

HOME ELECTRICAL INSTALLATION

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ABOUT MKJC

Marudhar Kesari Jain College for Women (Autonomous), Vaniyambadi, was established in 1994. It is recognized under Sec. 2(f) & 12(B) of the UGC Act 1956, approved by the Government of Tamil Nadu. The college has been affiliated to Thiruvalluvar University, Vellore. In November 2023, the college attained autonomous status. The college was accredited with an “A+” grade by NAAC, Bengaluru, in its 4th cycle in 2024 and is certified as an ISO 21001:2018 (EOMS) institution by BSI.

Located on a sprawling 25-acre campus along the Vaniyambadi-Tirupattur Highway, the college is surrounded by the scenic beauty of the Yelagiri Hills, providing an ideal environment for teaching and learning. With a focus on the empowerment of rural women, Marudhar Kesari Jain College strives to provide a high-quality, experiential education that equips women to become self-reliant and independent.

The college offers a diverse range of academic programs, including 20 undergraduate, 15 postgraduate, and 10 Ph.D. programs. It serves 3,051 students with the support of 195 teaching staff, 161 non-teaching staff, and 12 sports coaches and martial arts trainers. MKJC prides itself on delivering a holistic education that balances academic excellence with industry-relevant skills, preparing students for leadership, innovation, and entrepreneurship.

Committed to continuous growth, the college boasts a team of highly qualified teachers who regularly upgrade their skills to enhance teaching, research, and outreach initiatives. Guided by a code of professional ethics, all stakeholders of the institution work together to fulfill its vision and mission, focusing on quality education and sustainable practices.

With over 30 years of service, Marudhar Kesari Jain College for Women has become a beacon of educational excellence in the region, earning numerous accolades and making a significant impact on the lives of rural women. The college remains dedicated to surpassing educational standards and adapting to the evolving needs of society.



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ABOUT THIS BOOK

Home electrical installation refers to the process of setting up and wiring the electrical system in a house, which includes the distribution of electricity to various electrical outlets, switches, light fixtures, and appliances. This installation needs to be done properly and safely to ensure that the home's electrical system functions efficiently and doesn't pose any safety hazards. This basic content structure provides a solid foundation for a practical guide on home electrical installation. Each chapter can be expanded with diagrams, step-by-step instructions, and safety tips to make it both informative and accessible to a wide audience.

Books about home electrical installation can be useful for people who want to learn how to work with electrical wiring, or to perform electrical repairs and installations themselves. It can help you learn how to work with electrical wiring, and how to repair, replace, and install electrical system elements.

A proper electrical installation is critical for the safety and functionality of your home. Whether building a new home or upgrading an existing system, always ensure that the installation is done according to code and by a licensed professional. Regular maintenance, such as checking circuit breakers, inspecting outlets, and replacing old or worn wiring, can help prevent common issues and keep your electrical system running smoothly for years to come.

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1.1 CHARGE

One characteristic of matter is electric charge. Electric charge comes in two varieties, which are commonly referred to as positive and negative. The same charge causes two objects to exert repulsive forces on one another. Attractive forces are exerted by two objects with opposing charges.

Electric charge is represented by the symbol Q and is measured in coulombs(C). Since electric charge is quantized, an object's charge can only be an integer multiple of a specific value. The least possible value for the magnitude of charge that an object can possess is equivalent to the magnitude of charge of an electron, which is roughly 1.60×10^{-19} C. The charge of electrons is negative. A neutral thing becomes increasingly positively charged when it loses electrons. A neutral object becomes more negatively charged if it acquires electrons.

1.2 CURRENT

The rate at which charge flows is called current. One coulomb of charge passes a location in a circuit every second when the current is 1 A. ($1 \text{ A} = 1 \text{ C s}^{-1}$). An ammeter is used to measure current in a circuit by placing it in series with the circuit's relevant component.

$$I = \frac{\Delta Q}{\Delta t}$$

I stand for current in amperes (A), ΔQ for charge in coulombs (C), and Δt for time in seconds (S).

1.3 POTENTIAL DIFFERENCE

Potential difference is the work done per unit charge. The work done per unit fee is one possible difference. One joule of work is performed for every coulomb of charge when the potential difference is one V. ($1 \text{ V} = 1 \text{ J C}^{-1}$) A voltmeter is used to measure the potential difference in a circuit by connecting it in parallel with the component of interest.

$$V = \frac{W}{Q}$$

W is the work or energy transferred in joules, J is the charge in coulombs, C is the potential difference in volts, and V is the potential difference in volts.

1.4 RESISTANCE

In certain material, it is the opposing force that the flowing electrons experience. This prevents electricity from flowing through a substance. A substance is considered to have one Ohm of resistance when a current of one ampere passes through it and there is a one volt potential difference across it.

