Manonmaniam Sundaranar University,
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OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES
(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

II YEAR

B.Sc. Physics

Course Material

Maintenance of Electrical appliances

Prepared
By

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MAINTENANCE OF ELECTRICAL APPLIANCES

Unit –I

Basic Electric components Active & passive components – Resistance – capacitance types – inductance – its units- Galvanometer, ammeter, voltmeter and multimeter- Transformers- types- coils- wire gauges Electrical energy- power- consumption of electrical power.

Unit –II

Basic home Electrical appliances Electric bulbs- working principles of LED lamps- Electric Fans – Wet Grinder – Water purifier basics and working –maintenance – Mixie – electric Iron box.

Unit –III

High Power Electrical appliances and safety requirements Water Heater- Storage and Instant types – basics and working of microwave oven – washing machine – Air conditioner- its maintenance- concept of water pumping motor- overloading rod- short circuiting –ground earthing of appliances.

Unit –IV

Thermal electrical appliances Room heater- basics and working of electric iron & immersion rod- automatic rice cooker electric kettle toaster & hair dryer – induction cooker & stove

Unit –V

Relays & Switches Electrical protection – Relays – Fuses – Electrical switches- Circuit breakers – MCB – basics and working of ELCB – RCCB- ground fault protection

UNIT –I

Basic Electric components Active & passive components – Resistance – capacitance types – inductance – its units- Galvanometer, ammeter, voltmeter and multimeter- Transformers- types- coils- wire gauges Electrical energy- power- consumption of electrical power.

1.1. Basic Electric components Active & passive components

Active Components are made up of Diodes, Integrated Circuits, MOSFETs, JFETs, Optoelectronics, Oscillators and Transistors. Passive Components are made up of Capacitors, Inductors/Magnetics, Resistors, Substrates & Interconnects, Energy and High Frequency Components.

Active and passive electronic components are found in everyday items like lights, sound systems, computers, phones, cars, and many more devices.

By definition, active components are found in every single electronic device. Examples include any device with computing power (integrated circuits), devices with a built-in battery or display, and LED lights (light-emitting diodes).

Examples of devices with passive components include incandescent light bulbs, loudspeakers, sensors, microwaves, remote keyless entry systems, and antennas.

Electronic Components:

Most devices have tiny electronic circuits in them that can control machines and process information, and electronic components are used to construct those circuits.

An electronic component is any basic discrete electronic device or physical entity part of an electronic system used to affect electrons or their associated fields.

Electronic components have a number of electrical terminals or leads. These leads connect to other electrical components, often over wire, to create a circuit with a particular function (for example, an amplifier or radio receiver).

Basic electronic components may be packaged discreetly, as arrays or networks of like components, or integrated inside of packages like semiconductor integrated circuits, hybrid integrated circuits, or thick film devices.

What is an Active Component?

Active components are semiconductor devices that consist of semiconductor materials. They supply electric power to the circuit or power gain in the circuit. Common electronic devices

are diodes and transistors, which perform "active" operations like amplifying, rectifying, or converting supplied current (signal).

Semiconductors are substances like silicon or germanium that have a resistance rate somewhere between a conductor (iron, copper, gold, silver, etc.) and an insulator (rubber, ceramic, etc.).

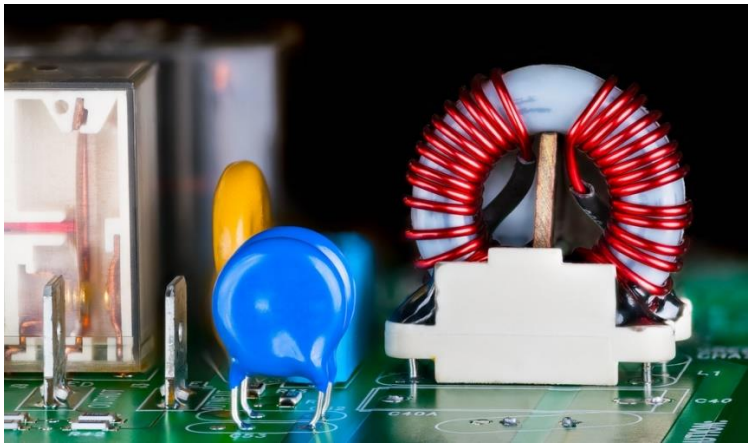
Semiconductor devices can be classified into:

- Single-function discrete (diode, transistor)
- Optical semiconductors such as light-emitting devices (LED, laser), light-receiving devices

  (Photodiode, image pickup element), and optical composite devices (photocouplers, photo relays)
- Sensors capable of detecting temperature, pressure, acceleration, magnetism
- Integrated circuits (ICs) loaded with multiple functions

What is a Passive Component?

Passive components are required electronic devices that perform "passive" operations like consuming, storing, or releasing electric power. They can only absorb electrical energy and dissipate it in the form of heat or store it in a magnetic or electric field. They cannot provide electric power or power amplification in an electric circuit. Common passive components include resistors, capacitors, and coils.



The following four examples are the most common passive components:

- Capacitors
- Inductors
- Resistors
- Transformers
- Diodes

Functions of Active and Passive Components

Functions of Active Components

- **Diodes**

A diode is a component capable of passing electric current in one direction but stopping current in the opposite direction (rectifying characteristics). This is done by combining semiconductors of type-p and type-n, and two types of materials, such as a semiconductor and a metal. LED (light-emitting diode) is also a type of diode, which is known for emitting light, but has the same characteristic of passing current only in one direction.

- **Transistors**

Transistors are semiconductor devices made by joining p-type and n-type semiconductors one after another and having three terminals called base (B), collector (C), and emitter (E). When a small current is applied between the base and emitter, a much larger current flows between the collector and emitter as an amplifying function. Similarly, a change in current between the base and emitter causes a large change in current between the collector and emitter as a switching function. Thus, transistors provide two functions. Transistors have a wide variety of applications, including an amplifier circuit, a switching circuit, a constant voltage circuit that suppresses power voltage fluctuation, and a logic circuit that uses input and output voltages for local operation.

- **Integrated Circuit(IC)**

Integrated circuits use semiconductor processing technology called photolithography to form multiple electronic components on a circuit substrate such as minute transistors and diodes on a semiconductor wafer. Types of ICs are largely grouped into digital ICs for handling signals and analog ICs for handling analog signals. These components are a central control function of electronic equipment, such as complex data computation, conversion process, and data memory.

Functions of Passive Components

- **Resistors**

Resistors maintain or change electric current that flows in the circuit by consuming supplied electric power. For example, a simple circuit could consist of a power supply and a resistor. While maintaining a constant power supply, if the resistor value is increased, the current in the circuit will get smaller. If the resistor value is decreased, the current gets larger. In actual circuits, resistors are used to suppress current to avoid allowing more flow than the rated value into other components. They can also be used to obtain the required current or voltage by dividing voltage or current flow, or for measuring the flow in the circuit.

- **Capacitors**

Capacitors store or release supplied electrical power (electrical charge) by blocking direct current (DC), while passing alternating current (AC). They pass high-frequency currents very well. When DC is applied to a capacitor, it stores electrical charge to a maximum level and then stops the current flow. When AC is applied, the capacitor stores and releases electrical charge every time the current flow direction changes. How much electrical charge can be stored in a capacitor is called capacitance. The higher the capacitance or the higher the frequency of AC, the more current flows through.

- **Inductors (Coil)**

A coil's function is to convert electricity (current) into a magnetic field or convert a magnetic field into a current. Coils pass DC but shut off AC, and it becomes difficult to pass current when the frequency gets higher. A coil's behavior toward DC and AC is opposite that of capacitors. Applying electrical current to wiring generates a magnetic field, but coils can store electrical energy as a magnetic field through their winding structure of coil. DC passes through a coil as it does a conductor, but AC generates a largely changing magnetic field by changes in current.

What is the Difference between Active and Passive Components?

Active components require an external source to operate in a circuit, while passive components do not. Active components produce energy in the form of voltage or current, and passive components store or maintain energy in the form of voltage or current.

Here are some other differences between active and passive components:

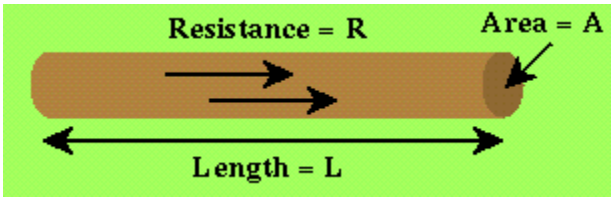
Active Component	Passive Component
An active device transforms and injects power or energy into a circuit.	A passive device uses power or energy from a circuit.
Examples: Diodes, transistors, SCR, integrated circuits, etc.	Examples: Resistors, capacitors, inductors, etc
They are capable of providing power gain (amplifier).	They are incapable of providing power gain.
They are energy donors.	They are energy acceptors.
They can control the flow of current.	They cannot control the flow of current.

A simple way to test whether a component is active or not is to measure the difference between its input and output signals. If there is a decline in power, the component is passive. If the signal is amplified, it is active.

All electronic circuits must contain at least one active component, and most electronic devices contain both active and passive components.

1.2. Resistance

It is the property of a material which opposes the flow of electric current through it. Conductors have low resistance while insulators have very high resistance. (i.e). Resistance is a value that measures how much the component "resist" the passage of electrical current, the value is measured in ohms (Ω). One way to calculate resistance:



$$R = \rho \frac{L}{A}$$

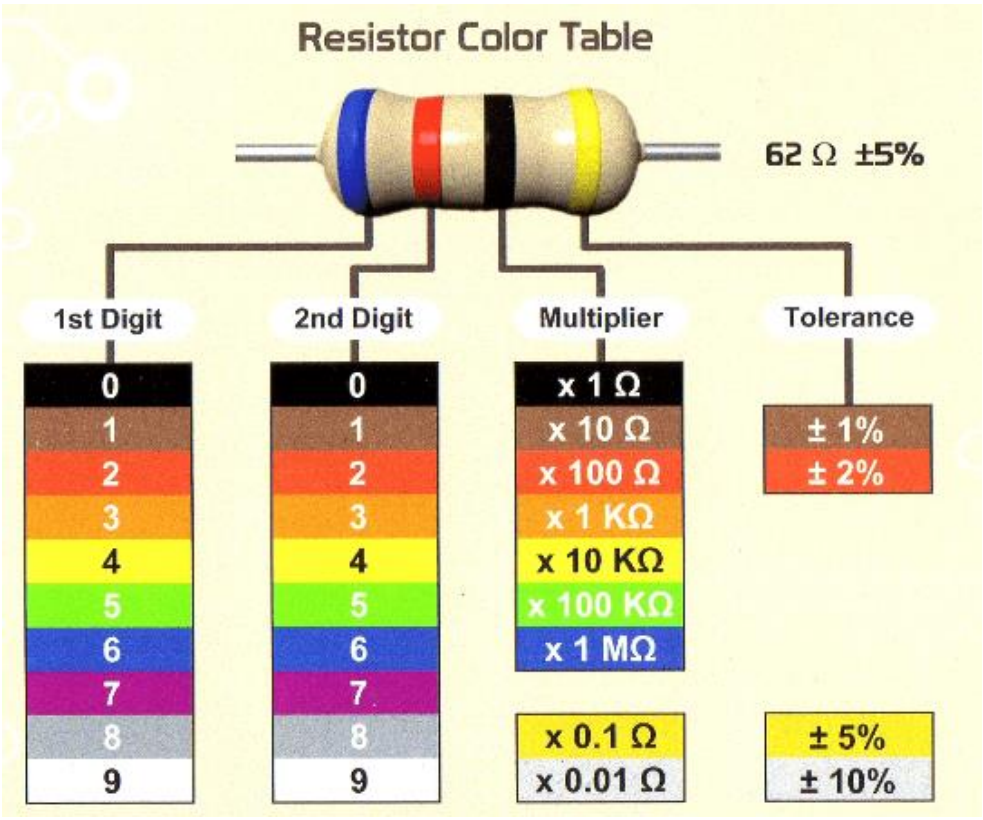
- ρ is the resistivity, a material's property.

Another form to calculate the resistance is applying Ohm's law.

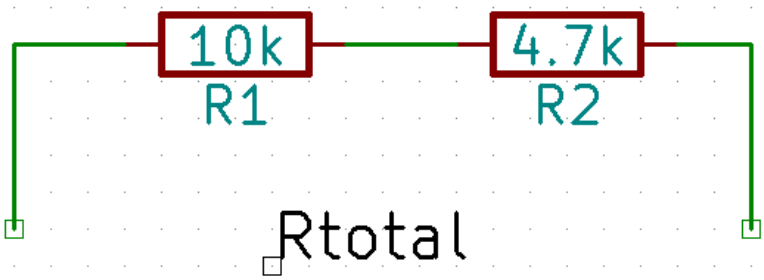
$$R = \frac{V}{I}$$

- V is the voltage and I is the current.

This is the resistor, the component with a defined resistance and the resistor's color code.

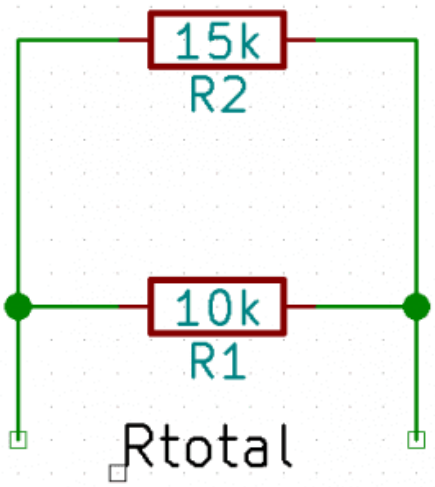


Resistors in series, the resistance is summed.



$$R_{total} = R_1 + R_2$$

Resistors in parallel:



$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

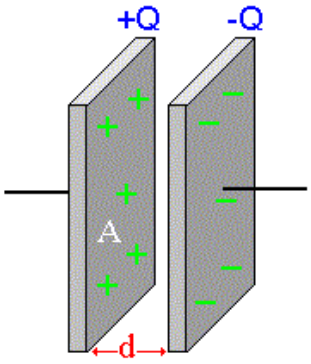
1.3. Capacitance

The amount of charge that can be stored inside a capacitor at a given voltage is called Capacitance. It gets charged when charges are forced into the positive (or upper) plate of the capacitor due to emf. Similarly, it discharged when charges are forcefully pulled out of the capacitor. Capacitance is measured in Farad.

Capacitance is calculated in this form: $C = \frac{Q}{V}$

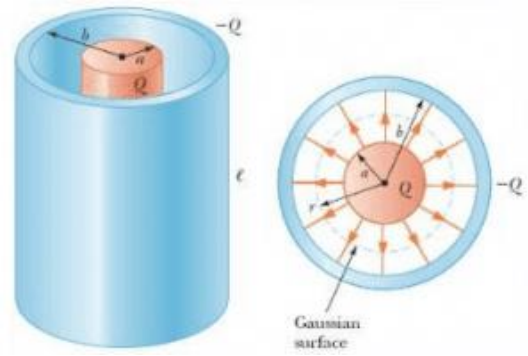
- Q is the charge and V is the voltage

The capacitance in a capacitor with parallel plates



- ϵ is the electric permissiveness;
- A is the plate area;
- d is the distance between plates.

Capacitance in a cylindrical capacitor

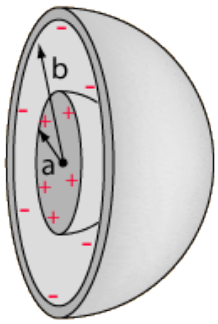


$$C = 2\pi\epsilon \frac{L}{ln\left(\frac{b}{a}\right)}$$

L is the cylinder's length.

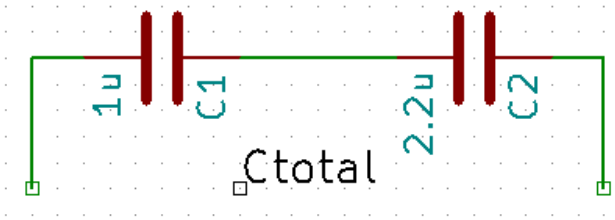
Capacitance in a spherical capacitor

$$C = 4\pi \in \frac{ab}{b-a}$$



Capacitance in an isolated sphere $C = 4\pi \in R$

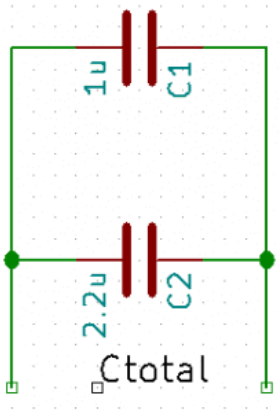
Capacitors in series:



$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Capacitors in parallel:

$$C_{total} = C_1 + C_2$$



1.4. Inductance

While the capacitor stores energy in an electrical field, the inductor stores energy in a magnetic field. Inductance is the inductor's capacity to resist variation of electric current and is measured in henries (H). The inductor is nothing more than a rolled wire in spirals which can have a nucleus inside to increase the magnetic field and the inductance. Here are various types of inductors. Sometimes inductors are called solenoids.

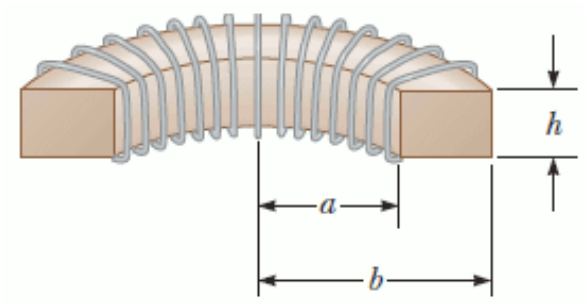
The formula to calculate inductance in a solenoid:

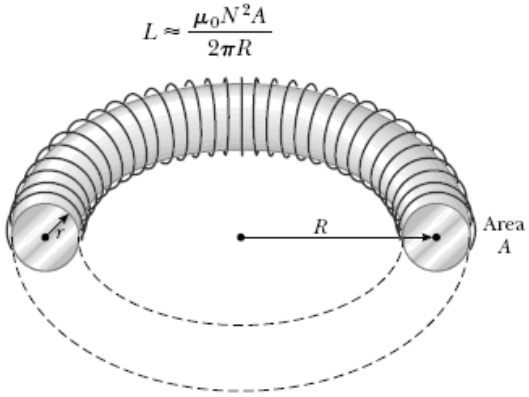
$$L = \frac{\mu N^2 A}{l}$$

- μ is the magnetic permeability;
- N is the number of spires or turns in the inductor;
- A is the section area;
- l is the length.

The equation to calculate the inductance of a toroid, ring-shaped coil. With a square cross section.

$$L = \frac{\mu N^2 h}{2\pi} \ln \frac{b}{a}$$





If the cross section area is circular.

The inductor's association in series and parallel is equal to the resistors and the total inductance is calculated in the same way.

1.5. Galvanometer

What is a Galvanometer?

A galvanometer is a device or an instrument that is used to measure small currents in an electric circuit. (A galvanometer is a device that measures current flow, while an ammeter and voltmeter are used to measure electric current and voltage). It can be used as both ammeter and voltmeter by adding resistance to it in parallel or series. A galvanometer consists of a coil which is placed between the poles of a horseshoe magnet. When an electric current passes through this coil, the pointer of the galvanometer deflects. Most popular and frequently used galvanometer today is the D'Arsonal type.

1.6. Ammeter and Voltmeter

Ammeter and voltmeter both devices are used in an electrical circuit to measure different aspects of electricity. Among them, an ammeter gives you the measure of current while the voltmeter helps in calculating the voltage or potential difference between two points in an electric circuit.

What is Ammeter and Voltmeter?

Ammeter – It is an instrument that is used to measure the current in an electrical circuit. It gets its name from Ampere which is the unit of electric current.

Applications of an Ammeter:

- This device is easily available and helps determine the flow of current quite accurately.
- It can be used both domestically and for industrial purposes.
- It is widely used by manufacturing and instrumentation companies.
- It can be used with a thermocouple to measure temperature.
- It can be used to check faulty circuits in offices and homes.

1.7. **Voltmeter** – This instrument measures the voltage between two points in an electrical circuit. It is present in both digital and analogue forms.

Applications of a Voltmeter

- A voltmeter is used for a number of purposes even though it is not as accurate as an ammeter.
- It measures the voltage in a circuit and is also used in both homes and big factories.
- It proves quite useful in debugging thereby certifying the presence of the optimal value of the required voltage.
- It can be coupled with cathode ray tubes to ensure the accuracy of the results and measurements taken.
- It is also used in labs by young students and scholars for experimenting and testing purposes.

What is the Difference between Ammeter and Voltmeter?

There are two ways to measure electricity

- Using current
- Using voltage

Ammeter and voltmeter are used to measure the flow of current and the measure of voltage, respectively. The significant difference between these two devices lies in their use.

The difference between an ammeter and a voltmeter

	Ammeter	**Voltmeter**
Use	The flow of current is measured using this instrument.	Voltage or potential between two points in an electric circuit is measured using this device.
Connection	The electrical circuit element is connected in series with an ammeter.	The electrical circuit element is connected in parallel mode with a voltmeter.
In Terms of Resistance	The resistance of an ammeter is low so that it	Since it is used to measure the difference in potential between two points, voltmeters have high resistance.

	does not affect the flow of current in a circuit.	
Accuracy of Ammeter and Voltmeter	It measures the flow of current accurately.	It is less accurate with the measurement
Ideal Case	An ideal Ammeter is supposed to have zero resistance, even though it is not practically possible.	In an ideal voltmeter, the current is zero and resistance is infinite. The ideal resistance of voltmeter and ammeter is infinity and zero, respectively.
Representation	'A' denotes an ammeter.	'V' is used to denote voltmeter.

Difference between Ammeter and Galvanometer:

Difference Between Ammeter and Galvanometer	
Ammeter	**Galvanometer**
It is a device used to determine the magnitude of current flowing in a circuit.	It is a device used to detect the strength and direction of a small current present in the circuit.
It works with or without the presence of the magnetic field.	It works due to the presence of the magnetic field.
It measures both alternating and direct current.	It measures only direct current.
It is less sensitive.	It is more sensitive.
It is more accurate.	It is less accurate.
It could be a mechanical or electronic device.	It is a mechanical device.
It is used in an electrical circuit.	It is used in bridges and potentiometers.

Galvanometer	Ammeter	Voltmeter
It is an instrument used to **detect the flow of current** in the circuit.	It is an instrument used to show the **amount of curren** t in the circuit.	It is an instrument used to show the **amount of potential difference** across two points in the circuit.
It tells the **direction of current** in the circuit.	It **doesn't tell about the direction** of current in the circuit.	It tells **nothing about the current** in the circuit.
It is **connected in series** in a circuit.	It is **connected in series** in a circuit.	It is **connected in parallel** in a circuit.
It has **moderate resistance** (10-100 ohms)	An ideal ammeter should have **zero resistance,** hence resistance of an ammeter is very small.	An ideal voltmeter should have **infinite resistance,** hence resistance of a voltmeter is very high.
Magnetic Field is required for Galvanometer to work	Ammeter **can work with or without** magnetic field	Voltmeter **can work with or without** magnetic field
It measures **only direct current**	It measures **both direct and alternating current**	It tells **nothing about current** in the circuit

1.8. Multimeter

What is multimeter and its principle?

The working principle of the multimeter is to use different measurement techniques to measure electricity. While there are many types of multimeters, the common type is the digital multimeter (DMM), which uses analog-to-digital conversion to display measurements on a digital screen.

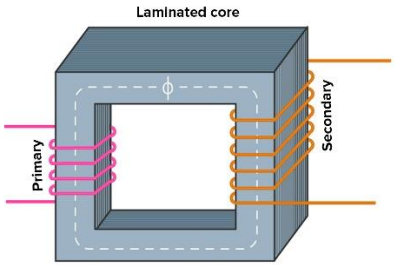
Multimeters are instruments used to easily and accurately measure the electrical properties of a circuit or device. There are two basic types of multimeters: digital multimeters and analog multimeters.

1.9. Transformers and Its types

What is a transformer and what are its types?

