OFF-ON switch and volume control of a radio receiver.

1. POTENTIOMETER:

This is a three terminal variable resistor in which all the three contacts are employed in a circuit. This is also termed as 'pot'. Pots are often as voltage dividers to control or vary voltage across a circuit -branch.

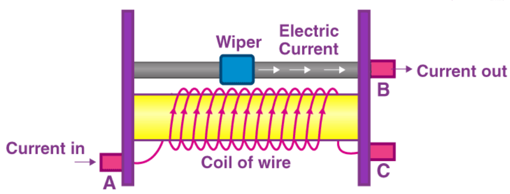




By moving the variable arm or sliding arm over the fixed resistance R between points A and B any part of input voltage can be tapped off. The potentiometer can be used as a rheostat.

2. RHEOSTAT:

A wire wound potentiometer that can dissipate more than 5W is referred to as a rheostat. The resistance wire is wound on an open tube of ceramic which is covered with vitreous enamel except for the track of movable contact. The movable contact is attached with a screw driver and hand wheel to control its movement. Rheostats are commonly used to control high currents such as motor and lamp loads.

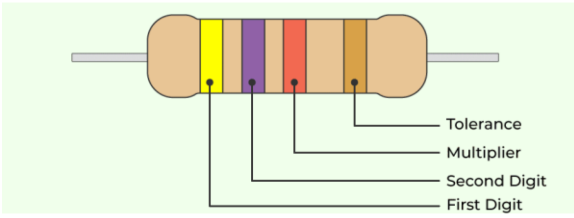


- **TOLERANCE:**

The tolerance is possible variation from marked value of a resistor. For example a 1000Ω resistor with 10% can actual resistance between 900Ω and 1100Ω. The specific tolerances are 5% , 10% and 20% for an ordinary resistor. The precision resistors have a tolerance close to 0.1%.

- **COLOUR CODING OF RESISTORS:**

Resistors are coded to indicate the resistance value and tolerance. For this colour bands are printed on one end of the resistor casing. So, the system of representing the resistor value is called colour coding.



The four colour bands A,B,C and D starting from left end on the resistor. The first two bands represent the first and second significant digits of the resistance value. The third band is the multiplier and the number of zeros that follows the second digit. The tolerance is given by the forth band.

Colour code for resistance designation

Colour	1st band (first significant digit)	2nd band (second significant digit)	3rd band (Multiplier)	4th band (Tolerance)
Black	0	0	$X1=10^0$	-
Brown	1	1	$X10=10^1$	±1%
Red	2	2	$X100=10^2$	±2%
Orange	3	3	$X1000=10^3$	-
Yellow	4	4	$X10000=10^4$	-
Green	5	5	$X100000=10^5$	-
Blue	6	6	$X1000000=10^6$	-
Violet	7	7	$X10000000=10^7$	-
Gray	8	8	-	-
White	9	9	-	-
Gold	-	-	$0.1 = 10^{-1}$	±5%
Silver	-	-	-	±10%
No Colour	-	-	-	±20%

1. Determine the resistance and tolerance ratings for the following colour code : yellow, violet, black and gold.

In this case we have Yellow - 4
Violet - 7
Black - 1 = x 10^0 = 1
Gold - ±5%

∴ Resistance value = 47 X 1 = 47 Ω ± 5%

Applications Of a Resistor As a Heating Element In Heaters And As a Fuse Element:

- **ELECTRIC HEATER :**

The resistance heaters have many design like power resistors are used in heater applications. They allow a designer to apply and control heat. Riedon offers a broad range of these resistors. Riedon power resistors are used in a variety of heater applications.There are very useful in situations where heat must be concentrated in small area.

Electric Heater

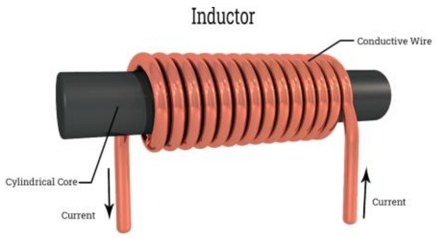
Power resistors dissipate the heat generated by current flow through the resistance. The heat generated is removed from the element. The heat is then transferred to the surrounding environment .

- **ELECTRICAL FUSE:**

A proper resistor is used in fuse used in electrical circuit. When there is a short circuit in the electrical circuit or an excess currents flows in the circuit,the resistor used in fuse burns due to heating effect. So the circuit is saved for any damage. So, current fuses are simplest device to protect a circuit. The resistors with fusing function protect the equipment or parts from burning by breaking the abnormal current.

INDUCTORS:

When a current is passed through a conductor the lines of magnetic flux are generated around it. This magnetic flux opposes any change in current due to induced e.m.f . The opposition to change in current is known as inductance. The component which produces inductance is known as inductor.