The ratio of the potential difference across a component to the current passing through it is called resistance (R), and it is expressed in ohms (Ω).

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

V stands for potential difference in volts, V I for current in amps, R for resistance in ohms, and A

SYMBOLS

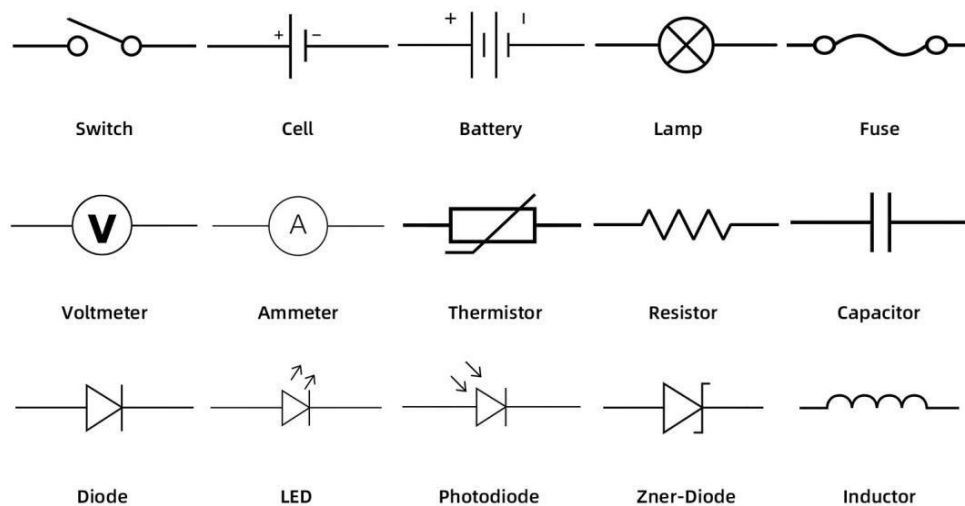


Fig.1.1 Types of Symbols

SIMPLE ELECTRICAL CIRCUITS

The electrical circuits are closed-loop or routes that allow electrons to travel across a network of electrical components. This road is powered by a source, such as a battery, and is constructed using electrical lines. The point at which electrons begin to flow is known as the source, and the point at which they exit the electrical circuit is known as the return. Let's do a little experiment; you'll need the following:

- Electric bulb
- Wire
- Electrical tape
- A battery

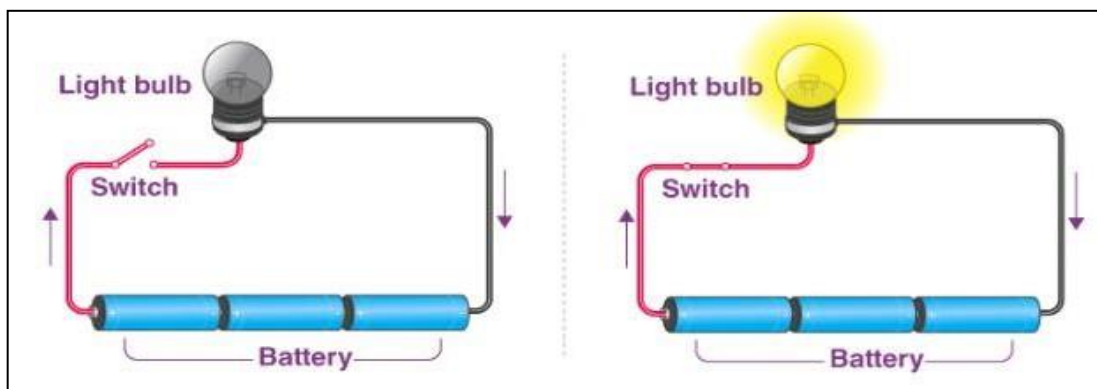


Fig.1.2 Simple electrical circuits

Attach one end of the wire to the battery and the other end to the light bulb. Observe what happens: the bulb won't change at all, but as soon as you connect the free wire to the battery and finish the circuit, you'll see that the bulb begins to glow. For the current to flow, the circuit must be finished.

Only when there is at least one closed loop from the positive to the negative end is an electrical circuit considered complete. The most basic type of electric circuit is this one. A television's circuit is more intricate and made up of various parts.

1.6 Ohm's Law

Ohm combined the elements of voltage, current, and resistance to construct the following formula:

V is an abbreviation for voltage in volts.

I stands for current in amps.

The resistance, expressed in ohms, is R.