Transformer:

1. A transformer is a device that transfers electric energy from one alternating-current circuit to one or more other circuits.
2. It does so by either increasing (stepping up) or reducing (stepping down) the voltage without a change in the frequency of AC between circuits.
3. It is a device used in the power transmission of electric energy.



4. It is a device employing the principle of mutual induction to convert variations of current in a primary circuit into variations of voltage and current in a secondary circuit.

5. Rating of transformer is in kilo volt-ampere (KVA)
6. There are three basic parts of a transformer:
    1. an iron core that serves as a magnetic conductor,
    2. a primary winding or coil of wire and.
    3. a secondary winding or coil of wire.

Types of transformer:

1. Transformers generally have one of two types of cores: Core Type and Shell Type.
2. These two types are distinguished from each other by the manner in which the primary and secondary coils are placed around the steel core.
3. Further, they are distinguished as step-up and step-down transformers.
4. Also other types are autotransformers, Power transformers, and Auxiliary Transformers.

Hence, a transformer is a device that transfers electric energy from one alternating-current circuit to one or more other circuits.

1.10. Wire Gauge:

Wires Gauge and Characteristics

Electrical wiring in homes and businesses consist of wires with a circular cross-section. They come in a variety of sizes, often referred to as the wire **gauge**. The American Wire Gauge (AWG) is a standardized system for expressing the size of a round, solid, non-iron conducting wire. While most of the wires used in household circuits are 12-gauge and 14-gauge, wires of other sizes are used for hobby applications (e.g., train layouts, speaker wiring) and long-distance power transmission. The gauge of a wire indicates information about the diameter, cross-sectional area, and expected resistance. **Table 1** illustrates these relationships for several gauges.

Table 1

AWG	Diameter (mm)	Area (mm^2)	Copper Wire Resistance (Ω/m)
32	0.202	0.0320	0.538
28	0.321	0.0810	0.213
24	0.511	0.205	0.0842
22	0.644	0.326	0.0529
20	0.812	0.518	0.0333
18	1.02	0.823	0.0209
16	1.29	1.31	0.0132
14	1.63	2.08	0.00828
13	1.83	2.62	0.00657
12	2.05	3.31	0.00521
11	2.31	4.17	0.00413
10	2.59	5.26	0.00328
9	2.91	6.63	0.00260
8	3.26	8.37	0.00206
6	4.12	13.3	0.00130
5	4.62	16.8	0.00103
4	5.19	21.2	0.000815

The amount of current that can be safely *carried* by a wire is affected by the wire gauge. A variety of factors in addition to gauge affect this current-carrying capacity - referred to as **ampacity**. Such characteristics include the nature of the insulating material wrapped around the wire, the temperature of the surroundings, the number of nearby wires, etc. The National Electrical Code (NEC) provides guidelines for the safe installation of electrical wiring in the United States. **Table 2** lists ampacities for various gauge wires used in houses, business, and for power transmission. Ratings apply to wires having plastic insulation with temperature ratings of 60°C, 75°C and 90°C.

Table 2

AWG	Ampacity (A) at T =		
	60°C	75°C	90°C
14	20	20	25
12	25	25	30
10	30	35	40
8	40	50	55
6	55	65	75
4	70	85	95

From http://www.usawire-cable.com/pdfs/NEC%20AMPACITIES.pdf

1.11. Power- consumption of electrical power

Energy consumption is the use of power or energy of a system by making use of supply. The consumption is done in Giga Joule per year, kilograms of oil equivalent per year (kg/a), and in Watts.

Formula of Energy Consumption

The energy consumption formula is articulated as,

$$E = P \times t/1000$$

Where,

- E is energy in kilowatt-hours(kWh),
- P is power in Watts,
- t is hours

Energy Consumption Solved Problems

Problem 1: Compute the energy consumption in a system that consumes 190 Watts of power and works for 3 hrs a day.

Answer:

Given: Power P = 190 W, total number of hours = 3 hrs

$$E = P \times t/1000$$

E =(190*3*60*60)/1000

E =2052 kWh

Therefore, the energy consumption is 2052 kWh

Problem 2: A toy car consumes energy of 500 Watts of power if it works for 2 hrs a day using it. Calculate the energy consumption a day.

Answer:

Given: Power P = 500 W, total number of hours= 2 hrs

$$E = P \times t/1000$$

E = (500*2*60*60)/1000

E =3600 kWh

Unit –II

Basic home Electrical appliances Electric bulbs- working principles of LED lamps- Electric Fans – Wet Grinder – Water purifier basics and working –maintenance – Mixie – electric Iron box.

2.1. What is Electronic Bulb?

The electronic bulb is the simplest electrical lamp that was invented for illumination more than a century ago. It was the small and simplest light that brightened the dark space. The electronic bulb is also known as an incandescent lamp, incandescent light globe or incandescent light bulb. Bulb comes in different sizes and light output and operates with a voltage range from 1.5 Volts to about 300 Volts. Now let us study the parts and structure of the bulb in detail.

Working of Electric Bulb

- ✓ An Electric bulb works on the principle of incandescence**,** a general term meaning light produced by heat. In an incandescent type of bulb, an electric current is passed through a thin metal filament, heating the filament until it glows and produces light.
- ✓ Incandescent bulbs typically use a tungsten filament because of tungsten's high melting point. A tungsten filament inside a light bulb can reach temperatures as high as 4,500 degrees Fahrenheit. A glass enclosure, the glass "bulb", prevents oxygen in the air from reaching the hot filament.
- ✓ After the electricity has made its way through the tungsten filament, it goes down another wire and out of the bulb via the metal portion at the side of the socket. It goes into the lamp or fixture and out a neutral wire.
- ✓ Electric bulb is compatible with either AC or DC current.

Structure of the Electronic Bulb

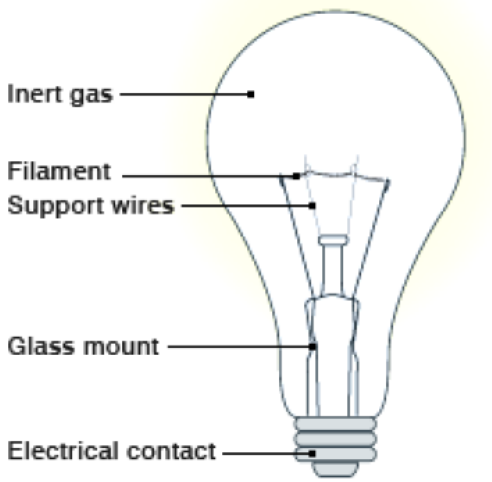


Fig (1) Structure of Electric Bulb

CFL:

- ✓ The term 'CFL' stands for Compact Fluorescent Lamp. It is also known as compact fluorescent light, energy-saving light, and compact fluorescent tube.
- ✓ The CFL was initially designed to replace the incandescent lamp in terms of its compactness as well as energy efficiency. The basic construction of a CFL consists a tube which is curved/spiraled to fit into the space of an incandescent bulb, and compact electronic ballast in the base of the lamp.

Working of CFL:

- ✓ A CFL uses vacuum pipe which is principle wise same to the strip lamps (commonly known as Tube light). Tube has two electrodes on both ends which is treated with Barium. Cathode is having a temperature of about 900° C and generates a beam of electrons which is further accelerated by potential difference between electrodes.
- ✓ These accelerated electrons strike Mercury and Argon atoms which in turn results in the arise of a low temperature plasma. This process initiates the radiation of Mercury in Ultra violet form. Tube's inside face contains 'Luminophore' whose function is to convert Ultra violet light into visible light.

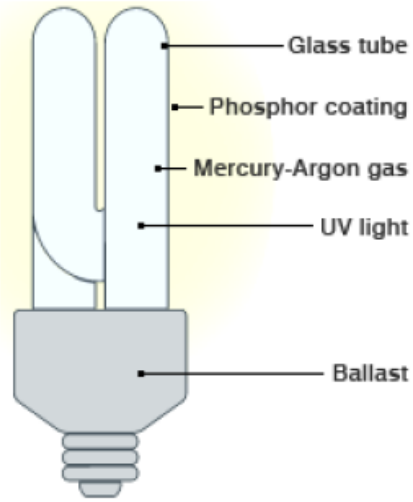


Fig (1) Structure of CFL

- ✓ This tube is fed with AC power supply which facilitate the changing functionality of Anode and Cathode. The CFL also consists a switched mode converter. It functions on a very high frequency and acts as a replacement of ballast (choke) and starter assembly.

Uses of Electronic Bulb

- It is used in portable lighting such as table lamps
- It is used in vehicle lights and car headlights.
- It is used in household and commercial lighting
- It is used in decorative and advertising lighting

Advantages and Disadvantages of Electronic Bulb

Advantages

- Bulbs offer longer life than any other light source.
- The working time ranges from 8000 to 15000 hours.
- It is affordable and economical.

- It is easy to install.
- It comes in various sizes and shapes.
- Produces relatively high output.

Disadvantages

- It is energy inefficient.
- A short lamp lifetime is about 1000 hours typically.
- It produces warm light.
- Requires higher operating cost.
- Since it is made of glass, it is fragile and should be handled with care.
- Bulb generates low lumen per watt.

Safety and Precautions

Here are some of the safety measures to be followed while handling bulb:

- Electronic bulbs must be handled carefully since they can break very easily.
- The breakable parts of the bulb are extremely sharp and can puncture the skin if touched.
- Since the bulb contains chemicals like argon and mercury, handling should be done carefully. Mercury is toxic to the human body.
- When the bulb breaks, the mercury inside escapes as vapour or fine droplets and can settle on nearby objects. Inhaling mercury is hazardous.
- Proper disposal of the bulbs should be ensured.

2.2. LED (Light Emitting Diode):

✓ The lighting emitting diode is a p-n junction diode. It is a specially doped diode and made up of a special type of semiconductors, which emits light when forward biased, then it is called a Light-Emitting diode.

✓ The emitted light may be visible or invisible. The amount of light output directly proportional to the forward current. The LED symbol is similar to a diode symbol except for two small arrows that specify the emission of light. The LED includes two terminals namely anode (+) and the cathode (-). The LED symbol is shown Fig 1(a)

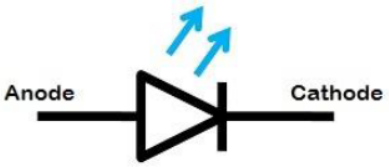


Fig 1(a) Circuit Symbol

Fig 1(b) Light Emitting Diode (LED)

Working Principle of Light Emitting Diode

An LED functions similarly to a standard p-n junction diode but is designed to emit light.

Working of LED:

✓ The light-emitting diode simply, we know as a diode. When the diode is forward biased, then the electrons & holes are moving fast across the junction and they are combined constantly, removing one another out.

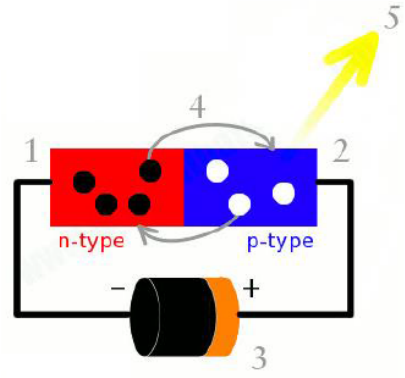


Fig (2) Working of LED

✓ Soon after the electrons are moving from the n-type to the p-type silicon, it combines with the holes, then it disappears. Hence it makes the complete atom & more stable and it gives the little burst of energy in the form of a tiny packet or photon of light.

1. From the Fig (2), we can observe that the N-type silicon is in red colour including the electrons which are indicated by the black circles.

2. The P-type silicon is in the blue colour and it contains holes, they are indicated by the white circles.

3. The power supply across the p-n junction makes the diode forward biased and pushing the electrons from n-type to p-type. Pushing the holes in the opposite direction.

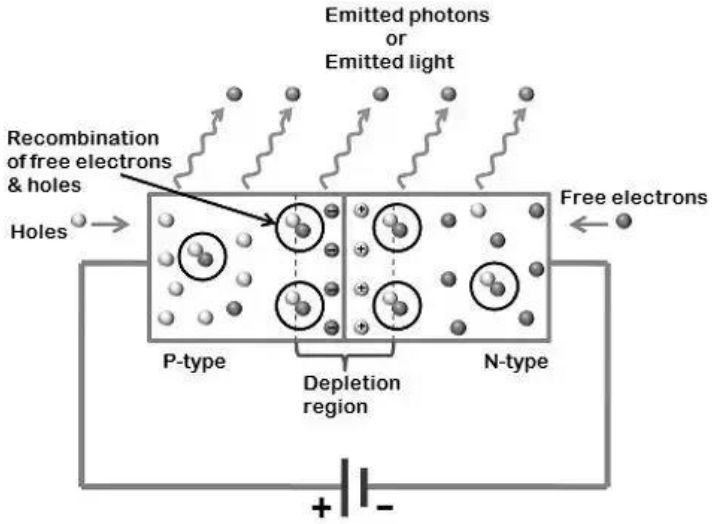
4. Electron and holes at the junction are combined.

5. The photons are given off as the electrons and holes are recombined.

(or)

In detail:

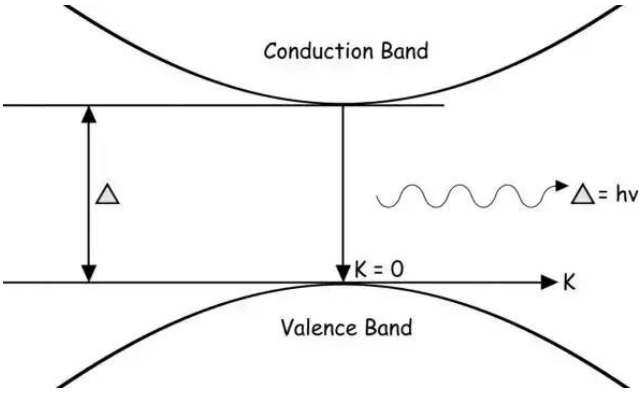
Like an ordinary diode, the LED diode works when it is forward biased. In this case, the n-type semiconductor is heavily doped than the p-type forming the p-n junction. When it is forward biased, the potential barrier gets reduced and the electrons and holes combine at the depletion layer (or active layer), light or photons are emitted or radiated in all directions. A typical figure blow showing light emission due electron-hole pair combining on forward biasing.



The emission of photons in an LED is explained by the energy band theory of solids, which dictates that light emission depends on the material's band gap being direct or indirect. Those semiconductor materials which have a direct band gap are the ones that emit photons. In a direct bandgap material, the bottom of the energy level of conduction band lies directly above

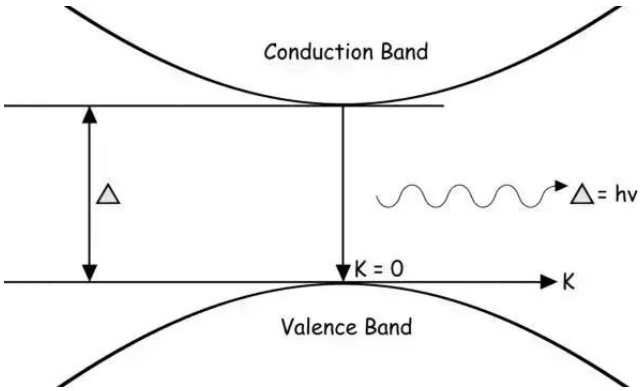
the topmost energy level of the valence band on the Energy vs Momentum (wave vector 'k') diagram.

When electrons and hole recombine, energy E = hν corresponding to the energy gap Δ (eV) is escaped in the form of light energy or photons where h is the Planck's constant and ν is the frequency of light.



Direct Band Gap

Indirect band gap materials are non-radiative, as their conduction band's bottom does not align with the valence band's top, converting most energy into heat. Examples are Si, Ge etc.



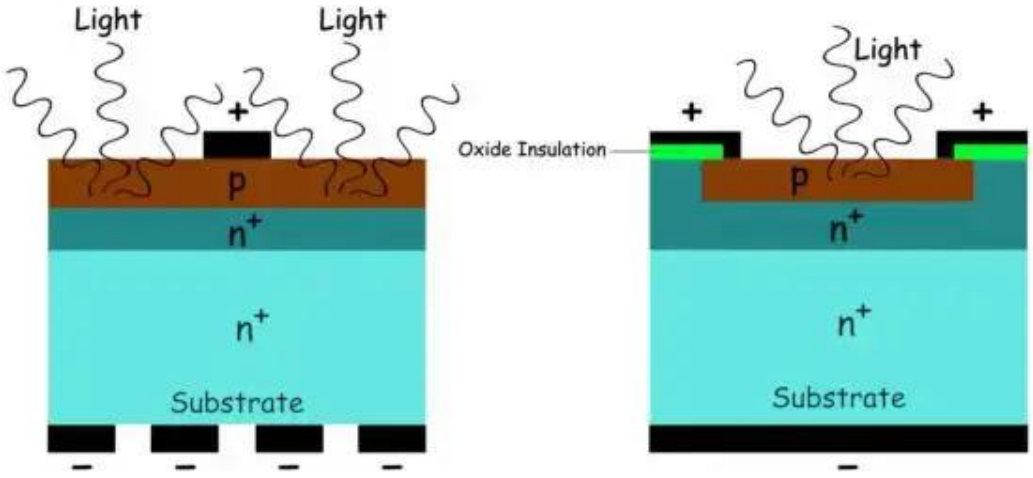
Indirect Band Gap

Example of material which has direct band gap is Gallium Arsenide (GaAs), a compound semiconductor which is the material used in LEDs. Dopant atoms are added to GaAs to give out a wide range of colors. Some of the materials used in LEDs are:

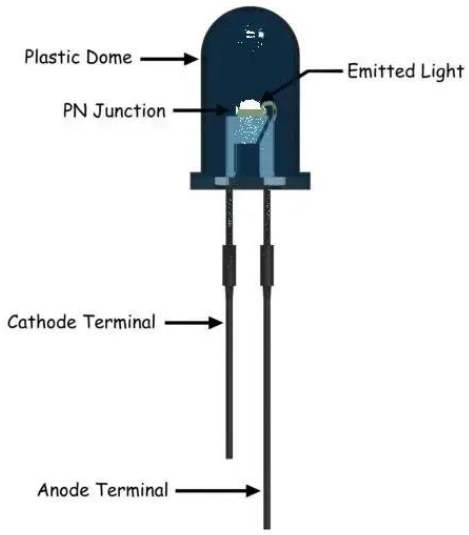
- Aluminium Gallium Arsenide (AlGaAs) – infrared.
- Gallium Arsenic Phosphide (GaAsP) – red, orange, yellow.
- Aluminium Gallium Phosphide (AlGaP) – green.
- Indium gallium nitride (InGaN) – blue, blue-green, near UV.
- Zinc Selenide (ZnSe) – blue.

Physical Structure of LED

LED is structured in such a way so that light emitted does not get reabsorbed into the material. So it is ensured that the electron-hole recombination takes place on the surface.



The above figure shows the two different ways of structuring LED p-n junction. The p-type layer is made thin and is grown on the n-type substrate. Metal electrodes attached on either side of the p-n junction serve as nodes for external electrical connection. The Light emitting diode p-n junction is encased in a dome-shaped transparent case so that light is emitted uniformly in all directions and minimum internal reflection to take place.



The larger leg of LED represents the positive electrode or anode.

LEDs with more than 2 legs are also available such as 3, 4 and 6 pin configurations to obtain multi-colors in the same LED package. Surface mounted LED displays are available that can be mounted on the PCBs.

LEDs typically require a current of a few tens of milliamps and need high resistance in series due to their higher forward voltage drop of 1.5 to 3.5 volts, compared to ordinary diodes.

White Light LEDs or White LED Lamps

LED lamps, bulbs, street lighting are becoming very popular these days because of the very high efficiency of LEDs in terms of light output per unit input power(in milliWatts), as compared to the incandescent bulbs. So for general purpose lightings, white light is preferred. To produce white light with the help of LEDs, two methods are used:

1. Mixing of three primary colors RGB to produce white light. This method has high quantum efficiency.

2. The other method is coating an LED of one color with phosphor of a different color in order to produce white light. This method is commercially popular to manufacture LED bulbs and lightings.

Applications of LEDs

- Electronic displays such as OLEDs, micro-LEDs, quantum dots etc.
- As an LED indicator.
- In remote controls.
- Lightings.
- Opto-isolators.

2.3. Electric Fan

What is the working principle of the fan?

Electric fan works on the principle of **electro - magnetic induction**. An electric fan works with the help of an electric motor the electric motor consists of a coil of wire wound around a metallic core. As electric current passes through the coil of wires, it produces rotational motion due to electro - magnetic induction.

How electric fan works?

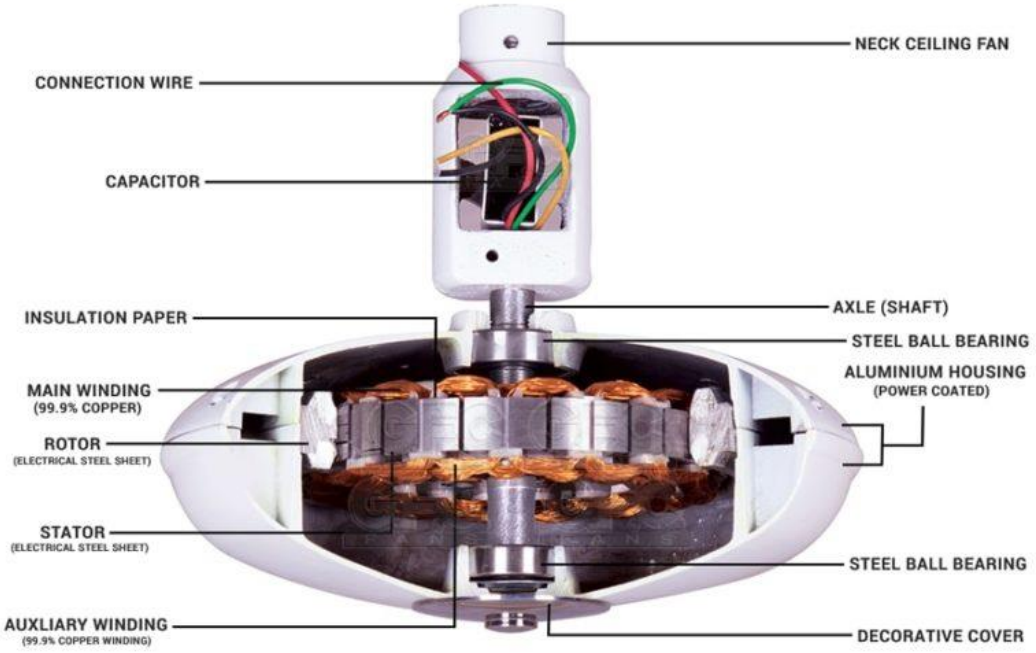
Electric fans, which every one of us has seen at homes is need of summers when the atmospheric temperature goes above the comfort level of human body.

Electric fan when rotates, blows away air around it towards the corners of room and thus speeds up the evaporation process resulting in the cooling of human body and room.

Components of electric fan:

Capacitor:

Start capacitor is used in electric fans, as we know capacitors stores energy and this stored energy is used to rotate the fan from rest state. This capacitor increases electric fan motor torque and allows motor to rotate rapidly.



This capacitor remains in to circuit until only the electric fan reaches predetermined speed, this predetermined speed is usually the 75% of the full speed of fan and when fan reaches the predetermined speed this capacitor is taken out of the circuit and will again be incorporated into circuit when fan comes at rest state. Learn more about Capacitors **here**.

Axle:

Axle or Shaft is the metallic rod mostly made up of mild steel. Axle is connected from ceiling to fan housing. It stays at rest motion while bearings supporting the housing over it rotates. It also has arrangement for transfer of current to the stator windings.

Bearings:

Ball bearings are used in the electric fan. As shown in the picture, two bearings which are link between housing and axle gives the rotary motion to the housing.

Stator:

Stator winding is simply the stationary winding in the electric fan motor winding. Stator winding means thousands of turns of conducting wire on any non-conducting structure like a coil. This winding has very low resistance. Main purpose of stator winding is to convert electric current into magnetic field.