The induced e,m,f (e) in an inductor is given by e = - L $\left(\frac{dI}{dt}\right)$

Where , L = inductance in henry and $\left(\frac{dI}{dt}\right)$ = rate of change of current.

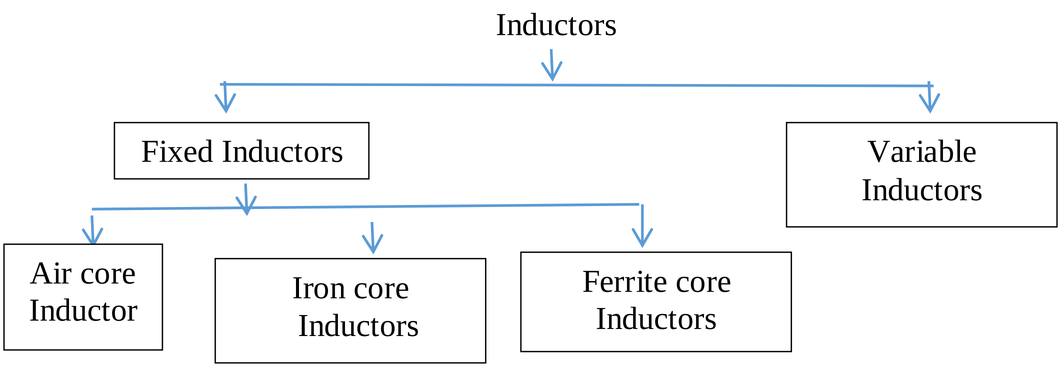
The current passing through the coil changes with time, an induced E,M,F . is set up in the coil. By Lenz's law , the direction of induced e.m.f is oppose the change in current. When the current is increasing the induced E,M.F is against the current and when the current is decreasing it is in the direction of current . So the induced e.m.f opposes any change of the original current. The phenomenon is called self inductance.

The property of the circuit by virtue of which any change in the mgnetic flux linked with it, induces an E.M.F in it is called inductance and the induced E.M.F is called back E.M.F.

When the current in a coil is switched on , self induction opposes the growth of the current and when current is switched off, the self inductance opposes the decay of current .

TYPES OF INDUCTORS:

The inductors are of two types are namely fixed inductors and variable inductors.

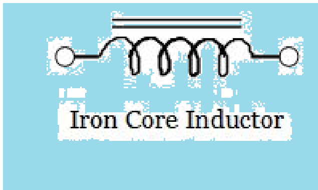


1. **Fixed Inductors:**

The fixed inductors are classified as follows:

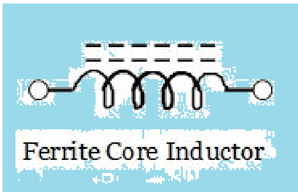
a. **Air Core Inductor** : This inductor is made of a number of turns wound on a non-ferrous materials such as ordinary cardboard. As there is air inside the coil and hence this is called as air core inductor. This inductor has low inductance from a fraction of µH to a few µH.Due to their low inductance they are suitable for high frequency (R.F) applications.

b. **Iron Core Inductor :** The inductor is made of a coil of wire wound over a solid iron core. By putting iron inside the inductor the inductance is increased. To avoid eddy current loss, iron core is laminated I.e consistss of thin iron laminations pressed together but insulated from each other. This inductor is also called as a choke. The iron core inductors are very suitable for audio frequency (A.F) applications.



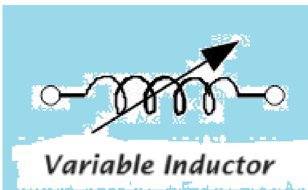
c. **Ferrite-core inducto**rs: The iron core inductors are not suitable for high frequency applications. This difficulty is overcome by the use of ferrite materials as core. A ferrite is basically an insulator having very high permeability.

This inductor cosists of coil of wire wound on ferrite core . The ferrite core has minimum eddy current loss even at high frequencies.



2. Variable Inductors:

In certain applications such as turned circuits,it is required to vary the inductance from a minimum value to maximum value by using variable inductors. These inductors are fixed ferrite core inductors but core is adjustable. A variable inductor is made of a long coil wound on a ferrite core provided with a slider contact. The slider contact can be used to vary the inductance of the coil.



Inductive Reactance:

The reactance (X_L) of an inductor of inductance L at frequency f is given by

$$X_L = 2\pi fL$$

The inductive reactance of a coil is not constant but depends on the frequency of alternating current f.At high frequencies the inductive reactance X_L is large and also at low frequencies the inductive reactance X_L is small.

For d.c currents f=0 I.e X_L = o

Inductance of a coil :

The inductance of a coil can be determine from its physical parameters. The inductance is given by

$$L = \frac{\mu_0 \mu_r A N^2}{l}$$

Energy Stored in a Inductor:

When the current passes through an inductor magnetic flux is produced for which energy is supplied by voltage source. This energy is stored in magnetic field. The energy is recoverable.