Ohm's Law Explanation

Ohm's law states that the voltage across a conductor is directly proportional to the current passing through it, provided that the temperature and all other physical parameters remain constant. The mathematical expression for this current-voltage relationship is

$$V=IR$$

In the equation, the symbol Ω stands for units of ohms, and the constant of proportionality, R, denotes resistance. To obtain the current and resistance, respectively, the same formula can be expressed as follows:

$$I= V/R$$

$$R=V/I$$

1.7 AMMETER

A tool for measuring the current flowing through an electric circuit is called an ammeter. Both direct current and alternating current can be measured using the instrument. The current is measured by the device in amperes.

Symbol



The ammeter is represented by the symbol A.

Parts of an Ammeter

As seen in the above illustration, an ammeter is made up of various elements. An ammeter's general construction consists of

U-shaped magnet: An ammeter's main component is the magnet. It is made up of concave poles.

Copper coil: Usually rectangular in shape, the copper coil is twisted around a metallic core.

Iron Core: A soft iron core is encircled by the copper coil. The soft iron cylindrical core keeps the field lines parallel while increasing the magnetic field between the poles. A low-value resistance that is connected parallel to the galvanometer is called a shunt.

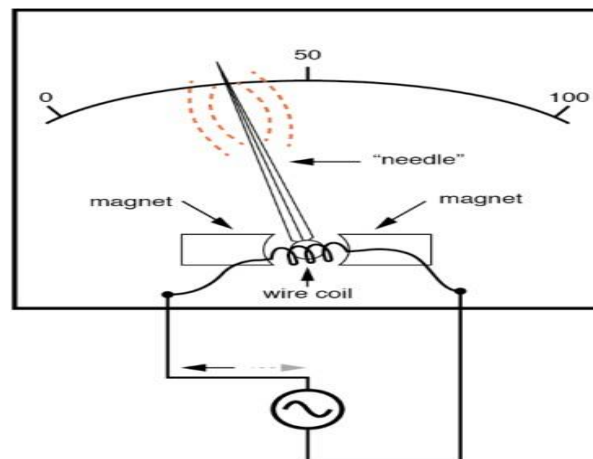


Fig.1.3 Ammeter

Working of Ammeter

The current passing through an ammeter is identical to the current passing through the circuit when it is connected in series with the circuit. This current causes the magnetic coil of the ammeter to deflect, which shifts the point across the graduated scale. As a result, the load current is measured.

In order to improve the range of current measurement, a galvanometer can alternatively be converted into an ammeter by connecting an a shunt resistance parallel to the galvanometer.

Classification of Ammeter

According to the current passed, it is divided into:

- a) AC Ammeter
- b) DC Ammeter

The rate at which electric charge flows is called current. Direct current (DC) is the current that results when this electric charge solely moves in one direction. Direct

current is measured with a device called a DC ammeter. If we place the resistor in parallel with the Permanent Magnet Moving Coil (PMMC) galvanometer, the entire set works as a DC ammeter. The parallel resistance seen in DC ammeters is also known as shunt resistance, or simply shunt. A moderate resistance is necessary to measure a DC current of significant significance.

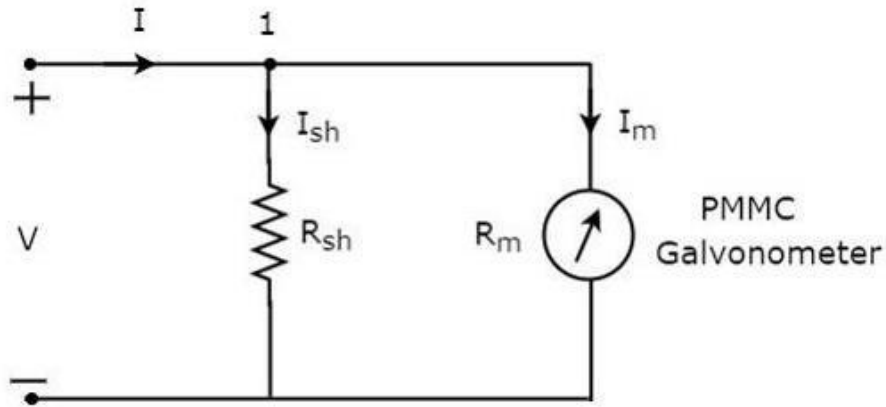


Fig. 1.4 DC ammeter

This DC ammeter needs to be connected in series with the electric circuit branch where the DC current is to be measured. The voltage across the parallel-connected elements is the same. The voltage across the galvanometer resistance, R_m , and the voltage across the shunt resistor, R_{sh} , are equal since those two parts are connected in parallel in the circuit above.