Rotor:

Rotor in the electric motor is the permanent magnetic in the shape of half circles. Usually 2 pcs of Magnets are used in Electric fan but this can change to 3 pcs or to single pc depending upon size and capacity of electric fan.

Housing:

Housing is the outer part of the electric fan which carries stator, rotor and drive shaft bearing assembly on inside and blades on outer sides.

Blades:

Blades or wings are the hanging part bolted on the outer area of housing. Three blades are mostly used and their length and the angle of air throw depends upon the size and capacity of electric motor.

Working principle of Electric fan:

Electric fan works on the principle of conversion of electric energy into mechanical energy by means of magnetic fields and in this case converted mechanical energy is consumed as rotary motion of fan blades.

When AC is supplied to electric fan it first reaches the capacitor and Capacitor delivers high energy to the stator windings. When stator winding energizes, it develops the rotating magnetic field and which forces the rotor to rotate in the direction of rotating magnetic field.

In this way electrical energy is converted into mechanical energy which causes the rotor and housing to spin and the blades attached to the housing throws away the air nearby it while creating cooling effect.

2.4. Wet Grinder

A wet grinder consists of granite stones rotating inside a metal drum with the help of an electric motor. Food grains are crushed between stones in the drum. Modern wet grinders may use grinding stones that are circular or conical. Wet grinders have some advantages over electric mixers or blenders.

What is the working principle of wet grinder?

A wet grinder works on the principles of grinding and abrasion. The abrasive action is what helps to break down the ingredients into a fine paste or powder. This is achieved by the interaction of the grinding stones. Motor: At the heart of every wet grinder is a motor.

Working:

- Wet grinder consists of granite stones which rotate inside a metal drum with the help of an electric motor and the food grains get crushed between the stone and drum. Second, the stones remain sharp for a greater time than the metal blades.
- Wet grinders have two advantages over electric mixers or blenders.
- First, the stone grinder generates less heat than a mixer and heat affects the flavor of the food. Second, the stones remain sharp for a greater time than do metal blades.
- The wet grinder comes in contact with water all the time.
- This appliance comes with a rust-proof stainless steel drum that can store the batter for more extended periods.
- The 85- Watt motor is strong enough to ensure perfect grinding while ensuring that it does not heat up the batter.

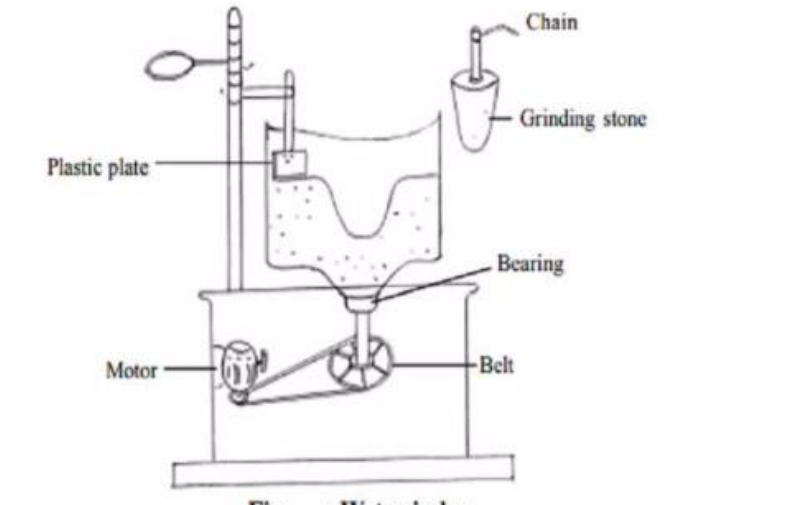


Fig. : Wet grinder

Types of Wet Grinder:

There are three types of wet grinder:

- Mixer grinder: A grinder-mixer is a portable mill that combines the mixing and grinding operations. Materials is held in the grinding chamber until it is reduced to the size of the openings in the screen.
- Stone grinder: It consists of a granite stones which rotate inside a metal drum with the help of an electric motor and the food grains get crushed between the stone and drum.
- Colloid mill: A colloid mill is a machine that is used to reduce the particles size of a solid in suspension in a liquid, or to reduce the droplet size in emulsions. Colliod mills work on the rotor-stator principle: a rotor turns at high speeds (2000 – 18000 RPM).

2.5. Water purifier basics and working:

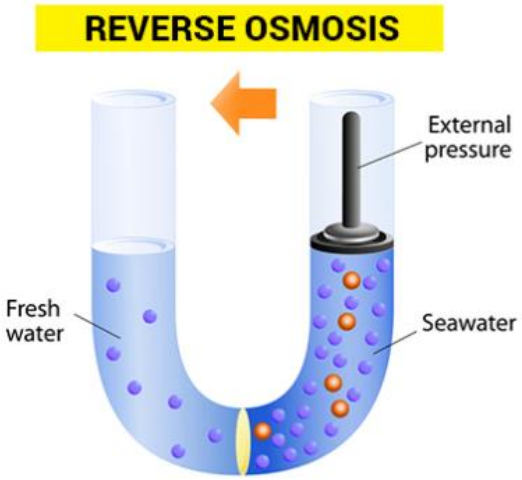
A water purifier removes contaminants from water to make it safe for drinking. The most common water purification technology is reverse osmosis (RO), which uses a semipermeable membrane to filter out dissolved solids and other contaminants.

What is the basic principle of water purifier?

RO (Reverse Osmosis) Water Purifier:

Reverse osmosis (RO) is a process in which a large pressure is applied to the solution side so as to overcome the osmotic pressure.

In the arena of water purification, Reverse Osmosis is a widely popular technology. Operating on the principle of pressurized movement through a semi-permeable Reverse Osmosis Membrane, this technique facilitates the demineralization or deionization of water.



Here are some basics of water purification and how RO systems work:

- **RO process**

Water is forced through a semipermeable membrane under pressure, which allows water molecules to pass through while leaving contaminants behind.

- **RO system components**

A typical RO system includes a cold water line valve, pre-filters, RO membrane, post-filters, storage tank, faucet, drain line, and more.

- **Pre-filters**

Sediment and carbon filters are common pre-filters that can remove silt and organic impurities.

- **Post-filters**

Treated water passes through a final post-filter before going to the faucet.

- **Cross filtration**

RO systems use cross filtration, which means the solution passes through the filter and is routed to different outlets for filtered and contaminated water.

- **RO effectiveness**

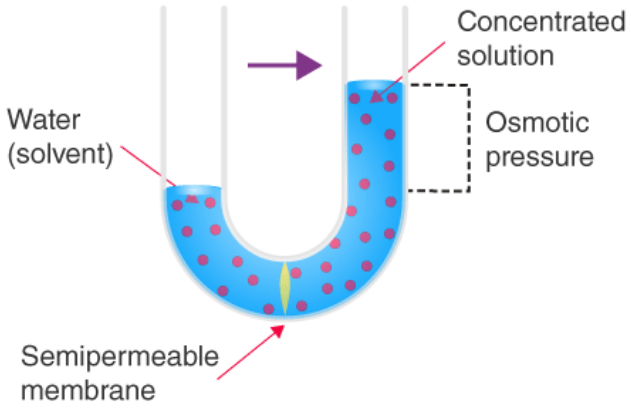
RO is highly effective, removing up to 99% of dissolved salts.

- **RO uses** -RO is used in the military, wastewater purification, food industry, and more.
- **Water purification importance**

Water purification is essential for human life, as it protects against waterborne diseases and promotes overall wellness.

How does a water purifier work step by step?

During the filtration process in water treatment, (1) raw water enters through the filter's inlet, (2) first passing through the coarse screen for removal of large debris and sediment, (3) then through the inner fine screen for removal of the remaining smaller particles.

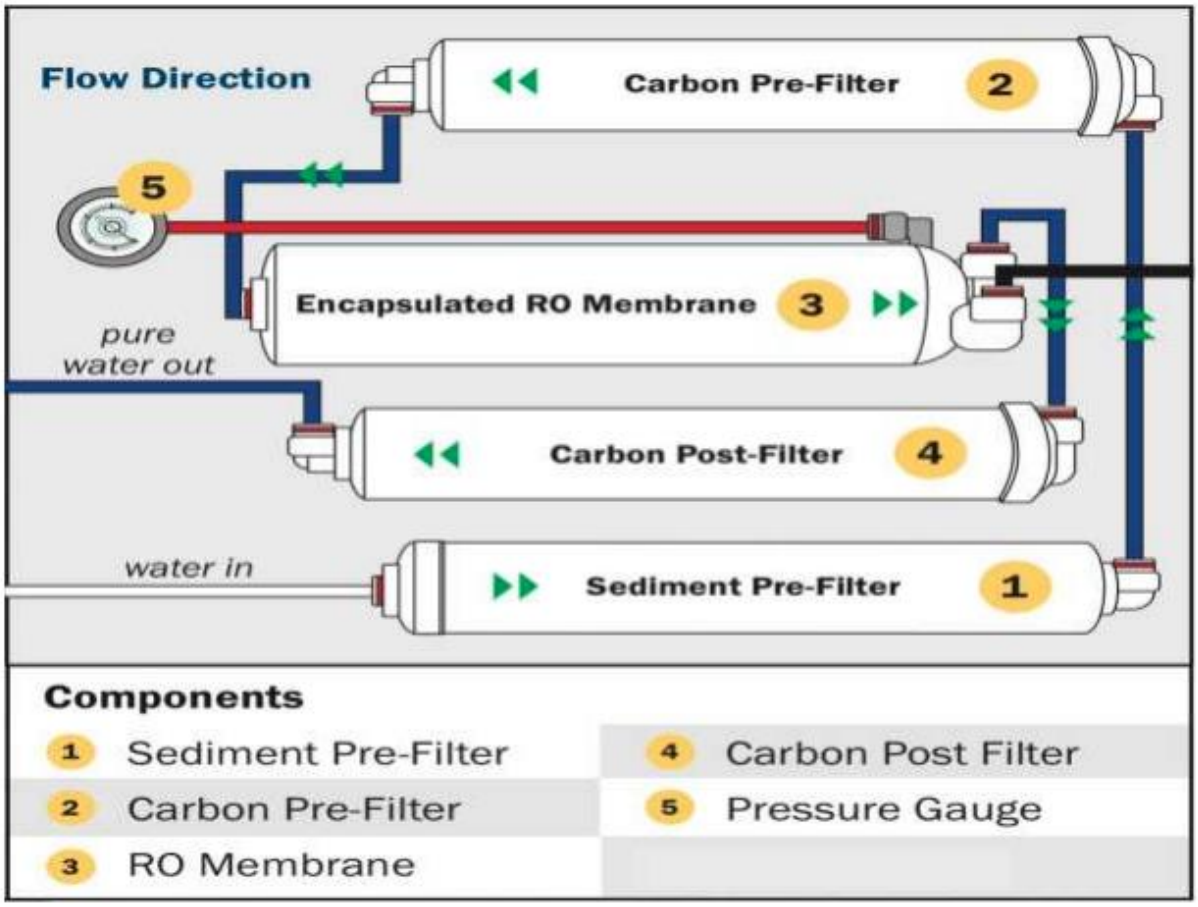


What are the 7 stages of purification of water?

Essential 7 Steps of Water Treatment

- Step 1: Coagulation and Flocculation. Coagulation and flocculation are the first steps in water treatment
- Step 2: Sedimentation

- Step 3: Filtration
- Step 4: Disinfection
- Step 5: pH Adjustment
- Step 6: Fluoridation
- Step 7: Distribution



Water Purification

RO is considered as one of the most important water purification technologies. The contaminants present in water are removed by pushing water under pressure through a semi-permeable membrane. Pure water is thus squeezed out which is fit for drinking. RO is also used in the desalination of seawater. RO is a reliable source for obtaining potable water.

- The process eliminates dissolved and suspended impurities, even bacteria.
- The membrane is small enough to allow the solvent molecules to pass but does not allow large ions or molecules to pass through its pores.
- Polymer membranes are used for the desalinization of seawater.
- Cellulose acetate is often used as a semi-permeable membrane. It allows water molecules to pass but is impermeable to impurities.
- It finds application in the military, wastewater purification, food industry, landfill leachate purification, etc.

Maintenance of Water Purifier:

- **Filter changes**: Filters can become clogged with contaminants or worn out over time, so they should be replaced regularly. The manufacturer's instructions will specify how often to replace the filters.
- **Clean the tank**: Sanitize the water storage tank and RO tank regularly, especially when changing the filters.
- **Clean the pipes**: Clean and sanitize the pipes every two years.
- **Check the pressure nozzle**: Check the pressure nozzle regularly.
- **Replace parts**: Replace any parts that need to be replaced.
- **Get regular service**: Regular maintenance is important for the water purifier to function smoothly and provide clean water.
- **Reduce water waste**: Minimize water loss during purification to reduce stress on the inner components.

2.6. Mixie:

Mixers work by converting electrical energy into mechanical energy to rotate blades that mix ingredients:

1. Motor

When a mixer is plugged in, the motor converts electrical energy into mechanical energy.

2. Coil

A coil is placed in a magnetic field, and when an electric current passes through the coil, it experiences a magnetic force that causes it to rotate.

3. Blades

The mechanical energy from the motor rotates the blades of the mixer, which mix the ingredients.

4. **Circular motion**

The blades create a circular motion that swirls the ingredients, creating a vacuum in the center and pushing the ingredients towards the axis and upward.

5. **Mixing**

The constant movement of the ingredients turns them into a paste or powder. The speed of the mixer can be adjusted to suit the ingredients and desired consistency. For example, a higher speed setting may be used to grind tougher ingredients like lentils, rice, or nuts into a smooth paste or batter.

Basic principle of mixie

Whenever a current flows through the coil, it encounters a magnetic force that causes it to rotate. This mechanical energy rotates the blades of mixer and grinder, which grind the ingredients.

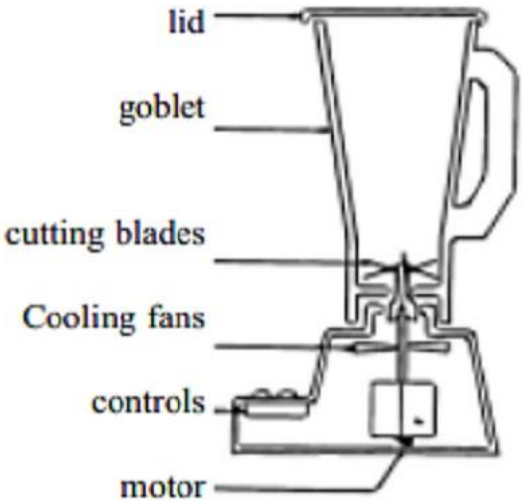


Fig. : Blender

2.7. Electric Iron Box:

- ✓ An Electric Iron Box is a general household appliance used to press the wrinkles out of the clothes. This works on the basis that the combination of heat and pressure removes wrinkles.
- ✓ The principle of the electric iron is that when current is passed through a coil, the coil gets red hot and transfers the heat to the base plate of the electric iron through conduction.
- ✓ There are basically two types of electric irons
  1. Automatic
  2. Non-Automatic
- ✓ There is not much difference between the two types. The former has one regulator to control the temperature of the element and in-turn the temperature of the iron.

Parts of Electric Iron Box:

1. Sole Plate:

The sole plate is the thick, triangular-shaped slab of iron that forms the base over which the electric iron is built up. The bottom surface and edges are heavily chromium plated, to prevent it from rusting.

2. Pressure Plate:

This plate is generally called the top plate as it follows the shape of sole plate.

The pressure plate has some holes through which the studs form the base plate passes through.

3. Heating Element:

The heating element is present between the sole plate and pressure plate. It is pressed hard between the two plates. The heating element consists of nichrome wire wound around a sheet of mica.

4. Cover Plate:

The cover plate is made of thin sheet of iron. It is placed on top of the base plate and it covers all the internal parts of the iron.

5. Handle:

The handle can be made either with wood or with plastic. The handle is attached to the cover plate with the aid of screws. Studs can also be used for this purpose.

6. Pilot Lamp:

The pilot lamp is housed in the cover plate of the electric iron. One end of the pilot lamp is connected to supply, while the other end is connected to the heating element. A shunt resistance is provided across the pilot lamp which assists in providing a voltage drop of 2-5 volts.

7. Thermostat:

- ✓ When it comes to an automatic electric iron, the thermostat is the most important item. It uses a

  Bimetallic strip to operate the switch which is connected in series with the resistance (or) heating element.

- ✓ The bimetallic strip is a simple element which converts a temperature change into mechanical displacement. Thus using bimetallic strip the temperature is kept constant within certain limits.

8. Capacitor: The thermostat helps in maintaining the temperature within limits. But frequent making and breaking of circuit damages the contact points and it may also result in interference with radio reception. To avoid this, a capacitor of certain range is connected across the two contact points.

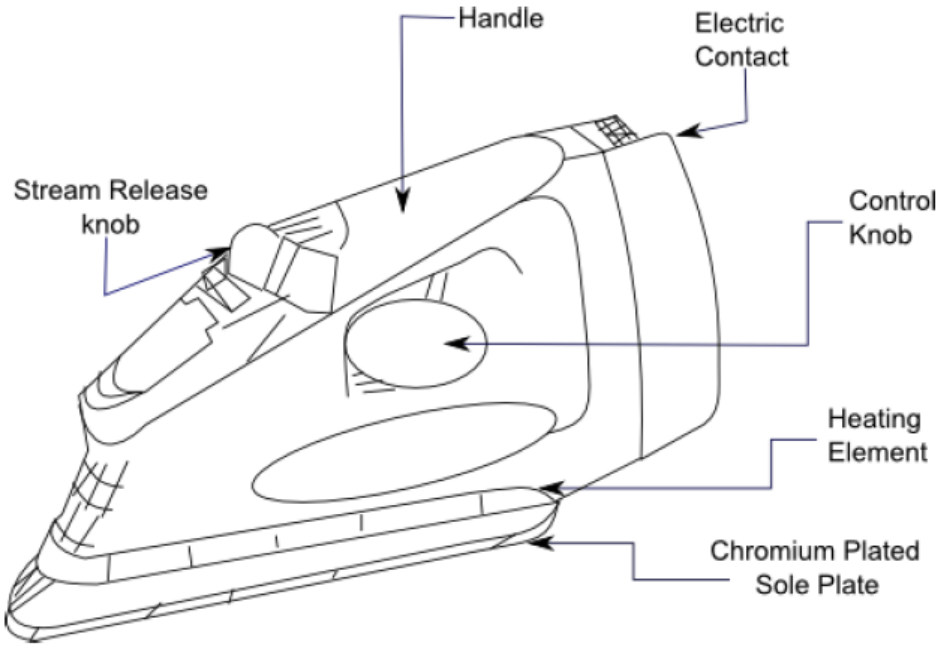
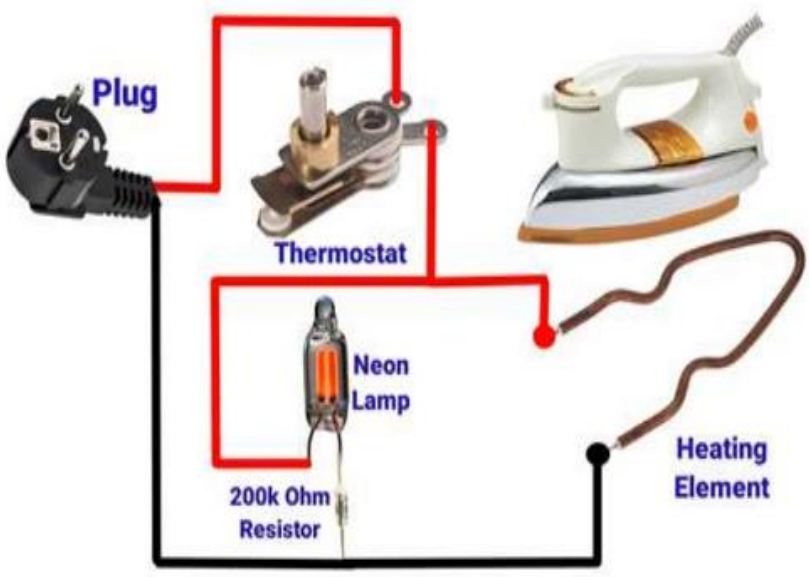


Fig (1) Parts of Electric Iron Box

Working of an Electric Iron Box:

- ✓ An electric iron relies on a basic combination of heat and pressure to remove wrinkles from clothing.
- ✓ If an electric current is passed through a coil or other heating element present in the iron, it becomes very hot. This heat is then transferred to the base plate (the smooth, flat surface that you place against clothes while ironing) through conduction, which elegantly irons your clothes.
- ✓ However, if the iron continuously draws electricity from the power supply, the heating element gets hotter and hotter. This causes a lot of energy waste, as an iron consumes a lot of electricity in just a few minutes, ruining clothes and, in the worst-case scenario, causing serious and potentially dangerous accidents.
- ✓ Therefore, it is essential that iron does not heat up to dangerous temperatures. For maintaining the optimum temperature, a thermostat is used along with pilot lamp which serves as an indicator.



Servicing of an Electric Iron Box:

1. Clean an electric iron:

- ✓ Unplug the iron and make sure it is cool before cleaning.
- ✓ Use a toothpick or pipe cleaner to remove buildup in the steam vents, making sure the debris doesn't fall into the vents.
- ✓ Use a fine sewing needle to carefully clean the spray nozzle of mineral deposits.
- ✓ To flush sediment from a steam iron, pour 1/2 cup water and 1/2 cup vinegar into the water tank. Place the iron on a rack over a broiling pan and set the iron to steam until the tank runs dry. Repeat if necessary. Or follow the instructions for using a commercial iron cleaner.

2. Service an electric iron steam and spray mechanism:

- ✓ Unplug the iron.
- ✓ Use a fine sewing needle to unclog the steam valve assembly. Also, check the valve spring and replace it if it is broken or has lost tension.

- ✓ If the spray pump is accessible, remove it and check for leaks by placing the spray tube in water and squirting the pump. Clean or replace as needed.

3. Clean an electric iron metal soleplate:

- ✓ Unplug the iron.
- ✓ Use a sponge and commercial soleplate cleaner or baking soda and water to remove dirt buildup on the soleplate. Rinse well with water and dry. Don't use harsh abrasives or immerse an electric iron in water.
- ✓ Use very fine steel wool or an emery cloth to remove scratches and burns on the soleplate, then clean the soleplate.

Unit –III

High Power Electrical appliances and safety requirements Water Heater- Storage and Instant types – basics and working of microwave oven – washing machine – Air conditioner- its maintenance- concept of water pumping motor- overloading rod- short circuiting –ground earthing of appliances.

3.1. Electric Water Heater:

The Electric heater used to heat up water is called Electric Water Heater.

Parts of Electric Water Heater:

1. Tank:

The tank itself has a couple different layers that all serve different purposes. The inner shell is a heavy metal tank that has a protective glass liner that holds about 40-60 gallons of hot water. The exterior of the tank is covered in an insulating material. 5

2. Gas Valve or Burner Assembly (Heating):

Gas water heaters use a flame underneath the tank to heat the water, while electric water heaters use a heating element.

3. Thermostat:

This serves as the temperature control device to determine how hot the water will get. You should be able to adjust the thermostat to meet your needs.

4. Dip Tube:

This is the tube where water enters into the tank to replenish the hot water being used. It's located at the top of the tank and goes down to the bottom where the water is then heated.

5. Shut-Off Valve:

This valve will stop water from flowing into the water heater. It's actually a separate component from the water heater and is located outside and above the unit.

6. Hot Supply:

This is located inside the tank at the top; this port allows the hot water to exit the tank and flow through your home's pipes to whatever appliance you want hot water from.

7. Drain Valve: This valve is not a part of your water heater's daily use, but was created to easily empty the tank to replace the elements and remove sediment or to move the tank to a new location. This is located near the bottom of the tank on the outside.

8. Pressure Relief Valve:

This a safety device that keeps the water pressure inside the tank within safe limits.