When a current builds up in a circuit containing an inductor of self inductance L the magnetic flux linked with the circuit changes. As a result a back E.M.F is induced in the circuit.

Let I be the instantaneous current in the circuit then back E.M.F. induced in the circuit is given by

$$e = -L\frac{dI}{dt}$$

The work done in moving a charge dq against this E.M.F. is

$$dW = -edt = L\frac{dI}{dt}dq$$

$$= L\frac{dq}{dt}dI$$

$$= L\,I\,dI \quad \left(\because\ I = \frac{dq}{dt}\right)$$

Therefore the total work done in building up the current from zero to a value I in the circuit is given by

$$W = \int_0^I L\,I\,dI$$

$$W = \frac{1}{2}LI^2 \text{ (joule)}$$

This energy is stored in the magnetic field of the inductor,

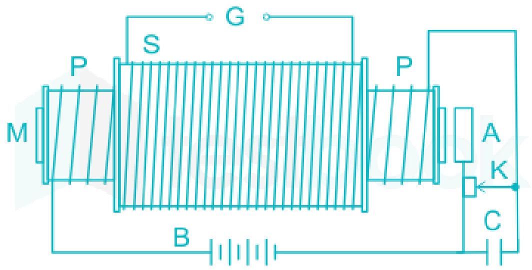
Where L = inductance of inductor (in henry)

And I = steady current in ampere.

Applications of Inductor:

Induction Coil:

Induction coil is a device used for transforming low potentials difference between terminals of a primary coil into a high voltage between the terminals of a secondary coil. It works on the principle of mutual induction.



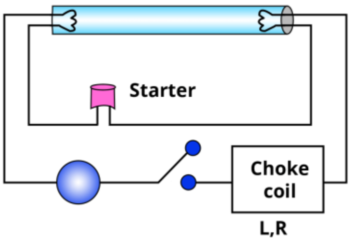
Construction:
1. Primary coil: Primary coil consists of insulated copper wire wound on a soft iron core and has small number of turns. One end of the core projects outside the coil and opposite to this end a hammer fixed to upper end of a metallic spring is placed.
2. Secondary coil: Secondary coil consists of insulated copper wire wound over the primary coil but separated from it by vulcanised tube and has large number of turns.
3. Interrupter : It is an arrangement of making and breaking the primary circuit and is provided by the screw and hammer arrangement. When primary circuit is connected between the screw and hammer.
4. Condenser: It is a parallel plate condenser of paper or mica. Its use increases the efficiency of the coil to a great extent.

Working: The screw is so adjusted that it makes a clear contact with the platinum point. When the current in the primary coil then the soft iron core is magnetised and hammer is attracted towards the iron core.When the iron core is demagnetised and the attracting force on the hammer disappears. When the primary coil if the current is flowing of intermittent current through primary frequency .
When the current is passing the number of lines of force linked with secondary increases and an inverse E.M.F. is produced in the secondary coil. The magnetic flux linked with the secondary decreases and an induced E.M.F. is produced in secondary in the same direction . When current in the primary is increasing , the resistance of the primary circuit is small as a result as a result the time constant of the circuit (L/R) is large. The resistance of the primary circuit is infinite due to air gap and the time constant is small.
When the current is induced E.M.F. is developed in due to self induction, the induced E.M.F. is produced in the primary contact. The efficiency of the coil increases in parallel with the contact of the primary circuit. The primary current increases and due to self inductance induced E.M.F. in the opposite direction is produced which decreases the rate of growth of current in the primary. The induced current is developed in the primary is used in charging the condenser and reduced as a result the rate of decay of current in the primary is not effected. The charged condenser and the primary coil forms a circuit damped oscillations. The condenser discharges, the magnetic flux in the core of primary coil is reversed at condenser at the end of the first half oscillations becomes oppositely charged . The amount of charge which flows in the secondary coil double the value than when no condenser is used.

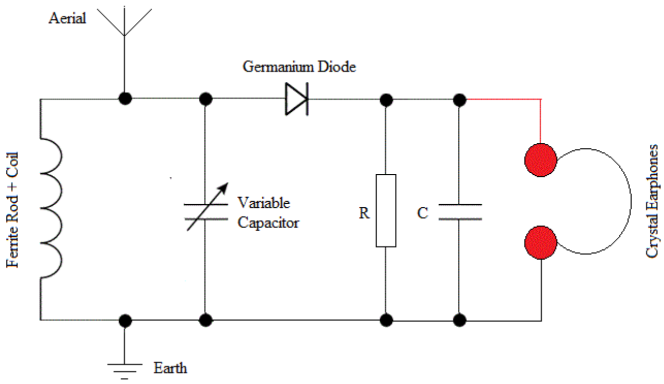
Choke: Choke is a passive device that adds inductance to a circuit.
According to Lenz's law the direction of induced E.M.F. in a closed circuit is it opposes the original cause that produces it.