In mathematics, it can be expressed as

$$I_{sh} R_{sh} = I_m R_m$$

$$\Rightarrow R_{sh} = \frac{I_m R_m}{I_{sh}} \quad (\text{Equation 1})$$

The **KCL equation** at node 1 is

$$-I + I_{sh} + I_m = 0$$

$$\Rightarrow I_{sh} = I - I_m$$

Substitute the value of I_{sh} in Equation 1.

$$R_{sh} = \frac{I_m R_m}{I - I_m} \quad (\text{Equation 2})$$

Consider the denominator term, which appears on the right side of Equation 2.

$$R_{sh} = \frac{I_m R_m}{I_m \left(\frac{1}{I_m} - 1 \right)}$$

$$\Rightarrow R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1} \quad \text{(Equation 3)}$$

Where, I is the total direct current that needs to be measured, R_{sh} is the shunt resistance, and R_m is the galvanometer's internal resistance. The full scale deflection current is represented by I_m .

The ratio between the galvanometer's full scale deflection current (I_m) and the total direct current (I) that has to be measured is known as the multiplying factor (m). In terms of mathematics, it can be expressed as

$$m = \frac{I}{I_m} \quad \text{(Equation 4)}$$

$$R_{sh} = \frac{R_m}{m-1} \quad \text{(Equation 5)}$$

Based on the information at hand, we can use either Equation 2 or Equation 5 to get the value of the shunt resistance.

Uses of Ammeter

The ammeter is used to measure the circuit's current (both AC and DC) as well as the amount of current flowing over it.

1.8 VOLTMETER

A device that detects the voltage or potential difference between two points of an electrical or electronic circuit is called a voltmeter, or voltage meter. The voltmeter is often used for direct current (DC) or alternating current (AC) circuits. As an alternative, specialized voltmeters may also detect radio frequency (RF) voltage.

Symbol of Voltmeter

The letter V is typically used to indicate the voltmeter and is positioned inside a circle that joins two terminals.



Types of Voltmeter

Many voltmeters nowadays are digital, providing readings in the form of numerical displays. Analog versions of the voltmeter are also available, though, and they provide readings by

displaying voltage on a scale when a pointer begins to move in a certain direction. Because they often have a better level of accuracy than analogue voltmeters, digital voltmeters are recommended. Below, we will talk about the mind detail.

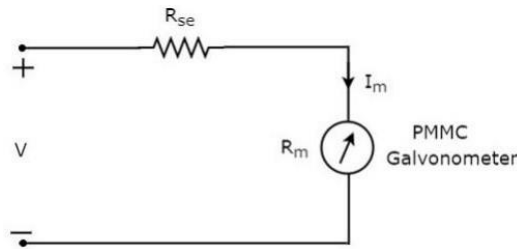


Fig. 1.5 DC voltmeter.

To find the DC voltage across any two points in an electric circuit, a measurement tool known as a DC voltmeter is utilized. When a resistor is placed in series with the Permanent Magnet Moving Coil (PMMC) galvanometer, it transforms into a DC voltmeter. These resistances are utilized in DC voltmeters and are frequently referred to as series multiplier resistance or simply multiplier. It effectively limits the amount of current that flows through the galvanometer to prevent the meter current from exceeding the entire scale deflection value.

This voltmeter must be positioned between the two points of an electric circuit in order to measure the DC voltage. Put KVL into the loop of the circuit above.

$$V - I_m R_{se} - I_m R_m = 0 \quad (\text{Equation 1})$$

$$\Rightarrow V - I_m R_m = I_m R_{se}$$

$$\Rightarrow R_{se} = \frac{V - I_m R_m}{I_m}$$

$$\Rightarrow R_{se} = \frac{V}{I_m} - R_m \quad (\text{Equation 2})$$

The resistance of the multiplier is found in the entire scale deflection current, the whole range DC voltage being measured, and the galvanometer's internal resistance. The

$$m = \frac{V}{V_m} \quad (\text{Equation 3})$$

multiplying factor, m , is the ratio of the DC voltage drop to the entire range of the DC voltage that needs to be measured across the galvanometer. The following equation for the whole range Equation 1 yields V as the DC voltage that must be monitored.

$$V = I_m R_{se} + I_m R_m \quad (\text{Equation 4})$$

The internal resistance of the galvanometer is increased by the full scale deflection current results in the DC voltage drop across the device. In mathematics, it may be

$$V_m = I_m R_m \quad (\text{Equation 5})$$

Substitute, Equation 4 and Equation 5 in Equation 3.

$$\begin{aligned} m &= \frac{I_m R_{se} + I_m R_m}{I_m R_m} \\ \Rightarrow m &= \frac{R_{se}}{R_m} + 1 \\ \Rightarrow m - 1 &= \frac{R_{se}}{R_m} \\ R_{se} &= R_m (m - 1) \end{aligned} \quad (\text{Equation 6})$$

expressed as

Based on the information at hand, we can use either Equation 2 or Equation 6 to determine the series multiplier resistance value.