9. Sacrificial Anode Rod:

This rod is suspended in the water tank to help keep your tank from corroding. This acts similar to a magnet by attracting corrosive minerals in the water to the rod instead of eroding the tank.

Working of Electric Water Heater:

- ✓ A typical water heater will use a storage tank and will use electricity to heat a certain amount of water at a time.
- ✓ There's also a thermostat to monitor the temperature and a pressure relief valve to help ensure the heating process doesn't produce unsafe levels of water pressure.

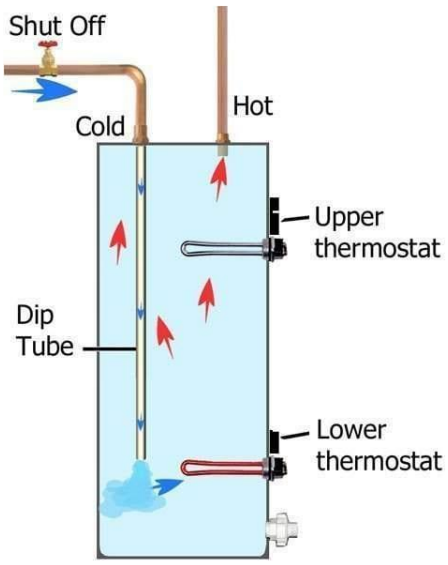


Fig (1) Working of Electric Water Heater

- ✓ Water enters the tank from the main water supply.
- ✓ The heating burner/element at the bottom of the tank starts to heat the water. As the water heats, it will rise to the top of the tank.
- ✓ When you need hot water, it's taken from the top of the tank where the hottest water is.

- ✓ For tank less water heater**,** the process is slightly different. Because there is no storage tank, there is a heating exchanger that is used to heat the water.

3.2. Microwave Oven:

Microwave ovens are one of a few electric methods of cooking. The microwave oven evolved from research on Doppler radar technology by accident when a researcher (Percy Spencer at Raytheon) found a chocolate bar in his pocket had melted when he was exposed to microwave radiation.

Parts of Microwave Oven:

1. Magnetron Assembly:

This is the component that generates the microwave energy which is in turn used to heat the food. The magnetron generates these waves using very high voltages**.**

2. Waveguide:

It is a hollow metallic tube that helps to along a certain path by making use of successive reflections within the surface of its inner walls. A microwave oven would typically use this to transmit the waves produced by the magnetron to the internal cavity where the food is placed.

3. Transformer:

Microwave ovens are high power devices. They need high voltages to work sufficiently A step-up transformer is used to transform this relatively low voltage to a high enough value for use within a microwave oven. The device needs about 4000 volts or more to generate the microwaves.

4. Cooling Fan:

As heating occurs in the microwave Oven, it is necessary to have a system in place that ensures the components do not overheat**.** For that reason, some microwave ovens come with a cooling fan. This is used to dissipate the heat generated by the microwave's components as do most electronics do.

5. The Control Panel:

This is the main component that users interact with. From here, we can set the duration, the level of intensity with which you want to cook the food, and even the operation you want to do, whether it is grilling, defrosting or microwaving a meal.

6. The Door:

Most microwaves will have a glass door that lets you see the food inside. This lets you monitor your food allowing you to choose to interrupt any process if need be. Another function of the door is to keep the microwaves inside the cavity of the device where the food is.

7. Case:

This makes up the body of the device. The case's purpose is to protect the microwave's components from damage and the elements like dust and excessive moisture.

Working of Microwave Oven:

- ✓ When we initiate a task to microwave Oven current enters the magnetron assembly and heats a filament inside it. This acts as a cathode and once heated, it releases electrons.

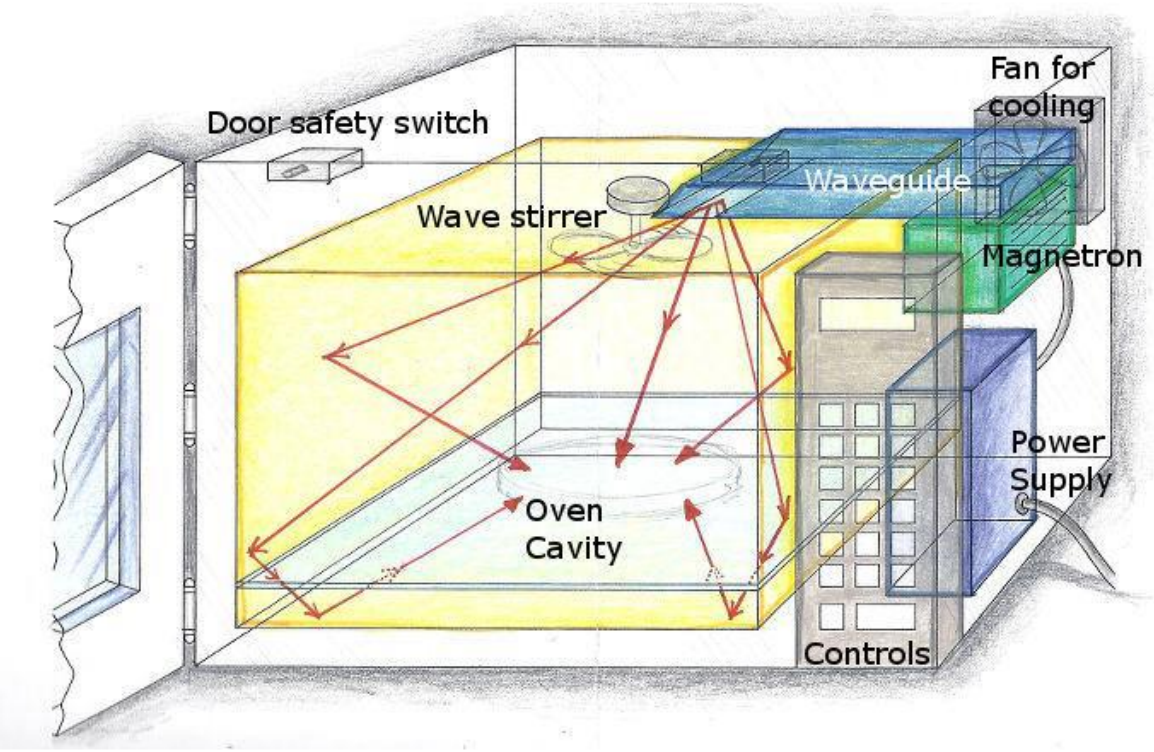


Fig (1) Structure of Microwave Oven

- ✓ These are accumulated and used to generate the microwaves which are then guided to the cavity where the food is placed.
- ✓ The waves themselves do not carry thermal energy. Unlike in non-microwave ovens where a heating element is used, microwave ovens cook food by generating the heat from within the food itself. This happens due to vibrations.

✓ The waves are absorbed by certain molecules within the food which in turn causes them to vibrate. This vibration produces kinetic energy which is then converted to heat energy and the food gets heated or cooked.

3.3. Washing Machine:

Principle:

The working principle of a washing machine is centrifugation. Centrifugation is a separation process that uses the action of centrifugal force to promote accelerated settling of particles in a solid-liquid mixture. The washing machine consists of a centrifuge for this purpose.

All washer machines work by using mechanical energy, thermal energy, and chemical action. Mechanical energy is imparted to the clothes load by the rotation of the agitator in top loaders, or by the tumbling action of the drum in front loaders. Thermal energy is supplied by the temperature of the wash bath. The spin speed in these machines can vary from 500 to 1600rpm.

The Physics behind a washing machine:

The agitation of water and detergent to remove dirt from your clothes. The machine's drum rotates, creating friction between the clothes. This friction, combined with water and detergent, works to dislodge and remove dirt.

MAJOR PARTS OF WASHING MACHINE:

Washing machine is made up of a number of components that are designed to work together and to stand up to the rigors of thousands of washing cycles. Here are the players:

Controls — The controls of your washing machine are made up of electrical switches and mechanical gears. These components send information to the motor and pump to control the wash and rinse cycles. The controls allow you to set the water temperature, rinse speed, load size, and the length of the washing cycle.

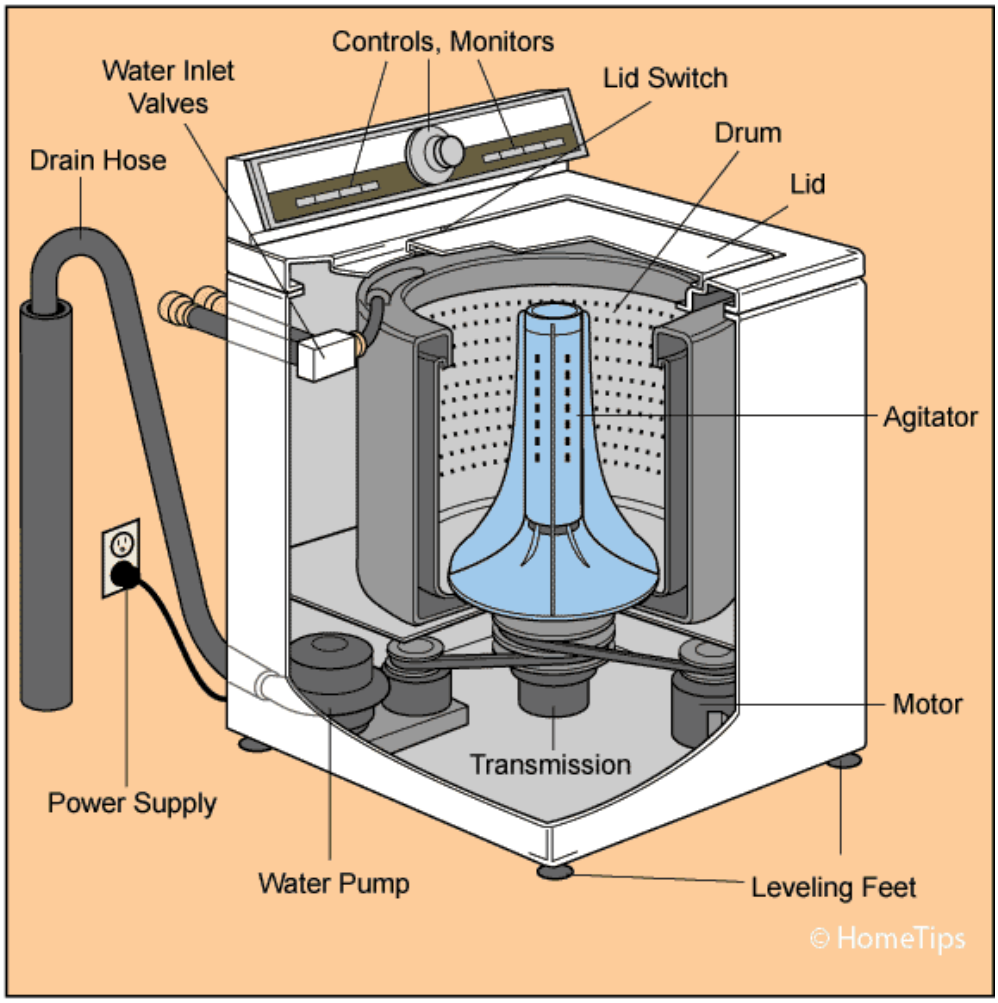
Motor — The motor of your washing machines is responsible for powering the agitator and washing tub. When agitating, the motor turns back and forth at about a three quarter rotation. While spinning, the motor turns in a singe direction at hundreds of revolutions per minute (RPMs).

Plumbing — A washing machine has a number of pluming components that handle water as it flows through the machine. Hot and cold water supply lines carry water from the house to the washing machine. These lines attached to a solenoid valve that mixes the water according to the temperature setting for the load of wash. A drain pump and hose carry dirty water away from the washing machine at the end of each cycle,

Tub — Your washing machine actually has two tubs: an outer, waterproof tub that holds the washing and rinsing water, and an inner tub that holds the clothes as they're cleaned. The inner tub is perforated with hundreds of tiny holes that allow water to escape during the spin cycle.

Agitator — This plastic cone rest in the center of the inner tub. The agitator has specially designed fins that create a current in the water when they turn. The current pulls clothes down from the surface and returns clothes from the bottom of the tub. The cycling of the clothes through soapy water creates the cleaning action of your washing machine.

Other components — Your washing machine contains other parts that protect the machine itself including shock absorbers, vibration dampers and a clutch/brake device to help the motor speed up and slow down safely.



Working Principle of a Washing Machine

The washing machine has two steel tubs. The inner tube is the one that holds the clothes. It has an agitator in the middle of it, and the sides are perforated with holes so that when the tub spins, the water can leave. The outer tub, which seals in all the water, is bolted to the body of the washer.

Superficially, washing clothes is a pretty straightforward process. Technically, this process is addressed as something called agitation. It is a process of improving the liquid's chemical or physical action by employing a forced circulatory or any other periodic motion (just like stirring). In a washing machine, agitation causes the clothes to move back and forth inside the washing drum that contains water mixed with detergent, rubbing against each other to

remove stains. This process is only efficient in cleaning the inter-yarn spaces and not the intra-yarn pores. Further cleaning is done by something called diffusion phoresis. It is the spontaneous motion of colloidal particles or molecules in a fluid induced by a concentration gradient of a different substance. The rinsing action of the washing machine clears off the dirt-containing micelles, creating a gradient of chemical concentration around the micelles that are holding on to the dirt molecules stuck inside the intra-yarn pores. Moreover, the electric field developed by incorporating the anionic surfactants also aids the removal of the dirt.

Types of Washing Machine

Depending on the position of loading the clothes in washing machine, there are two types of washing machines: top loading and front loading washing machines. Both these have been described below:

1) Top loading washing machine

In this washing machine the clothes are loaded from the top of the washing machine. There is a cover at the top that helps loading and unloading of clothes in the round vessel that perform the function of the washer as well as the rinser and drier in the fully automatic washing machine. The top loading washing machine is preferred by the people who don't want to bend the body while loading the clothes in the machine.

This washing machine is more widely used than the front loading washing machine in many parts of the world.

Top-loading washing machines are generally considered standard washing machines. The most prominent feature of these washing machines is the vertical axis washer that places the clothes in a vertically mounted perforated basket that is contained within a water-retaining tub. A finned water-pumping agitator is placed in the center of the bottom of the basket.

The laundry is loaded through the top of the machine, which is usually, but not always, covered with a hinged door. During the wash cycle, the moment of the agitator causes a circulatory motion of water, producing a centrifugal force that pushes water outward between the paddles towards the edge of the tub. The water then moves outward, up the sides of the basket, towards the center, and then down towards the agitator to repeat the process in a circulation pattern similar to the shape of a torus.

The agitator direction is periodically reversed because continuous motion in one direction would just lead to the water spinning around the basket with the agitator, rather than the water being pumped in the torus-shaped motion. Some washers supplement the water-pumping action of the agitator with a large rotating screw on the shaft above the agitator to help move water downwards in the center of the basket.

Advantages of Top-Loading Washing Machines

- The position of the loading inlet on top allows an easy operation for the user who need not bend to load the laundry.
- Some Top-Loading washing machines even allow adding additional laundry clothes after the initiation of the wash cycle.
- Top loading washing machines are usually less prone to water leakage.
- Top-loading washers require low maintenance, and may not need a regular "freshening" cycle to clean door seals and bellows.
- Top-loading washers are usually less expensive than their alternatives.

Disadvantages of Top-Loading Washing Machines

- In comparison to other types, top-loading washing machines are not considered efficient in cleaning.
- Due to the higher involvement of mechanical transmission, top-loading machines are generally noisier than other types.
- More water can remain in the wet load after the spin cycle, which may increase the drying time.

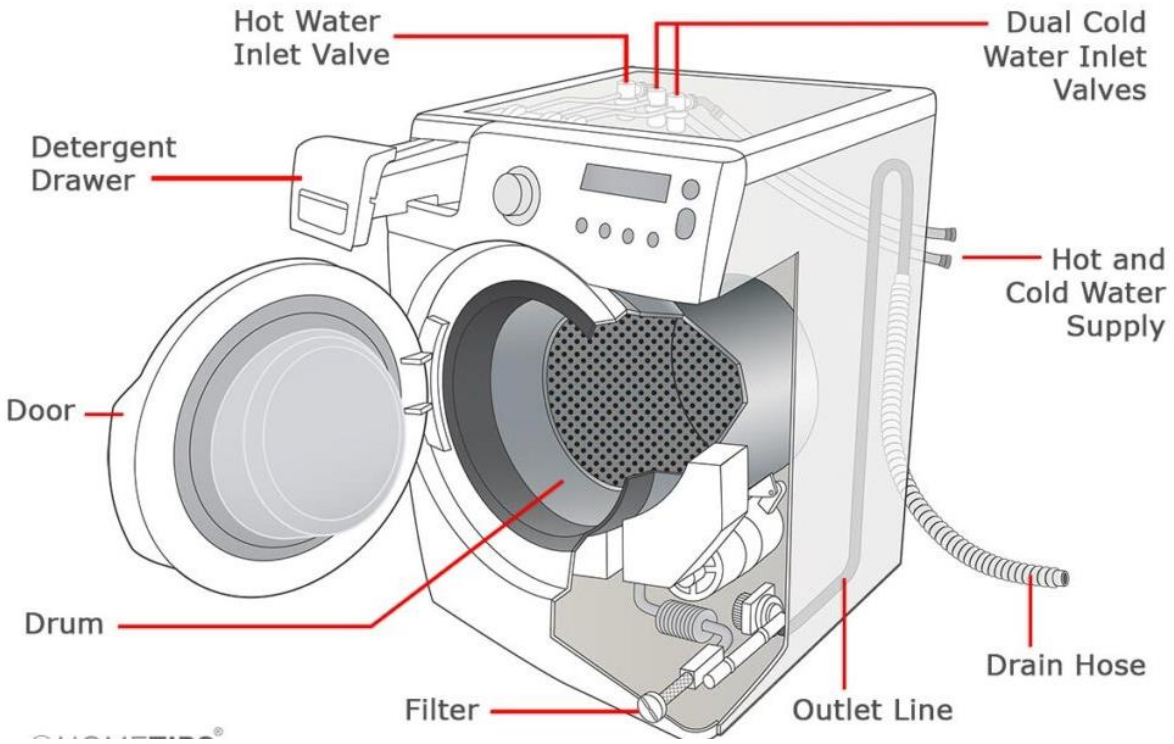
2) Front loading washing machine

In this machine the clothes are loaded from the front side. The studies have shown that the front loading washing machines consume less electric energy, water and detergent and also give better washing results compared to the top loading washing machine. Front-loading washing machines are considered more fancy and efficient than top-loading washing machines.

The general layout of a front-loading washing machine usually has a horizontal axis washing drum, and loading is done through a door present on the front side of the machine. A transparent window is frequently, but not always, present at the entrance. The cylinders back and-forth rotation as well as gravity provides agitation. The laundry is raised up, and then

it is lowered by the paddles on the inside wall of the drum. This motion flexes the fabric's weave, forcing water and detergent solution through a load of clothing. Because the wash action does not require the clothing to be freely suspended in water, only enough water is needed to moisten the fabric.

Front-loaders normally use less soap because less water is needed, and the tumbling action's repetitive falling and folding action can easily produce large quantities of foam or suds. A Front-loader washing machine makes use of water's surface tension and capillary action to regulate the water use inside the drum. A front-loader washer fills to the same low water level every time, but a large pile of dry laundry, standing in the water, absorbs moisture and causes the water level to decrease.



The washer then refills to keep the water level at the same level as before. As it takes time for this water absorption to occur with a motionless pile of fabric, nearly all front-loaders begin

the washing process by slowly plunging the laundry under the stream of water to rapidly saturate the clothes with water.

Advantages of Front-Loading Washing Machines

- The dimensions of front loading washing machines are usually smaller in comparison to the top-loading washing machines, which makes them a preferable choice when space is concerned.
- The front-loading washing machines are considered more efficient in cleaning than the top-loading washing machines.
- The front-loading washing machines use less energy since it requires less water than the other alternatives.
- The high spin speed of front loading washing machines extracts more moisture from wet loads, which means you can cut down on drying time.

Disadvantages of Front Loading Washing Machines

- With the advancement of technology and ease of access, the front-loading machines come with a higher price assigned to them.
- The washing time is usually 20-30% longer than the standard top-loading washing machines.
- Because of its design, water can get trapped inside, causing musty odors to form in the washtub and the detergent dispenser. Depending on the total automatic features available in the washing machine, the top loading washing machines are also classified as: semi-automatic washing machine and fully automatic washing machine. Let us see the details of the two:

1) Semi-automatic washing machine

This has separate tubs or vessels for the washer and the drier. There are two separate timers that enable setting washing and drying times. To wash the clothes you have to put the clothes in the wash vessel, put sufficient quantity of the water and detergent and then set the timer. After the specified time, the washing machine will stop. You can remove the clothes and dry the min the sun or you can dry them partially in the drier vessel by setting suitable time.

2) Fully automatic machine

In fully automatic washing machine there is only one tub that serves as the washer, rinser as well as the drier. Depending on the number of clothes or the weight of the clothes, the machine takes in the sufficient amount of water and detergent automatically and sets the timer for wash and drying automatically. All you have to do is just provide the water connection, put the detergent from time-to-time in its storage space and put the clothes, the fully automatic washing machine does the rest of things automatically.

Precautions while using Washing Machines

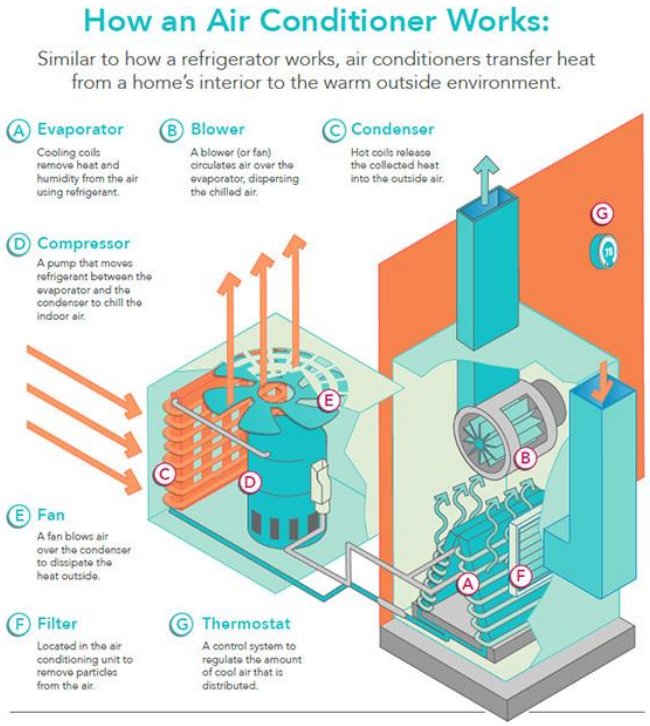
- The machine should be turned off before cleaning and maintenance.
- It is important to check the pockets of clothes before putting them into the washing drum as hard objects such as coins, safety pins, nails, screws, or stones can cause extensive damage to the machine.
- It is important to place the washing machine on a leveled surface as the turbulence caused by the high spinning motion of the drum can cause it to wobble a lot. Also, for the same reason, it is advised to place the machine a few inches away from the surrounding walls.
- Do not overload the washing drum than its specified capacity.
- It is advised to always wash clothes in small loads with less detergent. The use of excess detergent would not only damage the clothes and the water pipes, but heavy loads can cause leakage, which in turn can also cause severe damage to the motor of the washing machine.
- In a fully automatic machine, there will be an in-built dryer. It is important to remove the lint from the dryer after every cycle. The lint can clog the filter and restrict the airflow, which can lead to overheating of the dryer. This overheating can shrink delicate clothes.
- One of the most important steps is to thoroughly understand the settings and operating functions of the washing machine. The lack of proper understanding of the appliance can lead to energy and time wastage along with the damage caused to the clothes and the machine.

3.4. Air conditioner:

1. Basic Principle of Air Conditioner:

As the liquid refrigerant inside the evaporator coil converts to gas, heat is absorbed from the indoor air into the refrigerant, thus cooling the air as it passes over the coil. The indoor unit's blower fan then pumps the chilled air back through the home's ductwork out into the various living areas.