1. A choke is used in a fan:

The ceiling fan has a motor.The motor converts the electric energy to mechanical energy. The capacitor of the ceiling fan torques up the electric motor. The motor to start and run. The electric currents reaches the motor, it enters in coils of wire that are wrapped around a metal box. When the current passes through the wire, it creates a magnetic field which exerts force in closk wise motion.The electric energy is converted into mechanical energy. This causes the motor coils to spin. The blades attached to the motor start rotating.



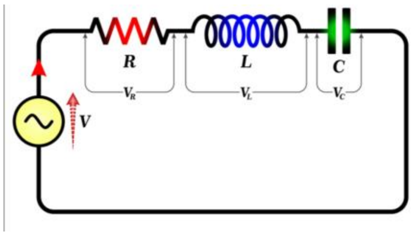
2. The circuit consists of antenna grounded system, tank circuit, peak detector and headphone. The antenna absorbs transmitted radio signals. The radio signals flow to the ground via other components. The combination L_1 and C_1 comprise a resonant circuit. This circuit is also known as tank circuit. The function of resonant circuit is to select a particular signal received from so many signals received by antenna. This is achieved by charging C_1 . The diode passes the positive half cycles of the R.F. removing the half negative cycle.



The capacitor C_2 sized to filter the radio frequencies from the R.F. envelope and passes audio frequencies. Finally signal is transmitted to headset.
The transistor detector produces a stronger output than a crystal detector. The crystal detector is not biased. It only conducts for half cycles of R.F. input. So, it detects the audio modulation . The advantage of transistor detector is amplification as well as detection.

Series Resonance Circuit as a Radio Tuning Circuit:

Introduction: A series resonance circuit, often referred to as a tuned circuit, plays a vital role in radio frequency (RF) circuits, particularly in radio tuning circuits. It is designed to resonate at a specific frequency, allowing it to selectively filter and amplify signals of that frequency while rejecting others. Here are some key notes on its operation and applications in radio tuning:



1. Components:

The series resonance circuit consists of three primary components:

Inductor (L): Provides inductive reactance (XL) which increases with frequency.

Capacitor (C): Offers capacitive reactance (XC) which decreases with frequency.

Resistor (R): Represents the circuit's resistance, which affects its bandwidth and selectivity.

2. Resonance Frequency (fr):

The resonance frequency of the circuit is determined by the values of the inductor and capacitor.

At resonance, the inductive reactance (XL) equals the capacitive reactance (XC), resulting in the impedance being purely resistive, and the circuit draws maximum current.

3. Tuning Function:

By adjusting either the capacitance or inductance, the resonance frequency of the circuit can be tuned to a specific frequency.

In radio tuning circuits, this adjustment is typically achieved through a variable capacitor connected in parallel with a fixed inductor.

4. Bandwidth and Selectivity:

Bandwidth refers to the range of frequencies around the resonance frequency where the circuit responds effectively.

Selectivity indicates how well the circuit can discriminate between desired and undesired frequencies.

Bandwidth and selectivity are inversely proportional; increasing selectivity narrows the bandwidth.

5. Application in Radio Tuning:

In radio receivers, the series resonance circuit is employed in the tuner stage to select the desired radio frequency from the incoming signals.

The tuner stage typically includes multiple resonance circuits, each tuned to a different frequency band, enabling the receiver to tune in to various stations.

6. Signal Amplification:

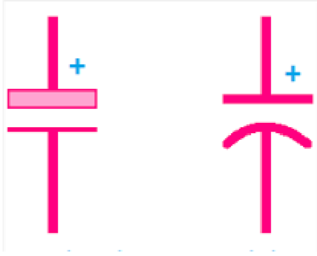
At resonance, the circuit exhibits maximum impedance, resulting in maximum voltage across the circuit.

This property is utilized to amplify the desired signal while attenuating others, thereby improving the signal-to-noise ratio.

CAPACITORS:

The capacitor like resistor and iductors is also another basics component commonly used in electronic circuits.A device or arrangement which can store considerable amount of charge is called as condenser or capacitor.It is also defined as a physical device which is capable of storing energy by virtue of the voltage existing across it. The voltage applied across the capacitor sets up an electric field within it.As a result ,the energy is stored in an electric field. A capacitor consists of two conducting plates separating by an insulating medium called dielectric as shown in Fig.(24).The

dielectric maybe air,mica,paper,ceramic,etc. .
The capacitor has the following properties:
(i)It has the ability to store charge.A resistor or inductor cannot do so.
(ii)It blocks the passes of direct current.
(iii)It opposes any change of voltage in the circuit in which it is connected.It is important to mention here that an inductor opposes the change of current.