1.9 OHM Meters

The term ohmmeter refers to the device that measures the resistance between any two locations in an electric circuit. Additionally, it can be used to determine an unknown resistor's value. Ohms are the units of resistance, and a meter is the measuring device. Thus, "ohm" and "meter" are combined to form the word "ohmmeter."

Types of Ohmmeters

Following are the two types of ohmmeters.

i. Series Ohmmeter

ii. Shunt Ohmmeter

Ohmmeter in Series

The ohmmeter is known as a series ohmmeter if the resistor's value is unknown and must be determined by connecting it in series with the ohmmeter. The image below displays the circuit diagram for the series ohmmeter.

The circuit's series ohmmeter is located on the left side of terminals A and B. Thus, by positioning it to the right of terminals A and B, we may determine the value of the unknown resistance. Let's now talk about the series ohmmeter's calibration scale.

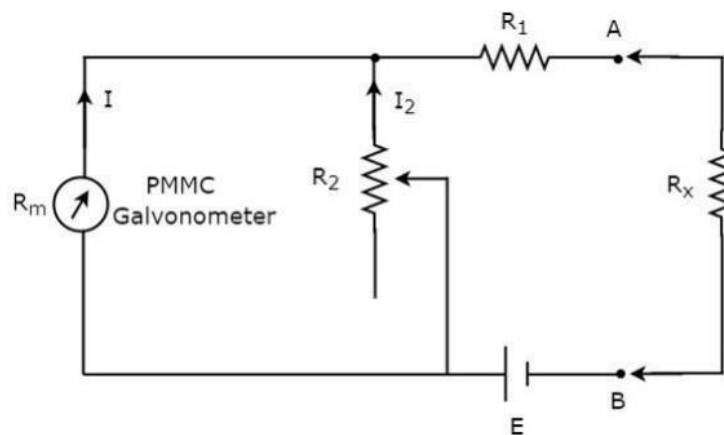


Fig.1.6 The circuit diagram for the series ohmmeter.

- iii. The terminals A and B will short circuit one another if $R_x = 0\Omega$. Thus, the resistors R_1 and R_2 split the meter current. Now, adjust the resistor R_2 such that just the resistor R_1 receives the entire meter current. The meter displays full scale deflection current in this instance. Therefore, 0Ω can be used to represent the full scale deflection current of the meter. Terminals A and B will be open circuited with one another if $R_x = \infty\Omega$. Therefore, resistor R_1 is not receiving any current. The meter displays null deflection current in this instance. Therefore, $\infty\Omega$ can be used to indicate this null deflection of the meter.
- iv. In this manner, the meter displays various deflections by taking into account various values of R_x . As a result, we can use the appropriate resistance value to represent those

deflections. The calibration scale is part of the series ohmmeter. It displays 0 and is located at the right and left endpoints of the scale, respectively. An effective tool for measuring high resistance values is the series ohmmeter.

Shunt Ohmmeter

The ohmmeter is known as a shunt ohmmeter if the resistor's value is unknown and it is to be tested by connecting it in parallel (shunt) with the ohmmeter. The graphic below displays the shunt ohmmeter's circuit diagram. The shunt ohmmeter is the component of the circuit that is located on the left side of terminals A and B. Therefore, by positioning it on the opposite side of terminals A and B, we may determine the value of unknown resistance. Let's now talk about the shunt ohmmeter's calibration scale. When the above circuit is not in use, close the switch S.

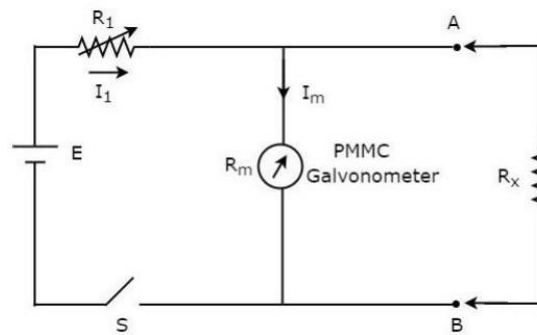


Fig. 1.7 Shunt ohmmeter

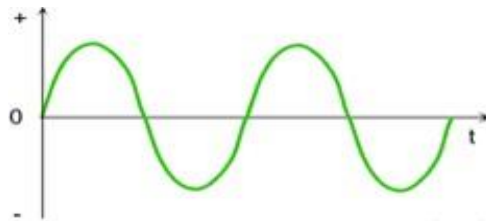
If $R_X = 0 \Omega$, then the terminals A & B will be short circuited with each other. As a result, the whole current, I_1 , passes through terminals A and B. No current passes via the PMMC galvanometer in this instance. Therefore, 0Ω can be used to represent the PMMC galvanometer's null deflection.