(i.e.) The basic principle of an air conditioner is a vapor compression cycle to minimize the air temperature with the help of a condenser, compressor, expansion valve, and evaporator. The complete cooling process is a heat transfer between the room air and refrigerant gas.



In its most basic description, the air conditioning process involves two actions that occur simultaneously, one inside the home and one outside the home.

1. **Inside the home** (sometimes referred to as the "cold side" of the system), warm indoor air is cooled as it blows across a cold cooling coil full of refrigerant. The refrigerant is first expanded to drop the pressure and then heat from indoor air is absorbed into the

refrigerant as the refrigerant turns from liquid to gas. The cooled air is distributed back to the house.

2. **Outside the home** (sometimes referred to as the "hot side" of the system), the refrigerant gas is compressed before entering a large coil in the outdoor unit. Heat is released outside as the refrigerant turns back to a liquid and a large fan pulls outdoor air through the outdoor coil rejecting the heat absorbed from the house.

The result is a continuous cycle of heat and humidity being removed from indoor air, cool air returning to the home, and heat and humidity exiting the home.

Working:

Air conditioners come in a variety of shapes and sizes, but they all operate on the same basic premise. An air conditioner provides cold air inside your home or enclosed space by actually removing heat and humidity from the indoor air. It returns the cooled air to the indoor space, and transfers the unwanted heat and humidity outside.

A standard air conditioning system works by using a specialized chemical called refrigerant, and has three main mechanical components: a compressor, a condenser coil and an evaporator coil. These components work together to quickly convert the refrigerant from gas to liquid and back again.

This process involves five steps:

1. The compressor raises the pressure and temperature of the refrigerant gas and sends it to the condenser coil where it is converted to a liquid.
2. Then the refrigerant travels back indoors and enters the evaporator coil. Here the liquid refrigerant evaporates, and cools the indoor coil.
3. A fan blows indoor air across the cold evaporator coil where the heat inside the home is absorbed into the refrigerant.
4. The cooled air is then circulated throughout the home while the heated evaporated gas is sent back outside to the compressor.
5. The heat is then released into the outdoor air as the refrigerant returns to a liquid state.

This cycle continues until your home has reached the desired temperature.

Maintenance:

The technician should:

- Check for correct amount of refrigerant
- Test for refrigerant leaks using a leak detector
- Capture any refrigerant that must be evacuated from the system, instead of illegally releasing it to the atmosphere
- Check for and seal duct leakage in central systems
- Measure airflow through the evaporator coil
- Verify the correct electric control sequence and make sure that the heating system and cooling system cannot operate simultaneously
- Inspect electric terminals, clean and tighten connections, and apply a non-conductive coating if necessary
- Oil motors and check belts for tightness and wear
- Check the accuracy of the thermostat.

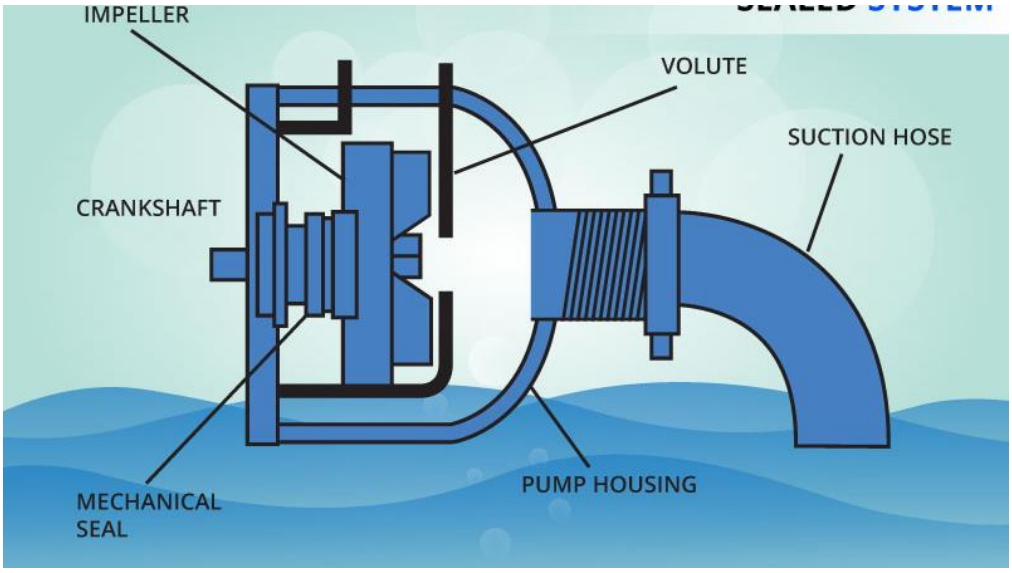
3.5. Concept of Water pumping motor:

Mechanism of water pump:

The basic mechanism of a water pressure pump primarily depends on the positive displacement principle in addition to kinetic energy to push the water. These pumps use AC or DC power to power the motor, whereas others can be powered by other types of drivers such as gasoline engines or perhaps even diesel engines.

Working principle of water pump motor:

When the water hits the rotating impeller, energy of the impeller is transferred to the water, forcing the water out (centrifugal force). The water is displaced outward, and more water can now enter the suction side of the pump to replace the displaced water.

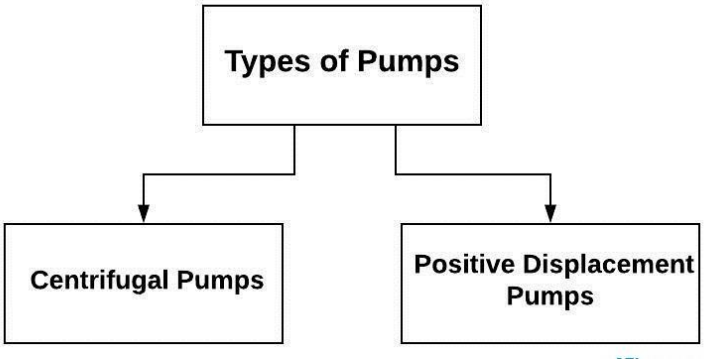


The water pump is a portable device and can be applied in several household applications. These pumps are used for pumping the huge amount of water from one place to another. The main purpose of a water pump is versatile. A quality pump which can be selected carefully may be perfect for draining water from a low flooded region, refilling the swimming pool, and bathtub, circulating pesticides otherwise fertilizers.

The collection of water pumps are very large, therefore, while selecting a strong and consistent one, one should think about the requirement.

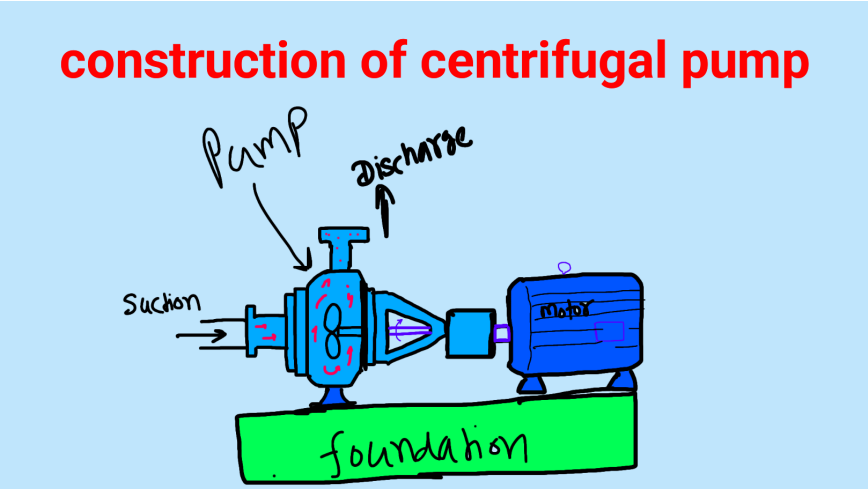
Types of Water Pumps

Water pumps are classified into two types namely positive displacement and centrifugal. These pumps are mainly designed for supplying water from one location to another constantly.



1. Centrifugal Water Pump:

Centrifugal pumps are designed with a rotating impeller which can be used for supplying the water into the pump and force the discharge flow. These pumps come in several types which includes trash, submersible, and standard models. By using these pumps, all types of liquids can be pumped with low-viscosity. And also these pumps work fine with thin fluids & gives high flow rates.



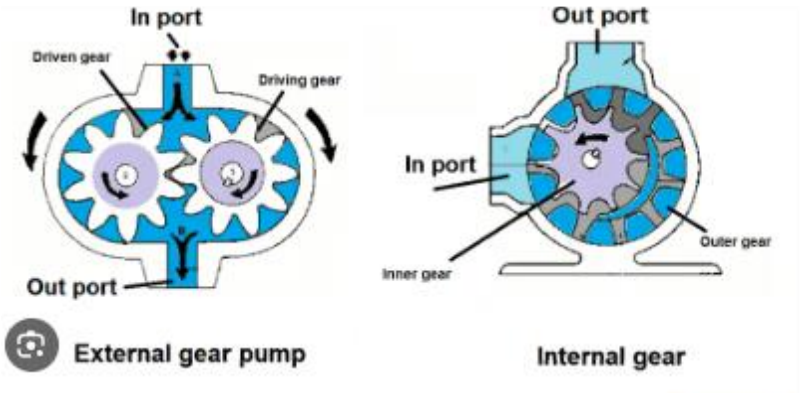
Considerations:

These pumps are applicable in several applications like building as well as the water system. These pumps are used to provide water supplies for buildings and well-matched with pneumatic systems where the no-suction lift is necessary. The main purpose of these water pumps is to pump water from wells in homes & to increase water pressure in intake lines. Centrifugal pumps offer a nonstop pressure supply for fire guard systems, and they can supply like sump pumps in horizontal otherwise vertical configurations.

Centrifugal pumps are horizontal to numerous general problems. These may require liquid circulation to stop overheating which is caused by low supplies. These types of pumps must be prepared to work properly. As a head of the positive suction system is very less while selecting the pump, it can consequence to cavitation, a situation wherever air bubbles form close to the impeller, then leads to shock signals within the water pump. At last, wear of the impeller of the pump can be degenerated by delayed solids within the fluid.

2. Positive Displacement Water Pump:

Positive displacement pumps supply a set amount of flow throughout the mechanical contraction and development of a stretchy diaphragm. These pumps are applicable in several industries that control high-viscosity fluids wherever responsive solids may be there. These are suggested for the applications wherever a combination of high pressure and low flow is required.



Considerations:

Sometimes, these pumps are also called rotary pumps, and these are very competitive because of the fact that they remove air from the lines and therefore get rid of air leakage. These are also efficient while dealing with high-viscosity fluids. The main disadvantage of these pumps is that they need extremely little clearance among the revolving pump & the external edge of the unit. Consequently, the revolution must happen at extremely slow speeds. When the water pump is functioned at high speeds, then the fluid can ultimately decrease the efficiency of the pump.

3.6. Overloading:

Electrical overloading:

An electric overload occurs when too much current passes through electric wires. The wires heat and can melt, with the risk of starting a fire.

Overloading an electric circuit occurs when more electrical devices are connected to a circuit than it can safely handle, causing the current to exceed the circuit's capacity. This can result in overheating, which may lead to electrical fires or damage to the connected devices and the circuit itself.

3.7. Short circuiting;

A short circuit occurs when an unintended connection is made between two points in an electrical circuit, bypassing the normal load. This creates a low-resistance path for electrical current to flow, resulting in excessive current flow and potentially causing damage to equipment or even starting a fire.

Causes of Short Circuits:

Overloaded Circuits

When electrical circuits are burdened with more current than their intended capacity, it can lead to overheating and ultimately short circuits.

Faulty Wiring

Wiring that is damaged, improperly installed, or suffering from deterioration can create conditions conducive to short circuits.

Equipment Failure

Appliances, electronics, or other electrical devices may experience internal faults, precipitating short circuits.

Deterioration of Electrical Cable Sheathing

Over time, the protective sheathing of electrical cables can degrade, exposing wires and increasing the risk of short circuits.

Water Contact with Wires

Moisture infiltration into electrical systems, whether due to leaks, flooding, or other sources, can compromise insulation and facilitate short circuits.

Effects of Short Circuits:

Short circuits can have serious consequences, including:

- Increased risk of electrical fires due to overheating.
- Damage to electrical equipment, potentially rendering them inoperable or unsafe to use.

Preventing Short Circuits:

To minimize the risk of short circuits, consider the following preventive measures:

Use of circuit breakers and fuses:

Both circuit breakers and fuses serve to interrupt excessive current flow and protect electrical circuits from damage.

Proper electrical installation:

Ensure that wiring, outlets, and electrical devices are installed by qualified professionals according to relevant safety codes and standards.

3.8. Ground earthing of appliances:

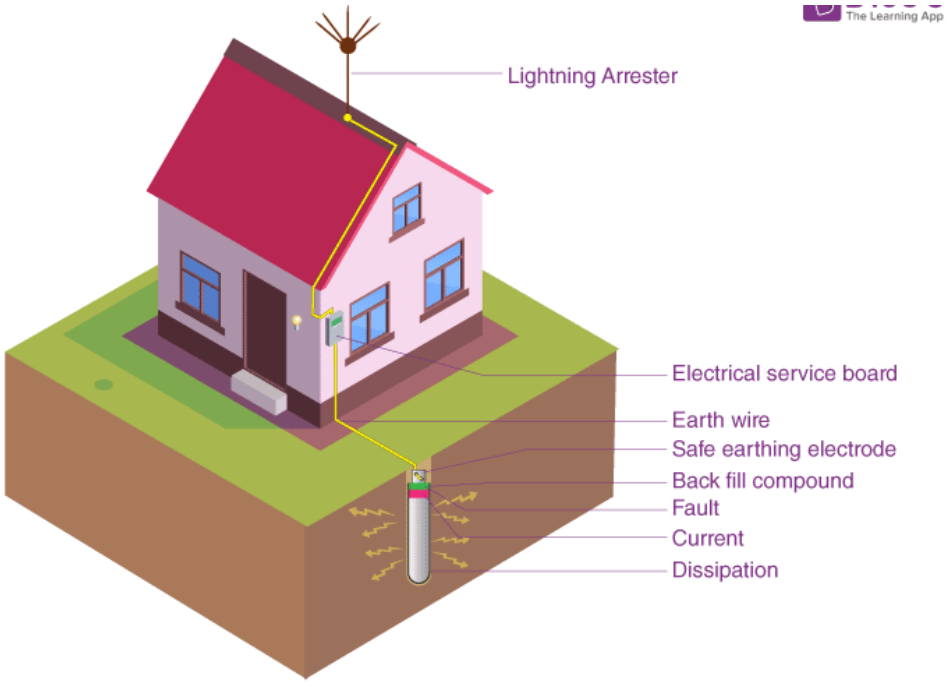
Earthing is defined as "the process in which the instantaneous discharge of the electrical energy takes place by transferring charges directly to the earth through low resistance wire."

How is Earthing Done?

To ensure safety, earthing can be done by connecting the electrical appliance to earthing systems or electrodes placed near the soil or below the ground level.

The electrode or earthing mat equipped with a flat iron riser is installed under the ground level. It helps to connect all the non-current-carrying metallic parts of the equipment.

This picture below shows the earthing system incorporated into an electrical system.



When the overload current is passed through the equipment or when the fault occurs in the system due to the current, the fault current from the equipment flows through the earthing system. The earth mat conductors aid in raising the voltage value equal to the resistance of the earth mat multiplied by a ground fault and helps guard the equipment against overload current or fault current.

In homes, there shall be three types of wires, live, neutral, and earth. Live and neutral carry electric current from the power station and the earth is connected to the buried metal plate. Electric appliances like refrigerators, iron boxes, and TV are connected to the earth wire while operating. Hence, these devices are protected from the surge or faulty electrical supply. Local earthing is done near the electrical meter of the house.

Types of Earthing:

There are three types of earthing, they are:

- Pipe earthing
- Plate earthing
- Strip earthing

Pipe earthing:

Pipe earthing is the best and most efficient way of earthing and is also easily affordable. Pipe earthing uses 38mm diameter and 2 meters length pipe vertically embedded in the ground to work as earth electrodes.

Plate earthing:

In plate earthing, an earthing plate made of copper or G.I. is buried into the ground at a depth more than 3 meters from the ground level. This earthing plate is embedded in an alternative layer of coke and salts.

Strip earthing:

Strip earthing is used in transmission processes. Strip electrodes of cross section not less than 25mm X 1.6mm of copper or 25 mm X 4mm of G.I. or steel are buried in horizontal trenches of a minimum depth of 0.5m.

Advantages of Earthing:

1. Earthing is the safe and the best method of offering safety. We know that the earth's potential is zero and is treated as Neutral. Since low equipment is connected to earth using low resistance wire, balancing is achieved.
2. Metal can be used in electrical installations without looking for its conductivity, proper earthing ensures that metal does not transfer current.
3. A sudden surge in voltage or overload does not harm the device and person if proper earthing measures are done.
4. It prevents the risk of fire hazards that could otherwise be caused by the current leakage.

Difference between earthing and grounding

Earthing VS Grounding	
Earthing	**Grounding**
This method protects human beings from electric shocks.	This method protects the entire power system from malfunctioning.
The earth wire used is green in colour.	The wire used for grounding is black in colour
Earthing is primarily used to avoid electric shocks.	Grounding is primarily used for unbalancing when the electric system overloads.
Earthing is located under the earth pit, between the equipment body and the underground pit.	It is located between the neutral of the equipment being used and the ground.

Unit –IV

Thermal electrical appliances Room heater- basics and working of electric iron & immersion rod- automatic rice cooker electric kettle toaster & hair dryer – induction cooker & stove

4.1. Electric Water Heater:

The Electric heater used to heat up water is called Electric Water Heater.

Parts of Electric Water Heater:

1. Tank:

The tank itself has a couple different layers that all serve different purposes. The inner shell is a heavy metal tank that has a protective glass liner that holds about 40-60 gallons of hot water. The exterior of the tank is covered in an insulating material.

2. Gas Valve or Burner Assembly (Heating):

Gas water heaters use a flame underneath the tank to heat the water, while electric water heaters use a heating element.

3. Thermostat:

This serves as the temperature control device to determine how hot the water will get. You should be able to adjust the thermostat to meet your needs.

4. Dip Tube:

This is the tube where water enters into the tank to replenish the hot water being used. It's located at the top of the tank and goes down to the bottom where the water is then heated.

5. Shut-Off Valve:

This valve will stop water from flowing into the water heater. It's actually a separate component from the water heater and is located outside and above the unit.

6. Hot Supply:

This is located inside the tank at the top; this port allows the hot water to exit the tank and flow through your home's pipes to whatever appliance you want hot water from.

7. Drain Valve:

This valve is not a part of your water heater's daily use, but was created to easily empty the tank to replace the elements and remove sediment or to move the tank to a new location. This is located near the bottom of the tank on the outside.

8. Pressure Relief Valve:

This a safety device that keeps the water pressure inside the tank within safe limits.

9. Sacrificial Anode Rod:

This rod is suspended in the water tank to help keep your tank from corroding. This acts similar to a magnet by attracting corrosive minerals in the water to the rod instead of eroding the tank.

Working of Electric Water Heater:

- ✓ A typical water heater will use a storage tank and will use electricity to heat a certain amount of water at a time.
- ✓ There's also a thermostat to monitor the temperature and a pressure relief valve to help ensure the heating process doesn't produce unsafe levels of water pressure.
- ✓ Water enters the tank from the main water supply.
- ✓ The heating burner/element at the bottom of the tank starts to heat the water. As the water heats, it will rise to the top of the tank.
- ✓ When you need hot water, it's taken from the top of the tank where the hottest water is.
- ✓ For tank less water heater**,** the process is slightly different. Because there is no storage tank, there is a heating exchanger that is used to heat the water.

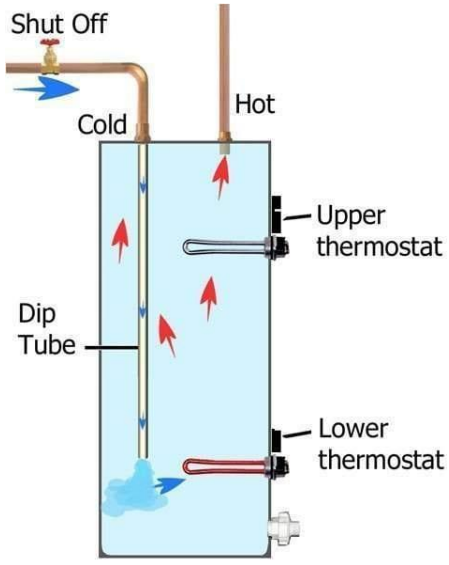
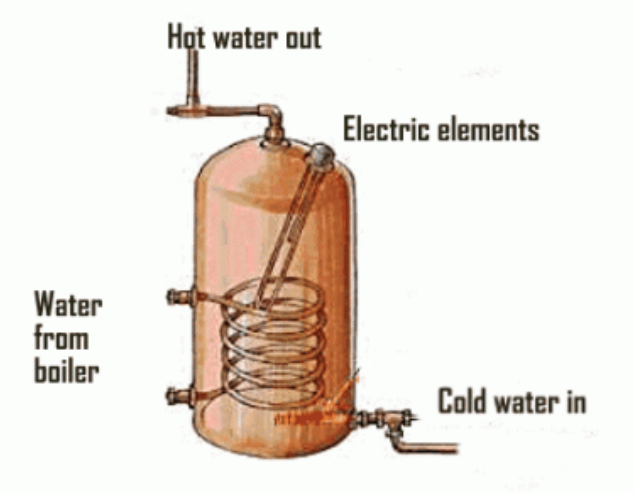


Fig (1) Working of Electric Water Heater

4.2. Immersion rod:

Immersion heaters are used to quickly and reliably heat liquids that they are immersed in either from the top of an open vessel, or through the side of the vessel into the liquid with a liquid and pressure tight fitting. Immersion heaters are available in many physical configurations, materials and temperature ranges to cover a wide range of applications in industry, science, utilities, domestic and appliances. While most immersion heaters are relatively inexpensive to purchase, they are not particularly energy efficient since they employ a direct electric heating.

Principle of Operation:



Immersion heaters are made by encasing a nichrome resistance heating wire in a ceramic jacket which is then surrounded by an Inconel sheath. Inconel is a highly corrosion- and heat resistant form of stainless steel used for the electric heating elements on electric stoves. As electricity flows through the nichrome wire, it gets hot to the point of glowing and spews heat at a high rate through the ceramic and through the Inconel, until its temperature is high. If it were not immersed, it would glow red just like stove heating elements.

Common Problems of Immersion heater and remedies:

If the water is not heating up efficiently or not heating up at all, then it could be a sign of a faulty thermostat or element. This will need to be tested by a proficient plumber or electrician. If the water is heating up to an extreme, the thermostat may be stuck on the 'on' position and will need replacing. Another common problem can be the timer switch burning out, which would also require replacement.

4.3. Automatic rice cooker:

Principle:

The bowl is filled with rice and water and heated at full power; the water reaches and stays at boiling point (100 °C, 212 °F). When the water has all been absorbed, the temperature can rise above boiling point, which trips the thermostat.

Fig. 1 Automatic rice cooker

Working Principle of a Basic Automatic Rice Cooker

The steps to cook rice in this model is simple. Put water and rice with a ratio of about 2:1 into the inner pan. Insert the pan into the main body. Put the lid on, and then plug in the cord. The main components of this basic model in Figure 2.