Capacitance:The capacitance of a single isolated conductor is given by

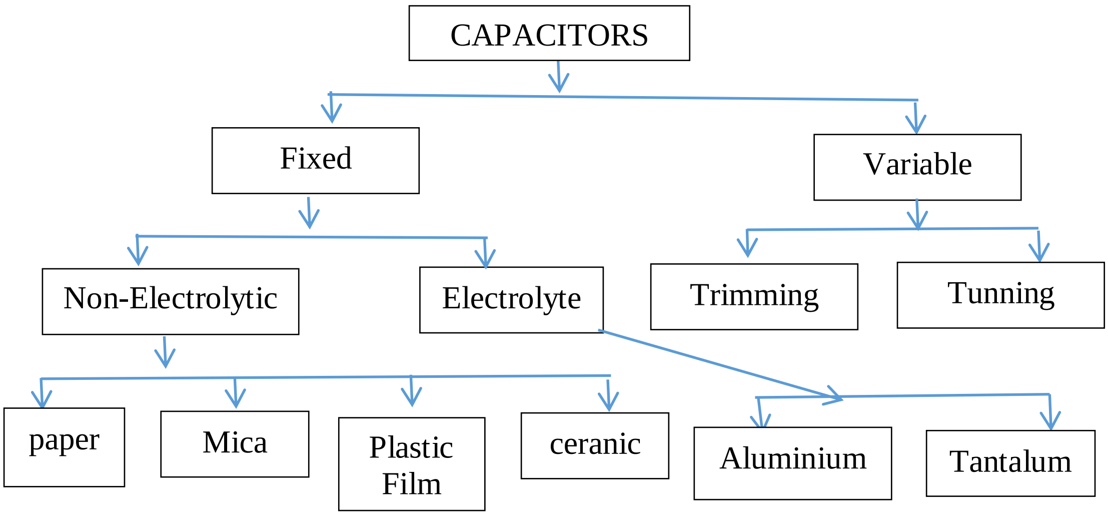
C=q/v

Thus,the capacitance is the ratio of the magnitude of charge q on either conductor to the potential v between them.When v=1 then c=q.hence,the capacity of a conductor may be defined as the charge required to raise its potential by unity.

Unit of capacitance:The unit of charge q is coulomb and the unit of potential v is volt. Therfore,the unit of capacitance will be coulomb/volt.This is called farad.Hence, the capacitance of a conductor is one farad if on giving a charge of 1 coulomb its potential is raised by 1 volt.The farad is too large for practical purposes and hence two other units are generally used. 1micro-farad(μf)=10farad and 1micro-micro farad or pico-farad(μμFor pF)=10farad

TYPES OF CAPACITORS:

All commonly used capacitors are divided into two general categories,i.e., fixed and variable capacitors. They are further divided as shown below:



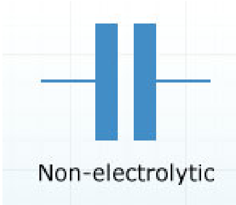
Fixed Capacitors

The fixed capacitors are divided into two classes . They are

A. Non- Electrolytic capacitors **B. Electrolytic Capacitors.**

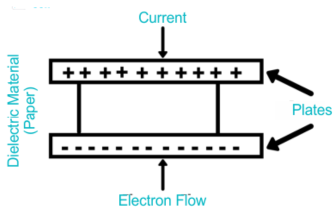
A. Non-Electrolytic Capacitors:

Such Capacitors have no polarity requirement I.e. they can be connected in either direction in circuit. They include paper, mic , ceramic and plastic film capacitors.



1. **Paper Capacitors** :

These capacitors are most widely used. It consists of two tinfoil sheets which are separated by thin sheets of tissue paper as a dielectric. The foil and the paper is rolled into a cylindrical shape. This is sealed in a paper tube or in a plastic capsule. The leads are connected to tinfoil t each end. Paper capacitors have a capacitance range from 0.001µF to 2.0 µF. They can be designed to withstand very high voltage (200 V). The leakage currents are high and tolerances are low. These capacitors are inefficient at higher frequencies.

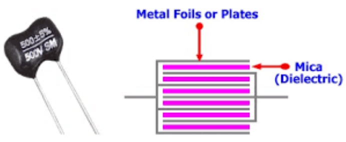


Paper Capacitor

2. **Mica Capacitors :**

Mica capacitor is sandwich of several thin metal plates separated by thin sheets of mica . Alternative plates are connected together and leads are attached from outside . Mica is a transparent high dielectric strength mineral and formed into uniform sheets as thin 0.0025mm. It has high breakdown voltage .