Terminals A and B will be open circuited with one another if $R_X = \infty \Omega$. Therefore, there is no current flowing via terminals A and B. In this instance, PMMC galvanometer R_1 is traversed by the full current, I_1 . If necessary, change or modify the resistor's value until the PMMC galvanometer displays the full scale deflection current. Hence, this full scale deflection current. Therefore, $\infty\Omega$ can be used to represent the PMMC galvanometer's full scale

In this manner, the meter displays various deflections by taking into account various values of R_x . Thus, we can use the appropriate resistance values to represent those deflections.

A calibration scale is part of the shunt ohmmeter. It displays the indicators at the left and right ends of the scale, respectively. Low resistance levels can be measured with a shunt ohmmeter. Therefore, depending on the resistance levels that need to be measured—high or low—we can use either a series or shunt ohmmeter.

1.10 Alternating Current (AC)

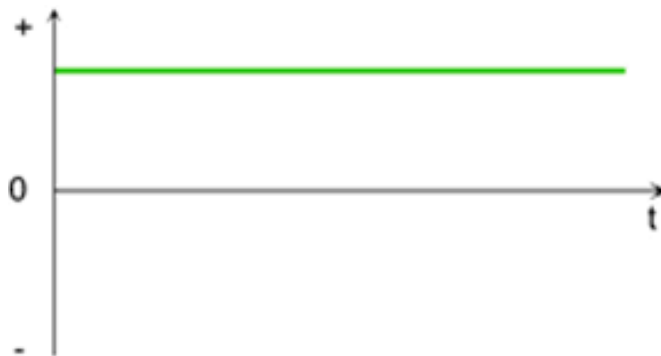


An electrical current that alternates between two or more directions at regular intervals or cycles is called an alternating current (AC). Alternating current is the type of energy that flows through power lines and from a wall socket in a typical home.

In the United States, the standard current is 60 cycles per second, or 60 Hz. In Europe and most other parts of the world, it is 50 cycles per second, or 50 Hz.

1.11 DC Current

The unidirectional transmission of electric charge is referred to as direct current. It is frequently utilized in solar cells and batteries.



DIFFERENCE BETWEEN DC AND AC

Alternating Current	Direct Current
Longer distances, including between two cities, can be easily covered by AC with little energy loss.	DC loses electricity when transferred over long distances.
The change in the indication of electric flow is caused by the rotating magnet.	DC flows in a single direction due to the constant magnetism.
Although the frequency of AC varies by country, it is typically 50 Hz or 60 Hz.	DC has zero or no frequency.
Periodically, the current in AC reverses its direction from forward to backward.	It flows steadily in one direction.
In AC, electrons are constantly moving both forward and backward.	The only direction that electrons may travel is forward.

The advantages of alternating current versus direct current are as follows:

- Compared to DC, AC is easier to generate and less expensive.
- Unlike DC, AC can be transferred across great distances with little energy loss.
- Compared to DC, there is less power loss during transmission in AC.

1.12 ELECTROMAGNETIC INDUCTION

When a conductor passes through a magnetic field or the magnetic flux in a magnetic field varies, "electromagnetic induction" is the process that produces an electromotive force.

Transformer

One tool used in the power transmission of electrical energy is a transformer. AC is the transmission current. It is frequently used to alter the supply voltage between circuits without altering the frequency of the AC. Transformers operate on the fundamental ideas of mutual induction and electromagnetic induction.

Construction

The primary P and secondary S coils, which are insulated from one another and wound on a common soft-iron laminated core, make up a transformer.

Working Principle of a Transformer

A fluctuating magnetic flux is created around the primary coil when the alternating current flows through it. Through the iron core, the shifting magnetic flux is transmitted to the secondary coil. The secondary coil induces an e.m.f by cutting the fluctuating magnetic flux.

This e.m.f. drives a current through a secondary winding if the load is connected to it. The number of main and secondary coils can be used to influence the output voltage's magnitude.

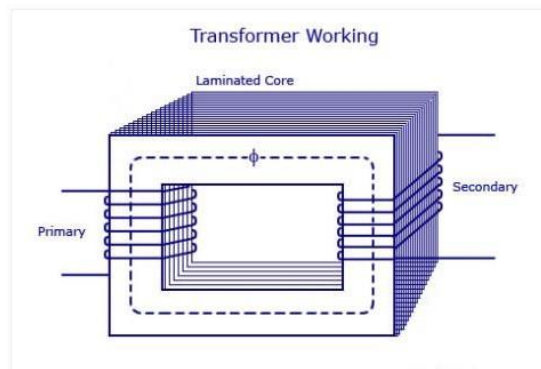


Fig.1.8 Mutual induction

Uses

- Radio receivers and televisions employ audio frequency transformers, whereas a.c. uses step-up and step-down transformers.
- Radio communication uses radiofrequency transformers at megacycle-scale frequencies. In radio communication, impedance transformers are used to match the impedance between two circuits.