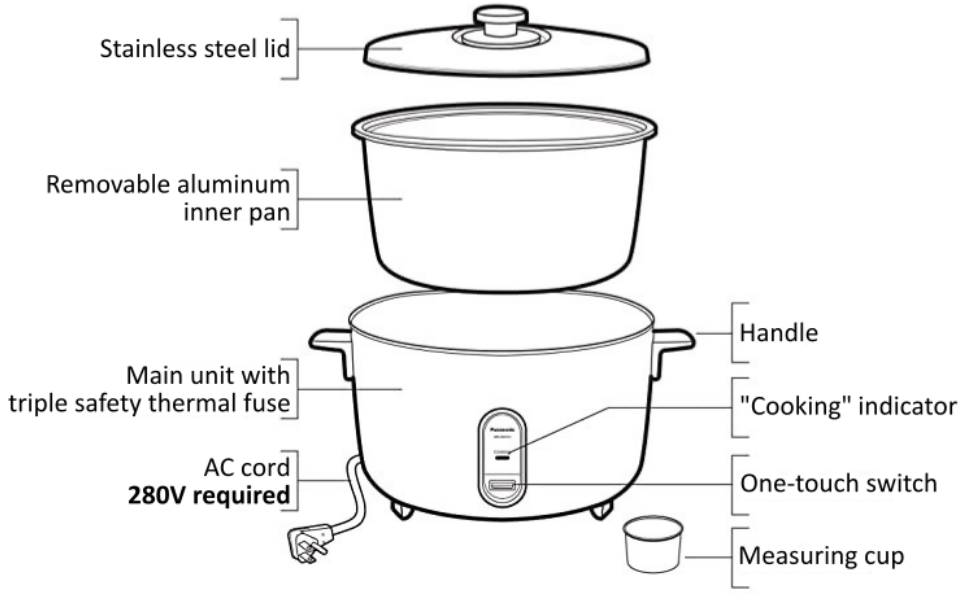


Fig. 2 Main components of a basic rice cooker

In the resting position, the one-touch switch will be on the "keep warm" position. To start the cooking process, press the switch down, and the rice will start to be cooked inside the pan.

As the heater gives heat to the water, the temperature of the water constantly rises until it reaches 100℃. Once the water reaches 100 degrees Celsius, which is the boiling point of water, the water will start to evaporate, and the hot steam will cook the rice. During the evaporation, the temperature of the remaining liquid water will stay at 100℃. At this point, the heat from the heater is used by the water molecules as the energy source to break up and change their phase from liquid to gas. The heat absorbed by the water to evaporate is called the latent heat of vaporization. Only after all the water evaporates, the temperature of the rice can increase. When the temperature of the rice reaches a certain predetermined temperature, the magnetic temperature sensor beneath the pan switches the electrical circuit to be on the "keep warm" mode, signaling that the cooking process has finished.

Working Principle of the Magnetic Center Thermostat

The magnetic center thermostat is the heart of the automatic operation of the rice cooker. It is located at the bottom and center of the rice cooker, as you can see in Figure 3. It is attached to a lever that is connected to the one-touch switch. It is also connected to the "cooking" indicator lamp through electrical wiring.

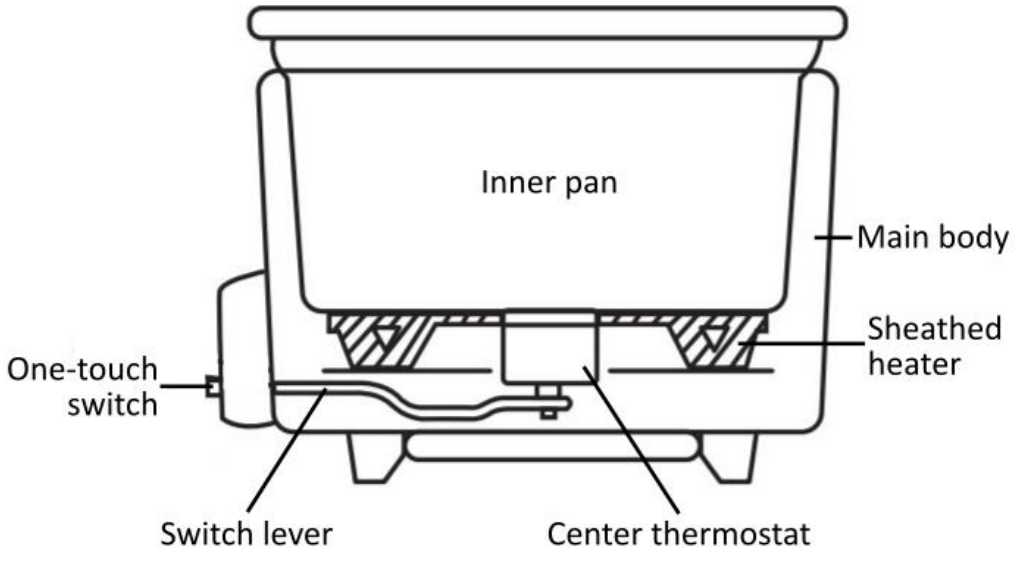


Fig. 3 The position of the magnetic center thermostat

The magnetic temperature sensor will be naturally pressed down by the weight of the inner pan that is inserted into the main body. The outer spring will be compressed; this signals that the inner pan has been properly placed, so it is safe to start the cooking process.

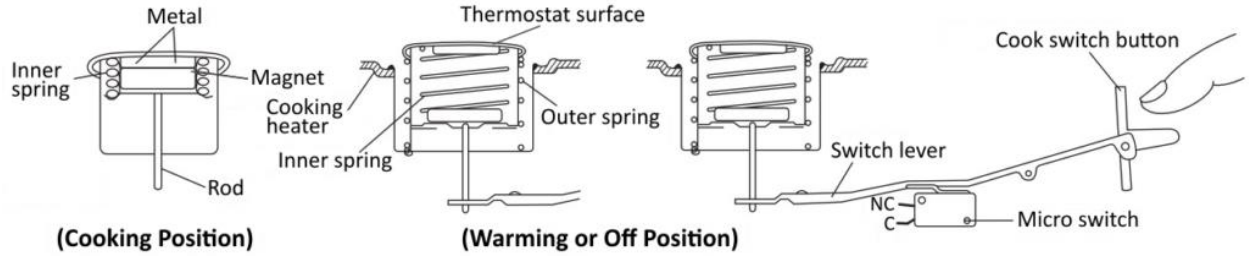


Fig. 4 Thermostat construction and positions

Figure 4 above shows the construction and positions of the magnetic center thermostat. The part that is labeled as "metal" is a soft magnetic material, e.g., the ferrite alloy. This alloy is ferromagnetic, meaning that it becomes magnetized in a magnetic field and retains its magnetism when the field is removed. However, above a certain temperature, this alloy will lose its magnetism. And the temperature above which this alloy loses its ferromagnetism and becomes a paramagnet is called the Curie temperature. The Curie temperature of this alloy should be just above 100 degrees Celsius, which is the boiling point of water. The interesting ability a ferromagnet has is it will regain its magnetism after it cools down, unlike the permanent magnet that will permanently lose its magnetism once it reaches its Curie point. The heat from the inner pan is well conducted to the ferrite alloy, so the inner pan and the ferrite alloy have more or less the same temperature all the time.

The part that is labeled as "magnet" is a permanent magnet. At a cool temperature, the ferrite alloy will be attracted to this magnet. As the temperature of the inner pan rises, the temperature of the ferrite alloy also rises. When the temperature of the ferrite alloy reaches its Curie temperature, e.g. 90-105℃, the ferrite alloy will lose its magnetism. As a result, the magnet and the ferrite alloy will be popped apart. In the Panasonic SR-GA721, the magnet and the soft magnetic metal will pop apart at the temperature of 134℃ ± 6℃.

Since the attraction between the magnet and the ferrite alloy has weakened, the force of the inner spring pulls the magnet down. As a result, the rod that is connected to the magnet

pushes the switch lever. And the switch lever presses the micro-switch button into the warming cycle.

The micro switch is also connected to the cooking indicator lamp through electrical wiring. When it is in the "cooking" cycle, the "cooking" lamp will be switched on. And when it is in the "keep warm" cycle, the lamp that is switched on is the "keep warm" lamp. And this is how the magnetic temperature sensor works on a rice cooker.

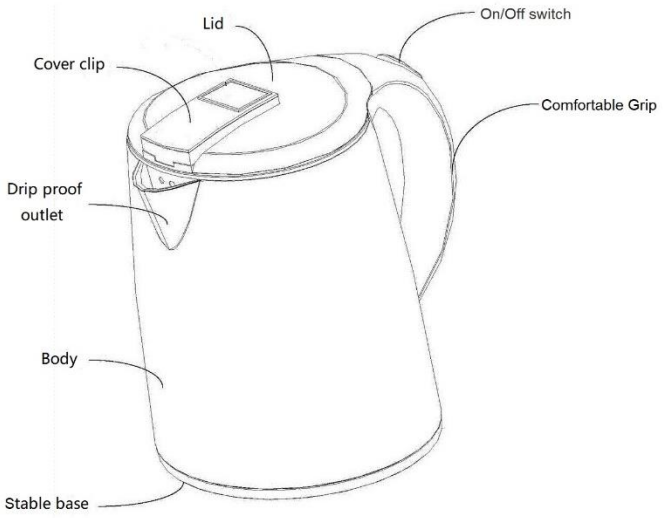
4.4. Electric Kettle:

When the kettle is turned on, a large electric current flows through the coil, or the 'heating element'. The coil has an electrical resistance (a measure of the difficulty to pass an electric current through it). This resistance turns electrical energy into heat as it passes through coil.

What energy is electric kettle?

In an electric kettle, electrical energy is transformed into thermal energy, which heats up the water. The thermal energy is transferred to the water through conduction.

Working principle of electric kettle:



About 5 minutes after the electric kettle is connected to the power supply, the water temperature gradually rises to 100 degrees, and the water starts to boil. If the steam switch fails,

the water in the pot will continue to burn until the water is boiled dry, and the temperature of the heating element will rise sharply.

There are two bimetallic plates at the bottom of the heating plate, and the temperature will rise sharply due to heat conduction, expand and deform, and break. Turn on the power. Therefore, the safety protection device of the electric kettle is designed very scientifically and reliably. This is the triple safety protection principle of the electric kettle.

Electric kettle insulation principle:

Most of the electric kettles with heat preservation function have two heating tubes, one of which is controlled separately by the heat preservation switch, which allows the user to control whether to keep heat or not. The heat preservation power is generally below 50W, and the power consumption usually does not exceed 0.1 kWh per hour.

Key components: The key component of the electric kettle is the thermostat. The quality and service life of the thermostat determine the quality and service life of the kettle. Thermostats are divided into: simple thermostat, simple + jump thermostat, waterproof, anti-dry thermostat. Consumers are advised to purchase waterproof and anti-dry thermostat electric kettles.

Other components: In addition to the key temperature controller, the composition of an electric kettle must include these basic components: the button to open the kettle, the top cover of the kettle, the power switch, the handle, the power indicator light, the heating plate, etc.

Electric kettle safety protection:

1. Automatic power off for dry burning and automatic power off for boiling water are safer;

2. Practical plastic parts should be PP food-grade materials:

3. The power cord should be high temperature resistant copper wire;

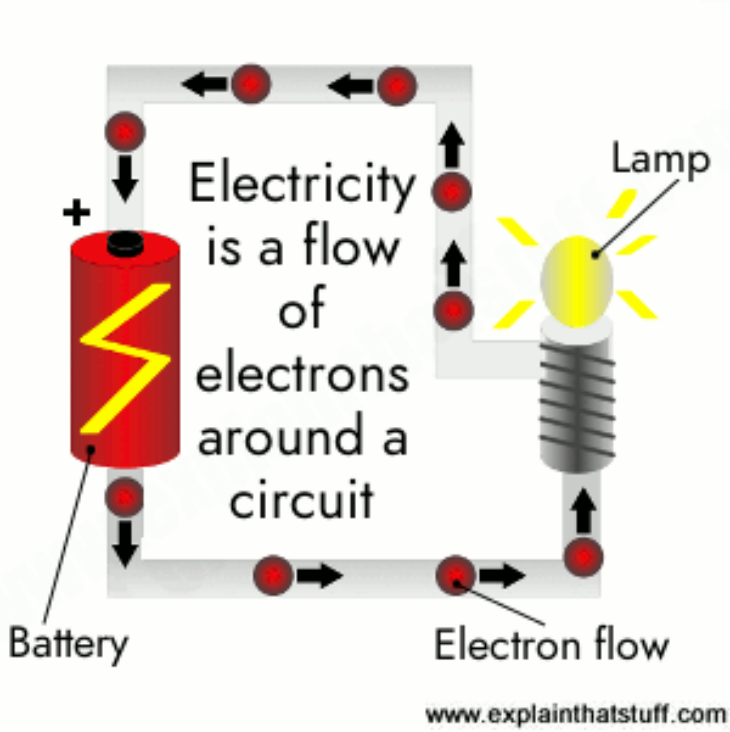
4.5. Toaster:

Basic definition:

As the electricity passes through the wire, energy is converted into heat energy, which sufficiently toasts the bread. To ensure that the bread is toasted evenly, the toaster also employs infrared radiation. It's utilized by the toaster to transfer heat energy to the bread to ensure that it's evenly toasted.

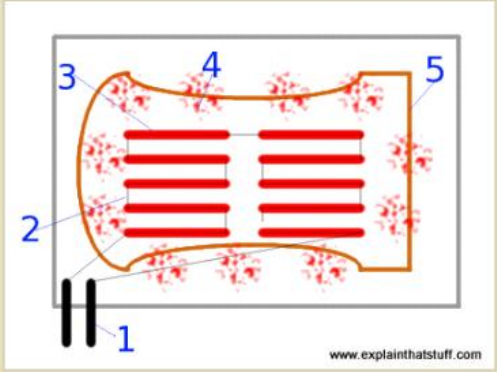
Working:

When electricity flows through a wire, energy is transmitted from one end of the wire to another. The movement of energy is a bit like water flowing down a pipe. The electrical energy is carried down the wire by electrons, the tiny particles inside the atoms of metal that make up the wire. As the electricity flows, the electrons jostle about and collide with one another, and with the atoms in the metal wire, giving off heat in the process. The thinner the wire, and the greater the electric current, the more collisions happen and the more heat is generated.



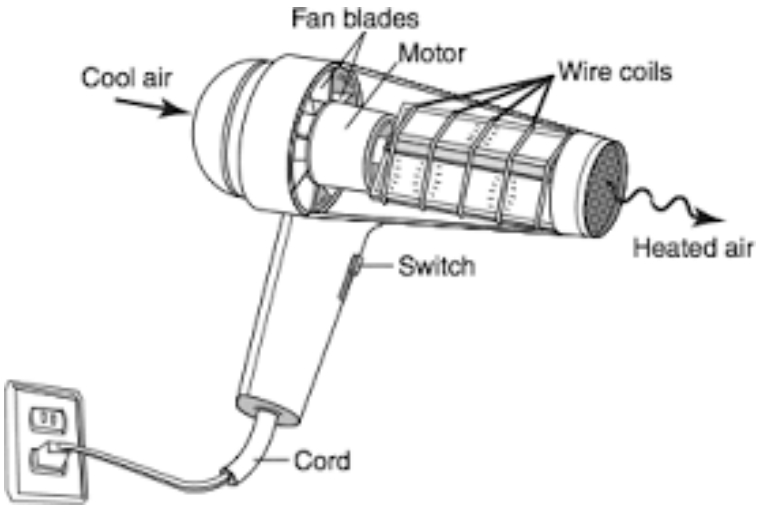
What happens inside a toaster?

1. Electrical energy flows into the toaster from a wire plugged into the domestic electricity supply.
2. The electric current flows through a series of thin filaments connected together but spaced widely enough apart to toast the whole bread surface.
3. The filaments are so thin that they glow red hot when the electricity flows through them.
4. Like a series of small radiators, the filaments beam heat toward the bread in the toaster.
5. The steady supply of heat rapidly cooks the bread. There are filaments on each wall of the toaster so the two sides of the bread cook at the same time.



4.6. Hair dryer:

The electric fan rotates and blows air across the heating element. As the air passes through the heating element, the air is warmed and heated up. The hot air exits the dryer through a nozzle, to concentrate the air flow. When it reaches wet hair, it absorbs the moisture and dries the hair.



Working Principle and Structure of Hair Dryer:

The hair dryer directly uses the motor to drive the rotor to rotate the air blade. When the air blade rotates, the air is drawn from the air inlet, and the resulting centrifugal airflow is blown out of the front mouth of the air duct. When the air passes through, if the heating wire on the heating support in the air nozzle is heated up, the hot air is blown out; if the selection switch does not power up the heating wire, the cold air is blown out. Hair dryer is used to achieve the purpose of drying and shaping.

Structure and function of hair dryer:

1. Shell:

It is the internal machine piece of protection, but also the exterior decoration piece.

2. Motor and wind blades:

The motor is installed in the housing, and the wind blade is installed on the shaft end of the motor. When the motor rotates, the air is inhaled by the air inlet and blown out by the air outlet.

3. Electric heating components:

The electric heating element of the hair dryer is made of the electric heating wire around, which is installed in the air outlet of the hair dryer. The wind discharged by the motor is heated by the electric heating wire in the air outlet, and turns into a hot wind to send it out. Some hair dryers in the electric heating element near the installed thermostat, when the temperature exceeds the predetermined temperature to cut off the circuit, play a protective role.

4. Windshield:

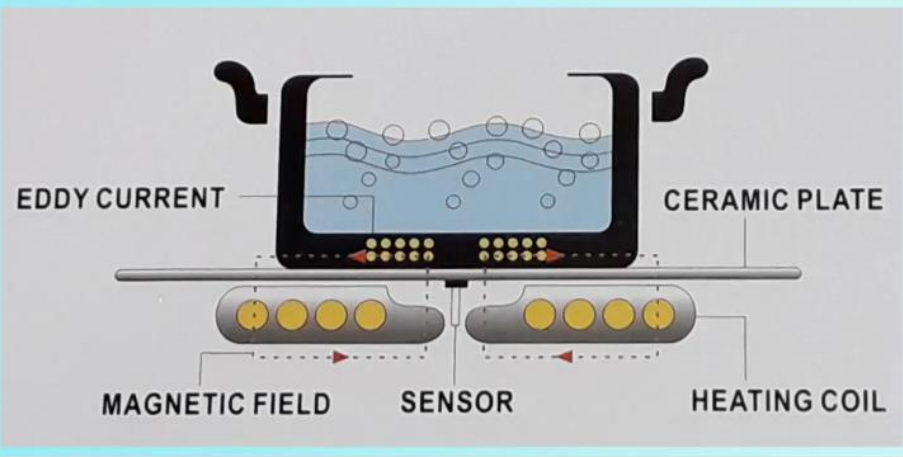
Some hair dryers have a round windshield at the air inlet to adjust the air intake.

5. Switch:

Hair dryer switch generally with white means "stop", red means "hot wind", blue means "cold wind".

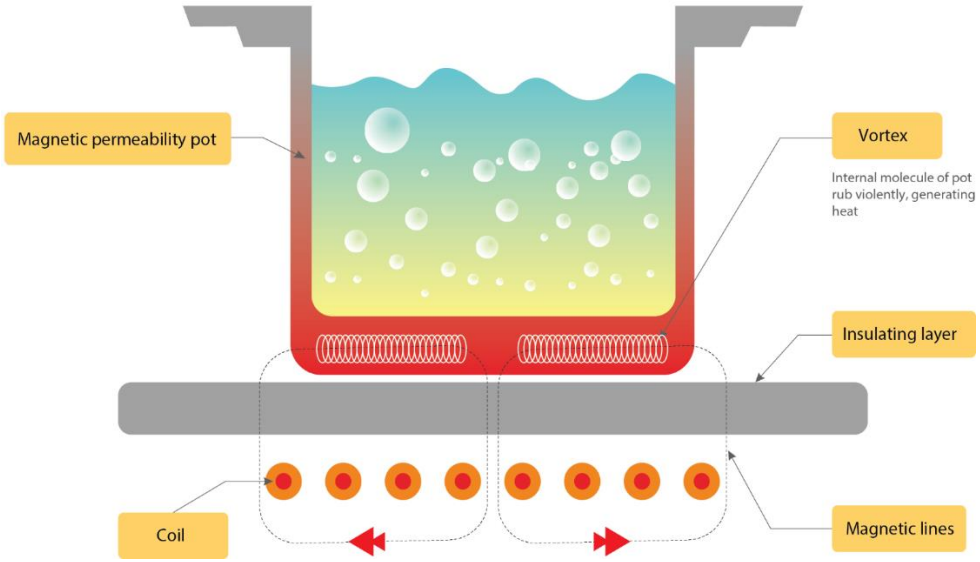
4.7. Induction cooker/Stove:

An induction cooker wirelessly transfers electrical energy by induction from a coil of wire into a metal vessel. The coil is mounted under the cooking surface, and a low radio frequency (typically ~25-50 kHz) alternating current is passed through it.

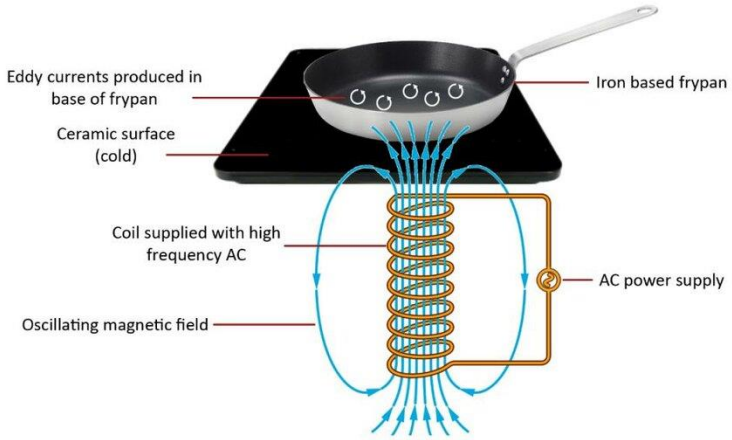


Working principle of an induction cooker:

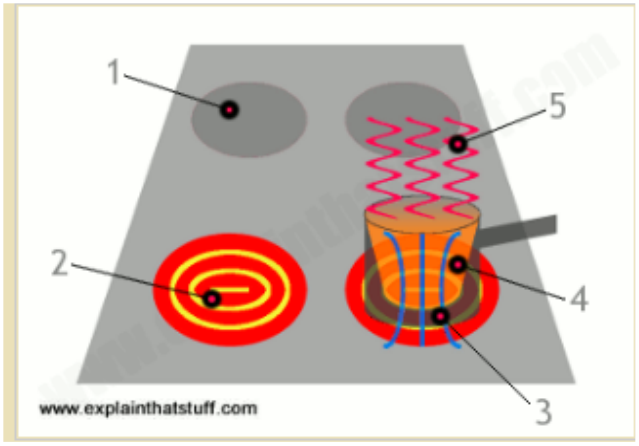
Induction cooking is a method of cooking that uses a copper coil underneath the cooking surface to generate electromagnetic energy. This energy transfers directly to your cookware to make it hot enough to cook food.



Induction Stove:



1. An induction cooker, the cooking surface is usually made from tough, heat-resistant glass-ceramic such as Schott CERAN.
2. Inside each cooking zone, there's a tightly wound coil of metal. When you turn on the power, an alternating current flows through the coil and produces an invisible, high-frequency, alternating magnetic field all around it. Unless there's a pan on the cooking zone, no heat is produced: the cooking zone remains cold. You might be wondering why we need a high frequency. Although your home power supply alternates at about 50–60Hz (50–60 times per second), an induction cooktop boosts this by about 500–1000 times (typically to 20–40 kHz). Since that's well above the range most of us can hear, it stops any annoying, audible buzzing. No less importantly, it prevents magnetic forces from shifting the pan around on the cooktop.
3. Place a pan on the cooking zone and the magnetic field produced by the coil (shown here with blue lines) penetrates the iron inside it.
4. The alternating magnetic field induces whirling electrical (eddy) currents inside the pan, turning it into a heater (shown here in orange). Magnetic hysteresis (energy loss during the repeated cycle of magnetizing and demagnetizing) also helps to heat the pan.
5. Heat from the pan flows directly into the food or water inside it (by conduction).



Advantages of induction cooking:

Energy efficiency:

Induction cooker makes pots and pans heated directly, so the energy used for cooking can be utilized at its best, turning induction stoves into one of the most energy-efficient kitchen appliances.