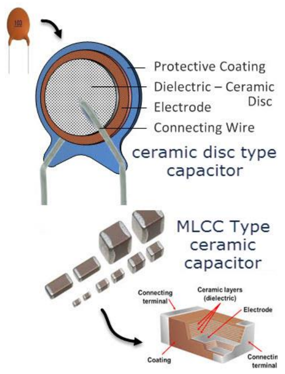
These capacitors have small capacitance values (50 to 500 pF). They have high stability voltages under temperature. They are used in radio circuits.



Mica capacitor

3. **Ceramic Capacitors :**

Mica capacitors are replaced by ceramic capacitors. Ceramic capacitors are dielectric materials. The ceramic capacitors are manufactured in the form of disc,hallow tubular or rectangular shaped plates. The disc type constructed used to build ceramic capacitors. A ceramic material mixed up with titanium dioxide and barium titanate is in the form of a disc which acts as a dielectri. The disc is coated with silver compound on both sides which acts as capacitor plates .



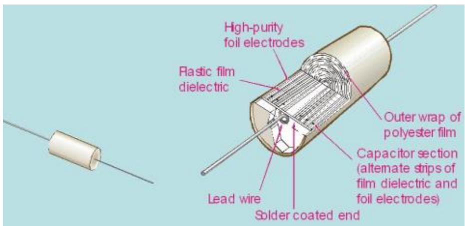
Advantages:
The capacitance range is 100pF to 0.01µF.
These hve high dielectric constnt nd smaller in size.
These capacitors have lower breakdown voltage.
The leakege resistance of these capacitors is high.

4. Plastic film Capacitors:

Plastic film capacitors, also known as film capacitors, are capacitors that use a thin plastic film as the dielectric. These capacitors are known for their stability, low inductance, and low loss. Here are some detailed notes on plastic film capacitors.

Dielectric: Thin plastic films like polyester, polypropylene, polystyrene, polycarbonate, or polyphenylene sulfide.

Electrodes: Metal foils or metallized films. Metallized films involve a very thin metal layer deposited on the dielectric.



Advantages

Stability: High thermal and environmental stability.

Reliability: Long operational life and high reliability.

Performance: Low dielectric loss and ESR, making them suitable for high-frequency applications.

Self-Healing: Particularly in metallized film capacitors, enhancing longevity and reliability.

Disadvantages

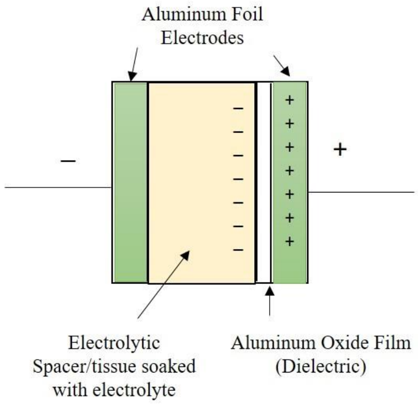
Size: Larger than electrolytic capacitors for the same capacitance value.

Cost: More expensive than some other types of capacitors, like ceramic capacitors, especially in higher capacitance ranges.

Temperature Limits: While they perform well over a wide range, extreme temperatures can affect some types more than others (e.g., polystyrene).

B. Electrolytic Capacitors:

Electrolytic capacitors are a type of capacitor that use an electrolyte to achieve a larger capacitance than other capacitor types. These capacitors are commonly used in applications requiring significant capacitance in a small volume. Here are detailed notes on electrolytic capacitors:



Types of Electrolytic Capacitors

Aluminum Electrolytic Capacitors

Characteristics: Widely used, inexpensive, high capacitance per unit volume.

Applications: Power supplies, audio equipment, and general-purpose circuits.

Tantalum Electrolytic Capacitors

Characteristics: More stable, lower ESR, and better performance at higher frequencies compared to aluminum.

Applications: Military, aerospace, medical devices, and high-reliability circuits.

Niobium Electrolytic Capacitors

Characteristics: Similar to tantalum but often used where tantalum may be too expensive or supply-constrained.

Applications: Consumer electronics and portable devices.

Construction

Anode: Made of metal (aluminum, tantalum, or niobium) formed into a porous structure to increase surface area.

Dielectric: Thin oxide layer formed on the anode surface.

Electrolyte: Can be liquid, solid, or a wet paste, serving as the cathode and ensuring the connection between the dielectric and the external circuit.

Cathode: The electrolyte itself or an additional conductive layer

Properties :

Capacitance Range: From 1 µF to several farads.

Voltage Ratings: Typically from 1V to several hundred volts.

Polarization: They are polarized, meaning they must be connected correctly in the circuit.

Leakage Current: Higher than other types of capacitors due to the nature of the electrolyte.

ESR (Equivalent Series Resistance): Higher than film capacitors but can vary

depending on the construction and materials used.
Tolerance: Generally, larger tolerance compared to other capacitors, often ±20%.