1.13 CHOKES

In an electrical circuit, a choke, sometimes referred to as an inductor, is used to block higher frequencies while allowing lower frequencies of alternating current (AC)

and direct current (DC) to flow through. The term "choking" refers to the blockage of high frequencies while passing low frequencies.

An a.c. circuit's current can be managed with a choke coil, which is an inductance coil with extremely low resistance. Power is wasted when current is controlled by a resistance because of the Joule heating effect in the resistance.

Construction

It is made up of many twists of insulated copper wire wound around a soft iron core. A laminated core is used to reduce eddy current loss.

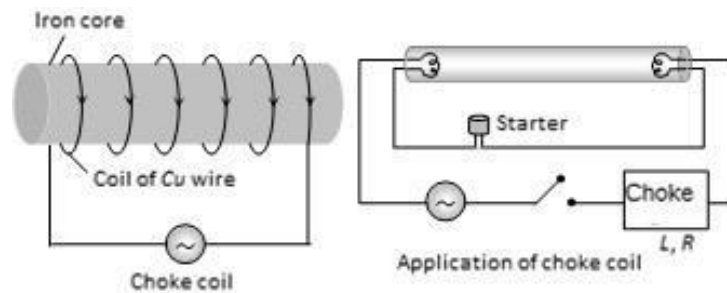


Fig 1.9 Chokes.

Working

The coil's inductive reactance is provided by

$$X_L = \omega L$$

In the case of an ideal inductor the current lags behind the emf by a phase angle $\frac{\pi}{2}$.

The average power used by the choke coil during a full cycle is $E_{rms}I_{rms}\cos\pi/2=0 = P_{av}$

A choke coil of inductance, however, has a modest resistance in practice. As a result, it could be thought of as a series combination of a tiny resistance and an inductor. In that instance, the average power used by the choke coil during a full cycle.

$$P_{av} = E_{rms} I_{rms} \cos \phi$$

$$P_{av} = E_{rms} I_{rms} \frac{r}{\sqrt{r^2 + \omega^2 L^2}} \quad \dots(1)$$

where $\frac{r}{\sqrt{r^2 + \omega^2 L^2}}$ is the power factor. From equation (1) the value of average power dissipated works out to be much smaller than the power loss I^2R in a resistance R .

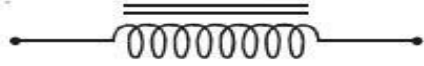


Fig.4.24a A.F Choke



Fig.4.24b R.F. Choke

Uses.

Chokes used in low-frequency a.c. circuits may have a large inductance since they have iron cores. Audio-frequency (A.F.) chokes are the name given to these chokes. Air chokes are utilized for radio frequencies since a low inductance is adequate. They are utilized in wireless receiver circuits and are referred to as chokes that are either high frequency (H. F.) or radio frequency (R. F.) (Fig.4.24a and Fig.4.24b). Fluorescent tubes that run on alternating currents commonly have choke coils.

1.14 CAPACITORS/CONDENSERS

An electrical device with two terminals that may store energy as an electric charge is called a capacitor. Two electrical conductors spaced apart by distance make up this structure. An insulating substance called a dielectric or a vacuum can be used to fill the space between the conductors. Capacitance is the capacity of the capacitor to store charges.

Capacitors separate opposite charge couples to store energy. A parallel plate capacitor is the most basic type, consisting of two metal plates separated by a gap. There are two typical methods for drawing a schematic capacitor. They are always equipped with two terminals that connect to the remainder of the circuit. Two parallel lines, either flat or curved, make up the capacitor sign. The lines should be close to one another but not touching.



Farad is the fundamental unit of capacitance. Farad, however, is a sizable unit for useful tasks. As a result, capacitance is typically measured in Farad subunits like micro-farads (μF) or Pico farads (pF).

Capacitance of a Capacitor

The capacity of a capacitor to store an electric charge per unit of voltage across its plates is known as its capacitance. The formula divides electric charge by voltage to determine capacitance.

$$C = Q/V.$$

Where C is capacitance, Q is charge, and V is voltage.

Factors Affecting Capacitance

It depends on the following factors:

Plate area

The capacitance is directly proportional to the area of the plate as a result. The capacitance value increases with plate area. It is expressed mathematically as:

$$C \propto A$$

Separation of plates

The distance between the plates has an inverse relationship with capacitance. It is expressed mathematically as:

$$C \propto 1/d$$

Dielectric Material constant

The dielectric is the insulating substance that sits between a capacitor's plates.

Applications

- Sensors
- Power Conditioning
- Energy Storage and Signal Processing

Transmission of Electricity

2.1 Generation of Electricity

The process of converting any form of energy into electrical power is called electricity generation. An electric power plant, sometimes referred to as a power generating station, is a group of components used to generate energy. There are many different ways to produce electricity these days; some of the more important ones are discussed below.