Rapid heating and precise control

Rather than depending on indirect conduction, induction cooker provides high power and a rapid temperature change in almost an instant. This allows you to quickly bring your cookware to the desired temperature and adjust it precisely as needed, ensuring optimal cooking results every time.

Enhanced safety and easy cleanup

With no open flames and the absence of LPG fuel, induction stoves eliminate the risks associated with gas leaks and fires, ensuring a safer cooking environment for you and your household.

Additionally, the smooth glass surface of induction cooktops is incredibly easy to clean, with minimal residue or spills. Simply wipe it down with a damp cloth after use, and your kitchen will be spotless in no time.

Smart functionality

Induction stoves feature smart working systems, including programmable timers and smartphone controls, add convenience and sophistication to cooking routines.

Smoke-free operation

Induction cooking preserves the quality of cookware and eliminates smoke production, ensuring a cleaner, healthier kitchen environment.

Disadvantages of induction cooking:

While induction cooking offers several advantages, there are a few potential drawbacks to consider:

Initial cost

Induction hobs come with a higher initial cost due to their advanced technology and safety features, though the long-term benefits often outweigh this investment.

Compatibility with cookware

Induction cooktops require specific cookware with a flat bottom and made from magnetic materials, such as cast iron, stainless steel, or certain enameled steel. If you have a collection of older cookware, you may need to invest in new pots and pans.

Learning curve

While induction cooking is generally easy to use, there may be a slight learning curve, especially if you're transitioning from gas or electric stoves. You may need to adjust your cooking techniques to take advantage of the instant heat and precise control offered by induction.

Potential noise

You may notice your induction cooker produces a humming or buzzing noise, especially at higher settings. This noise comes from the cooling fan or the vibrations in the cookware due to the electromagnetic field.

Unit –V

Relays & Switches Electrical protection – Relays – Fuses – Electrical switches- Circuit breakers – MCB – basics and working of ELCB – RCCB- ground fault protection

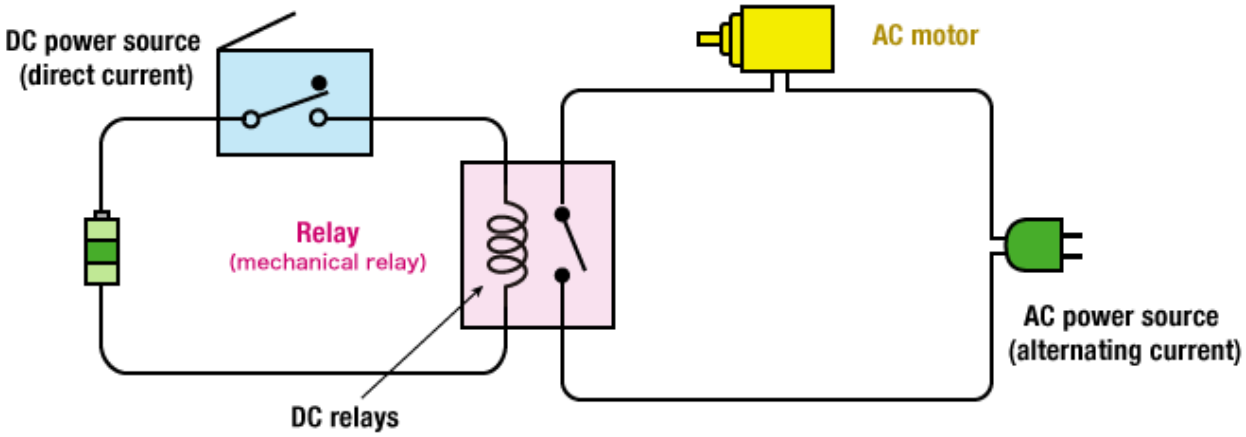
5.1. Relays & Switches Electrical protection:

Relay and Switches:

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Relay in a Circuit Diagram:

Relays are electrically operated switches that open and close the circuits by receiving electrical signals from outside sources.



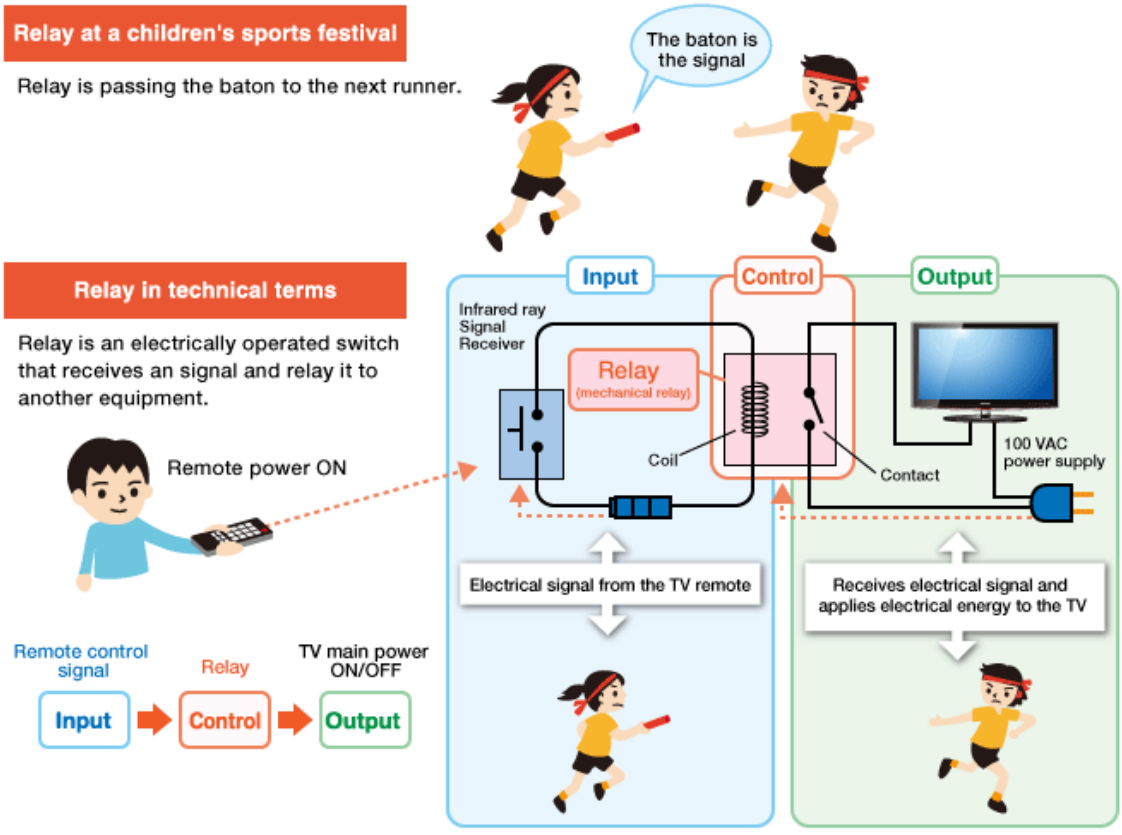
Working principle of Relay:

Relays function using electromagnetic induction. To operate the relay, the coil surrounding the relay's core is energized by electricity from the power source controlling it. As the relay is energized, it creates a magnetic field that attracts the contact and completes the circuit within the relay.

Electrical Relay Definition:

Relays are electrically operated switches that open and close the circuits by receiving electrical signals from outside sources. Some people may associate "relay" with a racing competition where members of the team take turns passing batons to complete the race. The "relays" embedded in electrical products work in a similar way; they receive an electrical signal and send the signal to other equipment by turning the switch on and off.

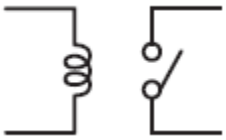
For example, when you push the button on a TV remote to watch TV, it sends an electrical signal to the "relay" inside the TV, turning the main power ON. There are various types of relays used in many applications to control different amounts of currents and number of circuits.



Electrical Relay types and Classification:

Relay technology can be divided into two main categories: Movable contacts (mechanical relay) and no movable contacts (MOS FET relay, solid state relay).

Movable contacts
(Mechanical Relay)



This type of relay has contacts that are mechanically actuated to open/close by a magnetic force to switch signals, currents and voltages ON or OFF.

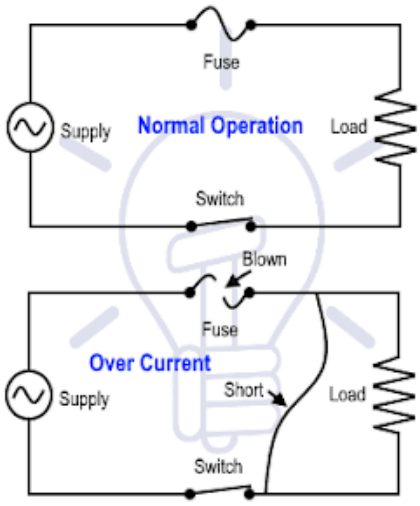
No movable contacts
(MOS FET relay, Solid State Relay)

Unlike mechanical relays, this type of relay has no moving contacts but instead employs semiconductor and electrical switching elements such as triac and MOS FET. By the operation of these electronic circuits, signals, currents and voltages are switched ON or OFF electronically.

5.2. Fuses

Working Principle of Fuse:

Electric Fuse is based on the principle of heating effect of Electric current. Heat is produced when current flows in the wire. When heat production is more due to excessive flow of current, it melts the Fuse which normally has a low melting point, thereby preventing any damage to the Electric circuit and appliances.



Working of a Fuse

Introduction

- An electrical fuse is a safety device that operates to provide protection against the overflow of current in an electrical circuit.
- An important component of an electrical fuse is a metal wire or strip that melts when excess current flows through it.
- It helps to protect the device by stopping or interrupting the current.
- In this article, let us know in detail about the Working Principle of the electrical fuse and its functions and types.

Working Principle of an Electrical Fuse

To understand the working principle behind an electrical fuse, two critical concepts should be kept in mind

1. Current flows in a loop
2. Heating effect of current

- Electric current can flow through a conductor only when the circuit formed is complete. If there is a break in the loop, electric charges cannot flow through.
- This is also how switches operate.

- For example, when you put on the light switches at home, the lights come on because you have just completed the circuit allowing charges from the power source to flow through and power your lights.
- When current passes through a conductor, the different electrical components of the circuit like the devices attached or even the wire itself, offer resistance to the current flow.
- The work done to overcome this resistance presents itself in the form of heat.
- This is a simple explanation of the "heating effect" of current.

Principle of Electrical Fuse (in detail):

- The primary use of an electric fuse is to protect electrical equipment from excessive current and to prevent short circuits or mismatched loads.
    - Electrical fuses play the role of miniature circuit breakers.
    - Apart from protecting equipment, they are also used as safety measures to prevent any safety hazards to humans.
- The fuse wire in an electrical fuse is selected in such a way that it does not face any damage when the normally stipulated amount of current flows through the circuit.
    - Under normal conditions, the fuse wire is a part of the circuitry, contributing to a complete loop for charges to flow through it.
    - However, when an excessive amount of current flows through the fuse wire, the heating effect of the current causes the fuse wire to melt.
    - This is because the fuse wire is chosen such that it has a low melting point.
    - This causes the loop to break thereby stopping the flow of charges in the circuit.
- It is important to select a fuse that is properly specified for the circuit in consideration.
    - For example, if the fuse that is used is underrated, then it will fail even under normal current conditions, unnecessarily breaking the circuit loop.
    - If it is overrated, then it will not break the circuit when required and cause equipment damage and failure and may even present itself as a safety hazard.

Will not break the circuit when required and cause equipment damage and failure and may even present itself as a safety hazard.

Function of Fuse

In the field of electrical engineering, a fuse is a device that provides overcurrent protection to the functional electrical circuit. Here, we have listed a few major functions of the fuse.

- Acts as a barrier between the electric circuit and the human body
- Prevents device failure due to faulty circuit operation
- Fuse prevents short-circuits
- Prevents overload and blackouts
- Prevents damage that is caused due to mismatched loads

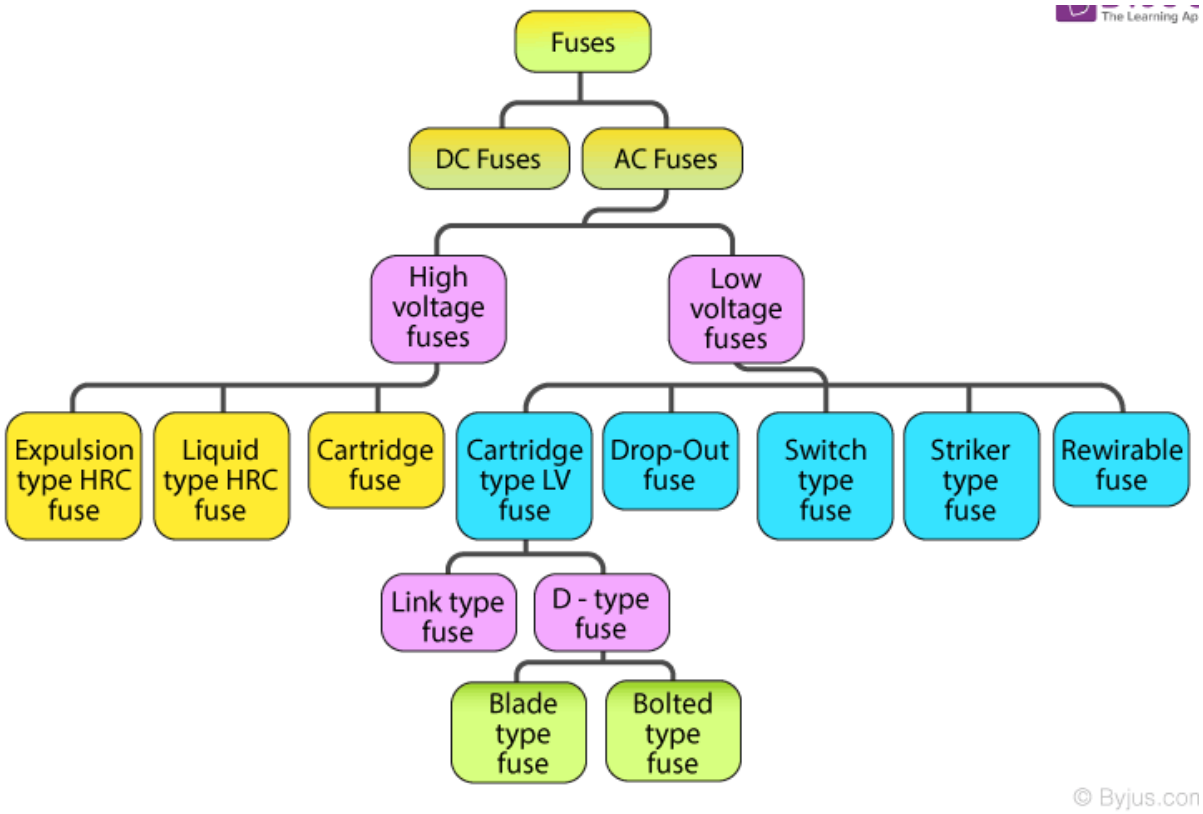
The markings on the fuse carry information such as the Ampere rating, voltage rating, and interruption rating.

Types of Fuses

Different types of fuses are available in the market, and they are classified on the basis of different aspects. But mainly, fuses can be divided into two categories based on the input supply as follows:

- AC fuses
- DC fuses

Given below is a flowchart of further classification of fuse:



Electrical Fuses Vs Circuit Breaker (5.4.);

Electrical Fuse and circuit breaker vary based on the factors like working principle, reuse, status indication, auxiliary equipment, temperature, function, protection, breaking capacity, operating time, cost, and mode of operation.

Electrical Fuse	**Circuit Breaker**
A fuse works on the electrical and thermal properties of the conducting materials.	A circuit breaker works on electromagnetic induction and switching from principle.
Fuses are not reusable	Circuit breakers are used multiple times
Fuse has no status indication and auxiliary contact	Circuit breakers provide a status indication, and auxiliary contact is available.
There is no fuse action	Circuit breakers are operated using switches

Fuses perform at 25°C and they get affected by changes in ambient temperature	Circuit breakers need warm temperatures due to the current flowing through them. But, if they become too hot, they will trip
The characteristic curve in a fuse shifts due to ageing	The characteristic curve does not shift in circuit breakers
Fuse provides detection and interruption processes	Circuit breakers only cause interruption
In a fuse, the breaking capacity is lower	The circuit breaker's breaking capacity is higher than fuse.
Single pole is available for fuse	Multiple poles are available for circuit breakers
Fuses are automatic	Circuit breakers are both manual and automatic
The operating time of the fuse is 0.002 seconds	The operating time of circuit breaker is 0.02 to 0.05 seconds

Advantages and Disadvantages of Electrical Fuse

Here are the main advantages and disadvantages of electrical fuses:

Advantages of Electrical Fuse:

- Protect circuits and wiring
- Simple and reliable
- Low cost
- Easy to replace
- Fuses come in a wide range of current and time ratings to match the requirements of different circuits

Disadvantages of Electrical Fuse:

- Manual intervention is required as there is no automatic reset.
- Components can still be damaged in the short time before the fuse interrupts excessive current

- Fuses completely interrupt power to the circuit when they blow, disrupting the operation of connected devices.
- A single fuse protects an entire circuit. If it fails for any reason, the whole circuit loses power

Uses of Electrical Fuse

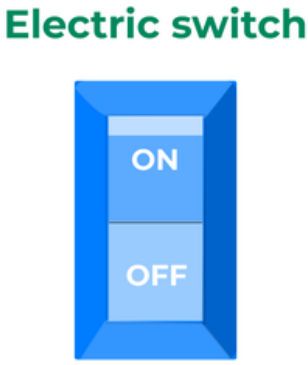
- An electrical fuse is the cheapest protection for circuits and home appliances and doesn't need maintenance.
- An electrical Fuse operation is automatic and requires less time than circuit breakers.
- The small size of the fuse offers a current limitation during shirt circuits.
- The inverse time current character of the fuse promotes its use for overload protection.
- Fuses protect the cables in low voltages, power circuits, and transformers not exceeding 200 KVA.
- Fuses are used in low and moderate-voltage appliances which do not need many operations.

5.3. Electrical Switches:

What is an Electric Switch?

An electric switch is an electromechanical device that connects or disconnects the electricity supply to a circuit. Electric switches are very important in electrical circuits because, without an electric switch, all the devices we are using are useless and cannot be operated without a switch. Electric switches can be used to connect and break the flow of connectivity in the circuit. Electronic switches can be used to perform all logical functions in the circuit. It is used to open close the circuit. So, the flow electrons totally depend on this, whether it will enable it or disable it. It does respond to the force, or we can say, external force so that electrical signal can be changes

- If the electric switch which is in the "ON" position completes the circuit and permits current to flow through.
- If the electric switch which is in the "OFF" position closes the circuit and prevents current from flowing through it.



Properties of Switches

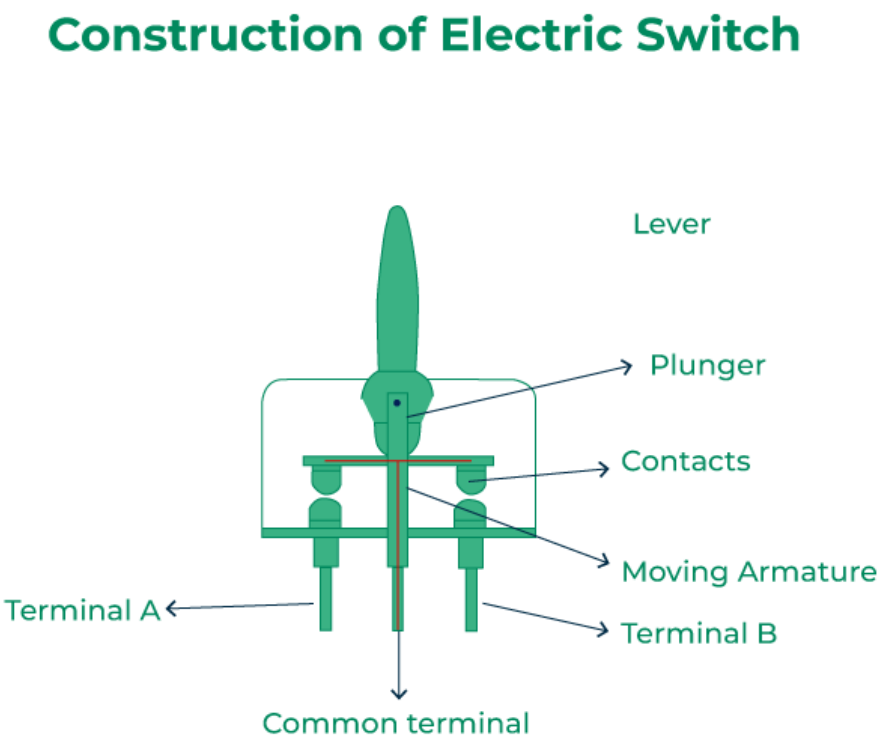
Some of the properties of switches are mentioned below:

- **Electric switch On/Off condition:** An Electric switch main property is to switch an electrical circuit from "on" to "off" condition or "off" to "on" condition.
- **Electric switch switching speed:** This property of electric switch describes how fast an electric switch may establish or break a connection. Certain electric switches are made to operate at fast speeds in electrical circuits.
- **Electric switch durability:** Electric switch durability refers to the number of cycles an electric switch can endure before malfunctioning or requiring replacement.
- **Electric switch contact resistance:** The resistance that the current encounters as it passes through the electric switch contacts is known as the contact resistance of the switch; this resistance must be as low as far as feasible to guarantee a functional circuit.
- **Actuation Force of Electric Switch:** This property of electric switch refers to the force required to physically operate a switch, for as by pressing a button or pulling a lever.
- **Environmental Protection of Electric Switch:** This property of electric switch refers to the fact that certain electrical switches are designed to withstand harsh environmental conditions, such as extreme heat or cold, moisture, and dust.

Construction of Electric Switch

The construction of electric switch consists of following components which works in its own way and these components are present internally or externally in it:

- **Actuator or Toggle:** This is the part of the switch that you physically operate to make or break the connection. It can be a lever, button, or rocker, depending on the switch type.
- **Contacts:** Contacts are conductive elements inside the electric switch which can make or break electrical connections. In an electrical switch, there are two contacts, one stationary and one movable. When the electric switch is in the "on" position, the movable contact touches the stationary contact, which allows the electric current to flow.
- **Terminals:** These are the points to which electrical wires are connected. In an SPST switch, there are two terminals, one for each contact.
- **Housing:** The switch components are enclosed in a housing made of insulating material to protect against electrical shock and environmental factors.

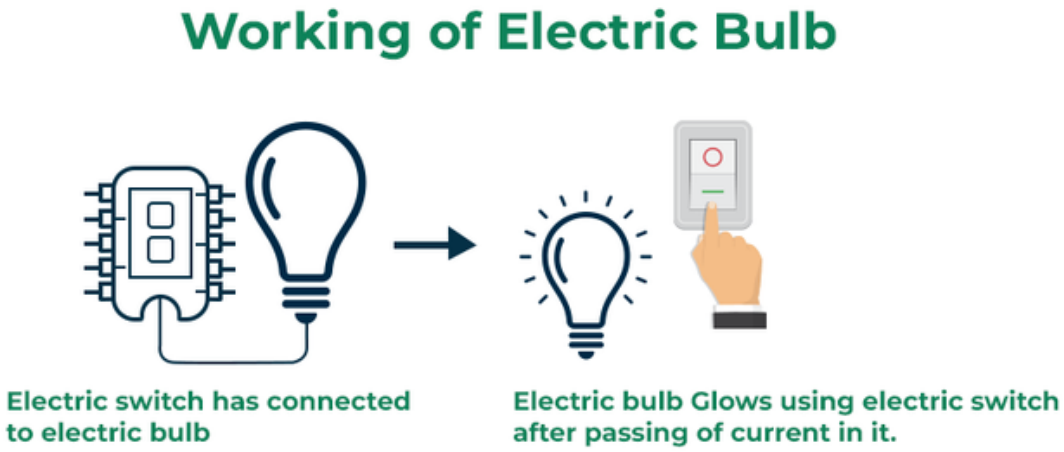


Working of an Electric Switch

A electrical switch are basically on/off toggle ones. Electric switch responds to an external force to mechanically change an electric signal. Electric switches are used to turn electric circuits ON and OFF and to switch electric circuits. The main function of an electric switch is to

regulate the current between the load and source of power. The power source is the electrons that push through the circuits. The voltage is the quantity of force or pressure applied by the power source. Electrical switches work according to a basic design. Electric switches control the amount of electricity passes on the circuit and passes the required power to electrical appliances as required.