Applications

Power Supply Filtering: Smooth out voltage fluctuations in power supplies.
Decoupling: Isolate different parts of circuits to prevent noise and interference.
Timing Circuits: Used in conjunction with resistors in RC timing circuits.
Audio Circuits: Provide coupling and decoupling to prevent signal distortion.

Advantages

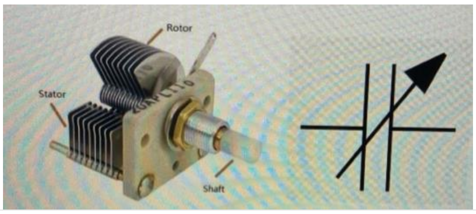
High Capacitance: Capacitance values can be very high compared to other types for the same volume.
Cost-Effective: Aluminum electrolytic capacitors are relatively inexpensive.
Availability: Widely available in various sizes and ratings.

Disadvantages

Polarization: Must be correctly oriented in the circuit; incorrect orientation can lead to failure or explosion.
Leakage Current: Higher leakage current compared to other capacitors.
Limited Lifespan: The electrolyte can dry out over time, reducing performance and leading to eventual failure.
Temperature Sensitivity: Performance can degrade at higher temperatures.

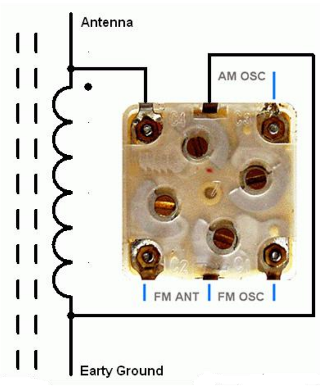
Variable capacitors are capacitors whose capacitance can be adjusted manually or electronically. They are primarily used in tuning circuits, such as those found in radios, and other applications requiring variable capacitance.

Variable Capacitors:



Tuning Capacitors

Characteristics: Large capacitance range, typically used in radio tuning circuits.
Construction: Composed of a set of stationary and movable plates. The capacitance changes as the plates overlap.
Plates: Made of conductive materials like aluminum.
Dielectric: Air or other insulating materials.
Mechanism: Rotational or sliding mechanism to adjust the plate overlap.
Applications: Radios, TV tuners, signal generators.



Trimmer Capacitors

Characteristics: Small, fine-tuning adjustments, limited capacitance range.

Construction: Usually a screw mechanism adjusts the distance between plates or the dielectric.

Trimmer Capacitors:

Plates: Typically small metal plates.

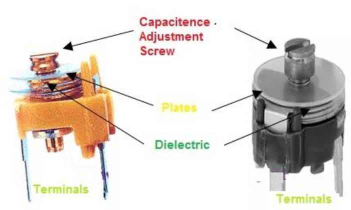
Dielectric: Air, mica, or ceramic.

Adjustment: Screw or other fine adjustment mechanisms.

Applications: Calibration of circuits, fine-tuning of frequency-sensitive components.

Applications: Calibration of circuits, fine-tuning of frequency-sensitive components.

Trimmer Capacitor



Properties and Performance

Capacitance Range: Typically from a few picofarads (pF) to hundreds of picofarads.

Voltage Ratings: Usually low voltage for trimmers and tuning capacitors; varactors operate based on the reverse bias voltage.

Q Factor: Quality factor, indicating the efficiency of the capacitor. High Q is desirable for tuning applications.

Stability: Stability can vary; mechanical stability is critical for tuning capacitors, while thermal and voltage stability are crucial for varactors.

Applications:

Radio Frequency (RF) Circuits:

Used for tuning and matching circuits in radios and communication devices.

Varactors are commonly used in phase-locked loops (PLLs) and RF filters.

Oscillators:

Provide adjustable frequency control in oscillators for signal generation and modulation.

Calibration and Adjustment:

Trimmer capacitors are used for fine-tuning and calibration in various electronic circuits, ensuring optimal performance.

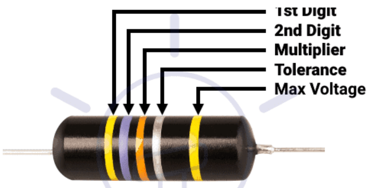
Advantages

Adjustability: Allows fine-tuning of circuits for precise operation.

Versatility: Used in a wide range of applications from consumer electronics to advanced communication systems.
Compactness: Trimmer capacitors are small and can be easily integrated into circuits for precise adjustments.
Disadvantages
Mechanical Wear: Moving parts can wear out over time, affecting reliability.
Limited Capacitance Range: Typically, the range is smaller compared to fixed capacitors.
Sensitivity: Susceptible to environmental factors like temperature, which can affect stability

Capacitor Color Code Chart

The color code chart for capacitors is the same as for resistors:



Colour	Strip 1	Strip 2	Multiplier 3	Tolerance 4		Operating voltage 5
				C >10pF	C<10 pF	V_{dc} (Volts)
Black	0	0	1pF	±20%	-	-
Brown	1	1	-	±1%	±0.25%	100
Red	2	2	-	±2%	±0.5%	250
Orange	3	3	0.001µF	-	-	-
Yellow	4	4	0.010 µF	-	-	400
Green	5	5	0.10 µF	±5%	-	-
Blue	6	6	-	-	-	630
Violet	7	7	-	-	-	-
Gray	8	8	0.01 pF	-	-	-
White	9	9	0.1 pF	± 10%	-	-

For a capacitor with color bands: Red, Violet, Yellow, Silver.

Red (2), Violet (7), Yellow (10,000), Silver (±10%)

Value: 27 × 10,000 = 270,000 pF (270 nF)

Tolerance: ±10%

Energy Stored in a Capacitor:

The energy stored in a capacitor is a fundamental concept in electronics and physics, as it represents the potential energy due to the electric field between the capacitor's plates. This energy can be released to perform work in electrical circuits.

Consider capacitor of capacitance C and carrying a charge q at any instant. Let the potential difference between the plates be V. Then

$$V = \frac{q}{c}$$

If an additional charge dq is to be given to this capacitor then some work must be done against the potential difference.
Work done in increasing charge by dq is given by

$$dW = V\,dq = \frac{q}{c}\,dq$$

∴ Total work done to charge a capacitor to a charge q_o

$$W = \int dw = \int_o^{dw} \frac{q}{c}\,dq = \frac{{q_o}^2}{2c}$$

The energy stored by a charged by a charged capacitor

$$U = W = \frac{1}{2}\frac{q^2}{c} = \frac{1}{2}CV^2 \qquad (\because\ q=CV)$$

For a parallel plate capacitor of area A and plate separation d, the capacitance C is given by

$$C = \frac{\varepsilon_o A}{d} \quad \text{and } V=Ed$$

∴ Energy stored $$U = \frac{1}{2}\frac{\varepsilon_o A}{d} X E^2 d^2 = \frac{1}{2}\varepsilon_0 E^2 Ad \text{ joule}$$

Energy stored per unit volume $$U = \frac{1}{2}\varepsilon_0 E^2 \text{ joule/m}^2$$

If the capacitor is placed in a medium of dielectric constant k, then the energy stored per unit volume is given by

$$U = \frac{1}{2}\,K\,\varepsilon_0 E^2 = \frac{1}{2}\,\varepsilon E^2$$

$$U = \frac{\varepsilon E^2}{2}$$

Where ε is the permittivity of the medium.

Applications of Capacitors in Power Supplies and Motors (Fans)

Capacitors are essential components in various electrical and electronic applications due to their ability to store and release electrical energy. Here, we will focus on their applications in power supplies and electric motors, particularly fans.

1. Capacitors in Power Supplies

Capacitors play several crucial roles in power supplies:

Energy Storage:

Smoothing and Filtering: Capacitors are used to smooth out voltage fluctuations in power supplies. They charge during voltage peaks and discharge during voltage drops, maintaining a steady output voltage. This is especially important in DC power supplies and converters.

Decoupling and Bypassing: Capacitors are placed close to active devices to decouple AC signals from DC signals, preventing noise from affecting the performance of sensitive components.

Power Factor Correction (PFC):

In AC power supplies, capacitors help improve the power factor by compensating for the reactive power caused by inductive loads. This improves the efficiency of power delivery from the source to the load.

Transient Suppression: Capacitors can absorb and mitigate voltage spikes and transients in power supplies, protecting electronic circuits from potential damage.

Voltage Regulation: In voltage regulator circuits, capacitors help maintain a constant output voltage by filtering out any residual ripple and noise from the rectified voltage.

2. Capacitors in Electric Motors (Fans)

Capacitors are also vital in the operation of electric motors, including those used in fans:

Start Capacitors:

Starting Torque: In single-phase induction motors, start capacitors provide the necessary starting torque. They create a phase shift in the auxiliary winding, producing a rotating magnetic field to start the motor.

High Capacitance: Start capacitors typically have a higher capacitance and are designed for short-term operation during the motor start-up phase.

Run Capacitors:

Continuous Operation: Run capacitors are used to improve the running efficiency and performance of the motor. They provide a continuous phase shift to the auxiliary winding, ensuring smooth and efficient operation.

Lower Capacitance: Run capacitors have a lower capacitance compared to start capacitors and are designed for continuous duty.

Dual Run Capacitors:

Two Motors or Windings: Dual run capacitors are used in HVAC systems and some appliances to power two motors (e.g., compressor and fan) or a motor with two windings, providing both starting and running support.

Phase Correction:

Power Factor Improvement: In larger motors, capacitors are used to improve the power factor, reducing the reactive power and enhancing the efficiency of the motor.