In the below image electric switch is given connection to an electric bulb. When the electric switch is toggled "ON", the power from the source passes to electric switch then, the electric bulb glows when the electric switch is toggled "ON".



Types of Electric Switch

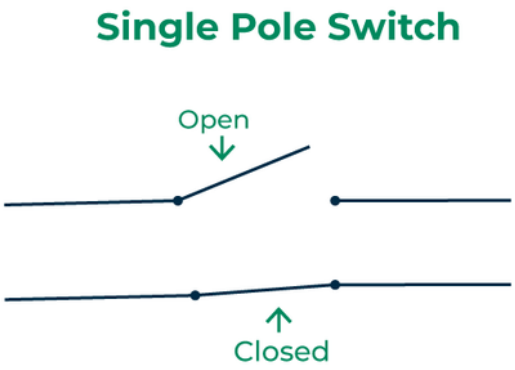
Switches are classified into different types based on the passage of electricity when required and based on the functionalities.

- Single Pole
- Double Pole
- Three Way
- Four Way
- Dimmer switch

Single Pole

- A single pole switch has one input and one output, it has two states: "on" or "off ". It controls just one circuit. A single-pole switch turns a light on and off from one location.

- Single pole switches are easy to operate.
- Single pole switches are widely in the home.
- A single pole switch is a simple switch often found in the home; they are easily wired and installed and are very common.
- Simpler single pole switches are used in situations like when on/off functionality is needed.
- Since single pole switches are more useful in daily life, they are likely to account for the majority of switches that we come into touch with.



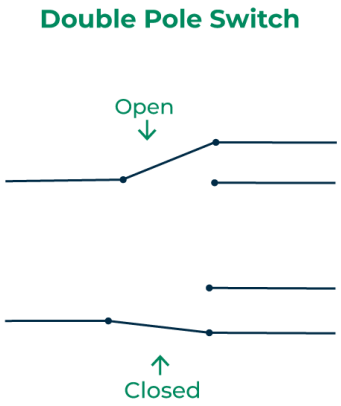
Applications of Single Pole Switches

- Used in Light switches
- Used in Alarms
- Used in Heavy duty machinery
- Used in Metal cutting and bending machines
- Used in Laser machines
- Used in Surgical equipment
- Used in Push to talk applications
- Used in household appliances

Double Pole

- Double Pole electric switches control separate circuits. A double pole switch has two connections to 2 separate circuits. They are essentially 2 switches in one.

- The connections can be staggered or connect simultaneously. These are also very easy to handle.
- A double pole switch has two connections to 2 separate circuits. They are essentially 2 switches in one. The connections can be staggered or connect simultaneously.
- For more demanding applications, double pole switches are more complex switches.
- Double pole switches are connected to two separate electric circuits. They essentially contain 2 switches which are linked together and can complete the circuit either simultaneously or staggered.
- Double pole switches are used in different types of application, they are popular in the medical industry as well as more commercial applications found in everyday life.



Applications of Double Pole Switches

- Double pole switch is used in light and fan combination
- Double pole switch is used in Motor direction reversal
- Double pole switch is used in power source selector
- Double pole switch is used in two-circuit control
- Double pole switch is used in medical industry

Three-Way

- A normal switch has two terminals that are either connected or disconnected. A three-way switch has three terminals in it. It generally consists of two brass screws.

- By using three-way switches, we can control the light from two different locations. The current supply can be controlled from two different locations by using three-way switches.
- A three-way switch has three terminals, and the switch connects the first terminal to either the second or the third terminal.
- A 3-way switch is larger than a single pole switch and has three screw terminals for wiring connections, plus a ground. Two of these take traveler wires that go from one switch to the other. For the third terminal, one switch is connected to the hot supply wire while the other switch is joined to the light.

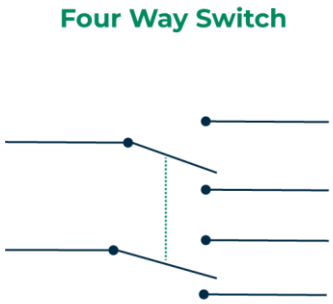
Applications of Three-Way Switches

- Three-Way Switch is used to control a lamp from three different locations.
- Three-Way Switch is used to control a light from three different locations.
- Three-Way Switch is used for switching from either of two locations.

Four Way

- Four-way switches have four terminals, two terminals are for traveler wires which are coming in, and two for traveler wires which are going out.
- The device will usually indicate which two terminals are for "incoming" and "outgoing" wires.
- By using Four-way switches we can control lighting from three or more locations. There are four terminals that provide two sets of toggle positions on a Four-way switch.
- There are four terminals that provide two sets of toggle positions on a 4-way switch. Each set of terminals is one of the toggle positions.

- When the switch is in the up position, the current can flow through two terminals. In the down position, the current flows through the other two terminals.



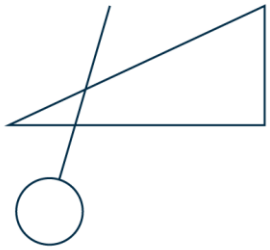
Applications of Four-Way Switches

- Four-way switch is used to control lighting from three or more locations.
- Four-way switch is used in typical applications include multi-floor stairways which are centrally illuminated.
- Four-way switch is used to control the lighting on any floor level.

Dimmer switch

- Dimmer switches simply raise or lower the brightness in electric light bulbs. They are often used in homes and businesses to conserve energy and to control the lighting environment.
- Dimmer switches can be hooked into your smart home's functions for controlling the ambiance in your home. It allows you to turn the light in several subtle shades.
- Dimmer switches simply raise or lower the brightness in electric light bulbs. They are often used in homes and businesses to conserve energy and to control the lighting environment.
- Dimmer switches can be hooked into your smart home's functions for controlling the ambiance in your home. You can automatically set the lights to dim at a certain time with timers or smart controls or adjust the light level manually.

Dimmer Switch



Applications of Dimmer Switches

- By using Dimmer Switches the light intensity can be adjusted from high to low and from low to high.
- Dimmer switches are used with halogen & incandescent lamps.
- Dimmer switches are widely used in residences and commercial buildings to regulate lights and conserve energy.
- Dimmer switches are used in LED lights and electric bulbs so that they will last longer.
- The living room, kitchen, bathroom, and bedroom are just a few of the rooms in the house where dimmer switches can be placed.

5.4. Circuit breakers:

Circuit breakers operate on the principles of thermal and magnetic protection to interrupt the flow of electricity when there's an unsafe condition:

- **Thermal protection**

A bimetallic strip heats up and bends when there's a rise in current, which trips the breaker and breaks the contact.

- **Magnetic protection**

When there's a current spike, the electromagnet becomes strong enough to move a spool, which trips the switch mechanism and breaks the circuit.

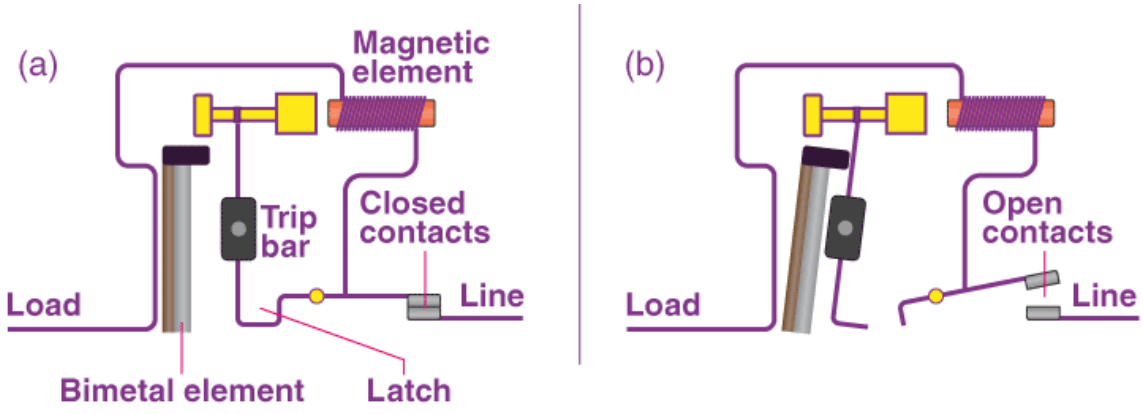
Working Principle of Circuit Breakers:

Internally, circuit breakers are basically made up of pairs of metallic contacts, both fixed and moving, in addition to an operating coil. Under normal conditions – closed circuit – these contacts are touching each other, allowing the flow of electric current.

5.5. MCB (Miniature Circuit Breaker):

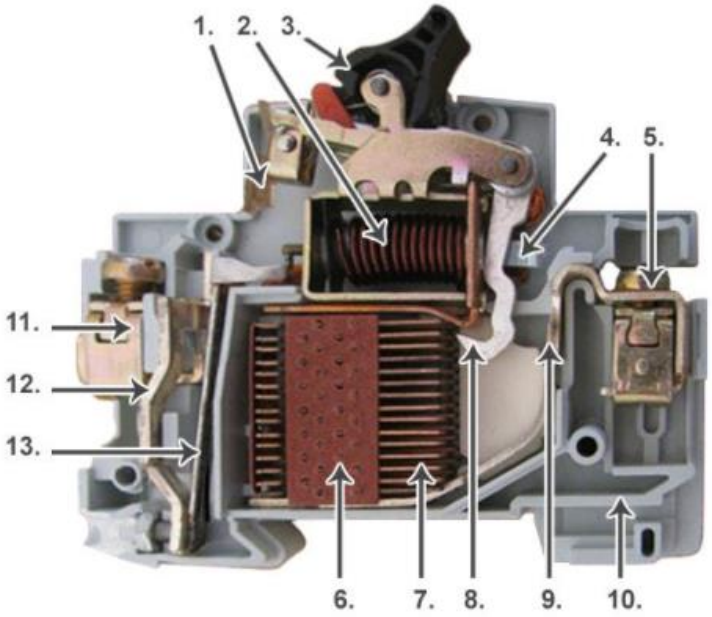
Working Principle of MCB:

When the current overflow occurs through MCB – Miniature Circuit Breaker, the bimetallic strip gets heated and deflects by bending. The deflection of the bi-metallic strip releases a latch. The latch causes the MCB to turn off by stopping the current flow in the circuit.



Working Principle of MCB

The typical working real-time MCB is shown in the picture below.



The components of the MCB are listed below:

1. Latch
2. Solenoid
3. Switch
4. Plunger
5. Incoming Terminal
6. Arc Chutes Holder
7. Arc Chutes
8. Dynamic Contact
9. Fixed Contact
10. Din Rail Holder
11. Outgoing Terminal

12. Bi-metallic Strip Carrier

13. Bi-metallic Strip

When the current overflow occurs through MCB – Miniature Circuit Breaker, the bimetallic strip gets heated and deflects by bending. The deflection of the bi-metallic strip releases a latch. The latch causes the MCB to turn off by stopping the current flow in the circuit. This process helps safeguard the appliances or devices from the hazards of overload or overcurrent. To restart the current flow, MCB must be turned ON manually.

In the case of short circuit conditions, the current rises suddenly in an unpredictable way, leading to the electromechanical displacement of the plunger associated with a solenoid. The plunger hits the trip lever, which causes the automatic release of the latch mechanism by opening the circuit breaker contacts.

An MCB is a simple, easily operable device and is maintenance-free too. MCB can be easily replaced. The trip unit is the key part of the MCB – Miniature Circuit Breaker on which the unit operates. The bi-metal present in the MCB circuit protects against overload current, and the electromagnet in the circuit protects against short-circuit current.

Types of Miniature Circuit Breaker

MCB trip curve decides the type of MCB that must be used for different appliances or devices. There are 6 types of MCBs, they are:

- A Type
- B Type
- C Type
- D Type
- K Type
- Z Type

A Type MCB trips off the circuit when the current exceeds 2-3 times the actual current rating. A type MCB – Miniature Circuit Breaker is highly sensitive to the short circuit, and hence we can find its application in the manufacturing of semiconductors.

B Type MCB trips off the circuit when the current exceeds 3-5 times the current flow and finds its application in cable protection.

C Type MCB trips off the circuit when the current exceeds 5-10 times the actual current flow and finds its application in domestic as well as commercial appliances like transformers, fluorescent lighting circuits, and IT equipment like personal computers, servers, and printers.

D Type MCB trips off the circuit when the current exceeds 10-20 times the current flow and offers high resistance. It finds its application in motors.

K Type MCB can withstand up to 8-12 times the current flow and finds its application in heavy-duty load devices like compressors, winding motors, and X-ray machines.

Uses of MCB

MCB is the key component for the safety and efficient functioning of electric machines and is used in most electrical appliances that are used for industrial or domestic purposes. In domestic usage, appliances like lights, heaters, and fans require MCB to constantly check and protect the connection.

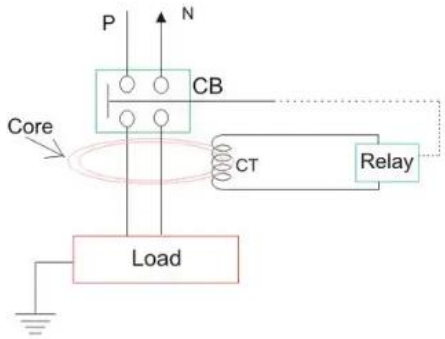
5.6. Basics and working of ELCB (Earth Leakage Circuit Breaker):

ELCB Definition:

An Earth-leakage circuit breaker (ELCB) is defined as a device that prevents electric shocks by detecting stray voltages on electrical equipment enclosures.

An Earth-leakage circuit breaker (ELCB) is a safety device used in electrical installations (both residential and commercial) with high Earth impedance to prevent electric shocks. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected.

ELCBs help detect current leaks and insulation failures in the electrical circuits that would cause electrical shocks to anyone coming into contact with the circuit.



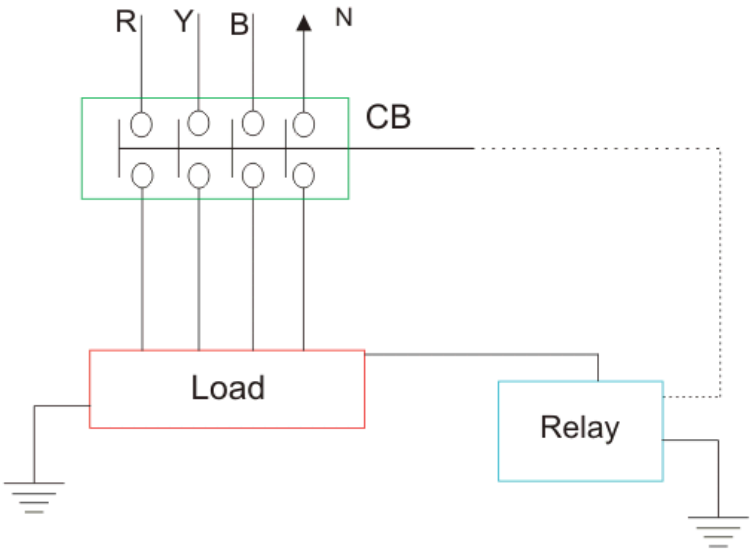
There are two types of earth leakage circuit breakers—

- a voltage ELCB and
- a current ELCB

Voltage Earth Leakage Circuit Breaker:

The working principle of a voltage ELCB is straightforward. One terminal of the relay coil connects to the equipment's metal body, while the other terminal connects directly to the earth.

If insulation fails or a live wire touches the metal body, a voltage difference appears between the coil terminal and the earth. This difference causes current to flow through the relay coil.



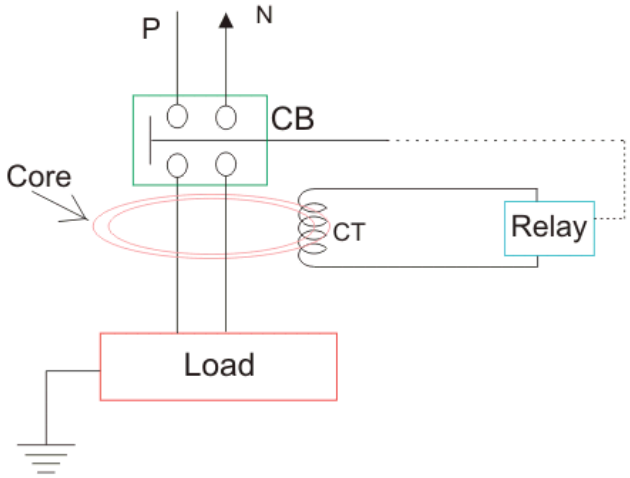
If the voltage difference crosses, a predetermined limit, the current through the relay becomes sufficient to actuate the relay for tripping the associated circuit breaker to disconnect the power supply to the equipment.

The typicality of this device is, it can detect and protect only that equipment or installation with which it is attached. It cannot detect any leakage of insulation in other parts of the system. Study our Electrical MCQs to learn more about the operation of ELCBs.

Current ELCB or Residual Current Circuit Breaker (RCCB-5.7.):

The working principle of current earth leakage circuit breaker or RCCB is also very simple as voltage operated ELCB but the theory is entirely different and residual current circuit breaker is more sensitive than ELCB.

ELCBs come in two types: voltage-based and current-based. Voltage-based ELCBs are often called simple ELCBs, while current-based ones are known as RCDs or RCCBs. In RCCBs, a current transformer (CT) core is energized by both phase and neutral wires.



Single Phase Residual Current ELCB. The polarity of the phase winding and neutral winding on the core is so chosen that, in normal condition mmf of one winding opposes that of another.

As it is assumed that, in normal operating conditions the current goes through the phase wire will be returned via neutral wire if there's no leakage in between.

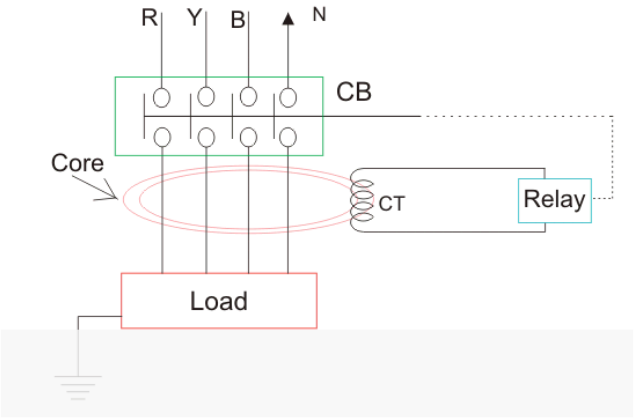
As both currents are same, the resultant mmf produced by these two currents is also zero-ideally.

The relay coil is connected with another third winding wound on the CT core as secondary. The terminals of this winding are connected to a relay system.

In normal operating condition there would not be any current circulating in the third winding as here is no flux in the core due to equal phase and neutral current.

When an earth leakage occurs, some of the phase current may pass to the earth through the leakage path instead of returning via the neutral wire.

Hence the magnitude of the neutral current passing through the RCCB is not equal to phase current passing through it.



When the imbalance exceeds a set value, the current in the third winding becomes high enough to activate the electromagnetic relay.

This relay causes tripping of the associated circuit breaker to disconnect the power supply to the equipment under protection.

Residual current circuit breaker is sometimes also referred as residual current device (RCD) when we consider the device by disassociating the circuit breaker attached to RCCB. That means, the entire parts of RCCB except circuit breaker are referred as RCD.

5.7. RCCB:

Principle of RCCB

RCCB works on the principle of Kirchhoff's law, which states that the incoming current must be equal to the outgoing current in a circuit. RCCB thus compares the difference in current values between live and neutral wires.

Difference between ELCB and RCCB:

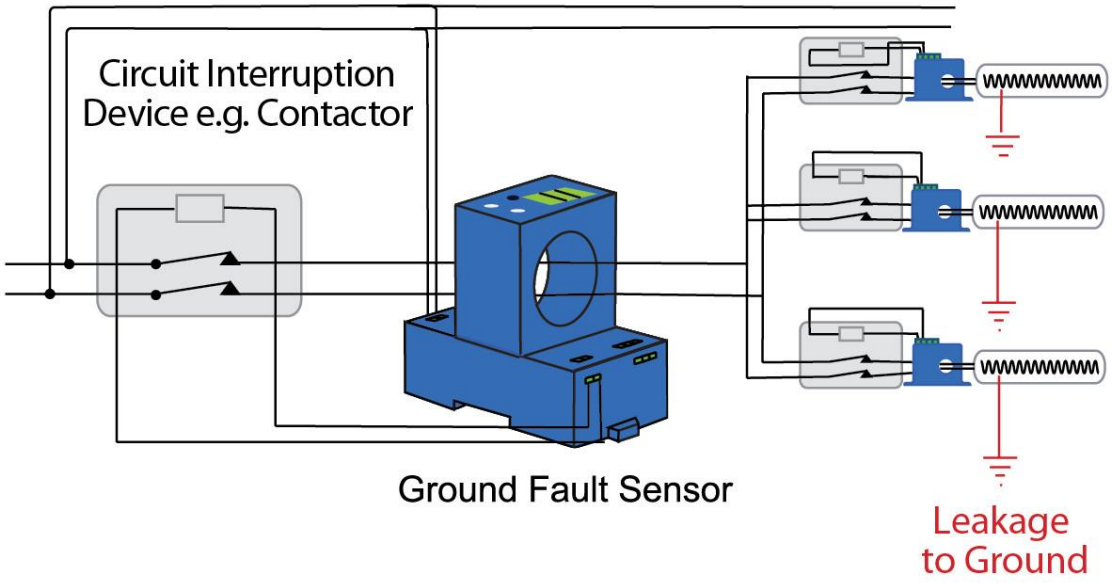
Both RCCB and ELCB are the protecting devices. However, there are several **differences between ELCB and RCCB** that the following table highlights-

Basis of Difference	ELCB	RCCB
Full Form	ELCB stands for Earth Leakage Circuit Breaker.	RCCB stands for Residual Current Circuit Breaker.
Definition	A safety device that is used in the electrical installation with high earth impedance to prevent the electric shock is called earth leakage circuit breaker (ELCB).	A safety device used in electrical installation that trips the circuit against the electrical leakage currents to ensure the protection from electric shocks due to indirect contacts is called residual current circuit breaker (RCCB).
Type of device	ELCB is a voltage operated device.	RCCB is a current operated device.
Connection	ELCB is connected to phase, neutral and earth wires.	RCCB is connected to phase and neutral wires only.
Fault detection	ELCB detects only those electrical faults in which the earth leakage current flows through the main earth wire.	RCCB can detect any kind earth faults.
Working principle	The working principle of an ELCB is based on the earth	The working of an RCCB is based on the principle of core balancing current transformer (CBCT).

	leakage current flowing through the main earth wire.	
Monitoring of earthing status	ELCB monitors the earthing status of the system. It ensures that the system is perfectly connected to the earth.	RCCB does not monitor the earthing status of the electrical system.
Need of earth connection	ELCB requires an earth connection to function.	In case of RCCB, there is no need of an earth connection to function.
Nuisance tripping	The nuisance tripping is the beak in the power supply without the situation being really hazardous. In ELCB, the nuisance tripping is less.	The nuisance tripping in an RCCB is high.
Cost	The cost of ELCB is more.	RCCB is comparatively less expensive.
Applications	ELCB is an old safety device used in electrical installations to, protect from electric shocks.	RCCB is a new technology used in almost all wiring systems to provide protection against earth leakage currents.

5.8. Ground fault protection:

Ground fault protection is a safety feature that detects electrical faults that occur when current leaks from an electrical circuit to the ground. This can happen due to damaged insulation, faulty wiring, or equipment malfunctions


Circuit Interruption
Device e.g. Contactor
Ground Fault Sensor
Leakage
to Ground