Electromechanical Process of Electricity Generation

The electromechanical process of generating electricity involves the movement of a conductor within a magnetic field. When the magnetic field lines are broken, electromagnetic induction generates electricity in the conductor. This method generates electricity using a machine known as a generator. Depending on the kind of power it generates, the generator can be either DC or AC. This is one of the most widely used methods of energy production in the world.

Electrochemical Process of Electricity Generation

This process transforms chemical energy into electrical energy. The power generated by a cell or battery is the most prevalent example of this technique of electricity generating. Chemical reactions in batteries provide power. This method is employed to generate power on a small scale.

Solid-State Electricity Generation

It is a modern technique for generating electricity. This method converts light energy into electrical power using a semiconductor device, like a photovoltaic cell. When strong light beams hit a photovoltaic cell, they produce a potential, which is a difference in the number of charge carriers (electrons and holes). When the solar cell is connected to an external circuit, an electric current starts to flow.

Various Electricity Generation Processes

There are several more ways to generate electricity, such as wind turbines, biomass, biogas, tidal, geothermal, and others. These are mostly sources of renewable energy.

The electrical transmission is carried out via transmission cables, or lines, which are supported on the enormous steel towers. It is common practice to transmit power in

the form of AC or DC at extremely high voltages. When broadcasting AC, the three-phase, three-wire transmission technique is used. Transmission lines are frequently terminated at receiving stations and substations.

Distribution and Utilization of Electricity

Delivering electricity to end users for use is known as electricity distribution. For this, a number of distribution substations are positioned at different locations throughout a metropolis. These distribution substations receive high-voltage energy from transmission cables and then lower the voltage level. Customers currently receive this low-voltage electricity from distributors and feeders. Consumers use this electricity to run electric loads like light bulbs, fans, motors, and other devices.

2.2 What Is the Power Grid?

A power grid is a system of interconnected parts that produces, transmits, and eventually delivers electricity to consumers. There's a difference between energy suppliers vs. utilities:

- Utility firms maintain power lines, substations, and generating facilities in order to produce and distribute electricity.
 - An alternative to utility corporations are energy suppliers. Sometimes they purchase electricity at wholesale prices and resell it to clients at a discount, or they own their own power facilities.

Working of Electric Grid

Power plants and renewable energy sources, which produce the electricity that is sent to the grid, are the backbone of any power grid. The next component of an electrical power grid is transmission.

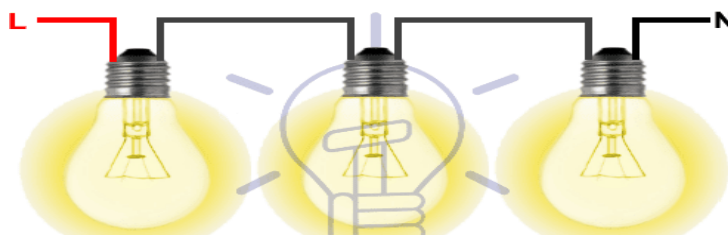
In order to efficiently send electricity over long distances over high-voltage transmission lines, a substation steps up voltages. The next component is the distribution. Substations reduce power to a lower voltage so that it can pass over nearby utility poles that you see along roads and lines that you might not notice buried underground—in order to safely provide power to consumers. Smaller green transformer boxes scale down the power even further to the 240V power that most consumers require before entering a home or office.

2.3 Series Circuit

There is only one way for electric current to flow across a circuit when resistors or loads are connected end to end. We call this a series circuit. Consequently, when several resistors are connected in series, the effective resistance (total resistance in the circuit) is calculated by adding the individual resistors algebraically. In other words, if resistors R_1 , R_2 , R_3 , and so on are linked in series, then

In series connections, the resistors have varying voltages across them because the same current goes through each branch of the circuit but the voltage across them varies. There will be a voltage loss in each resistor or load. The total voltage drop across the circuit's various components equals the applied voltage. When the resistance current is constant across the circuit, the voltage loss is proportionate. It is usual for loads to have a common switch when they are linked in series. This type of connection is used in streetlights and school halls.

$$R_{\text{eff}} = R_T = R_1 + R_2 + R_3 + \dots R_n.$$



Lamps In Series

Application of Series Connection

Some people connect security lights in their homes in series which will make them to have common switch. The problem with this kind of connection is that when a load develops a problem, the other connected system will fail. This circuit connection is all-or-none. There will be a blackout until one load receives energy before it provides it to the other and the one that delivers fails.

Series circuit connections are commonly used in electrical equipment. The tube filaments in tiny radios are usually connected in series. The current-controlling devices and the devices they safeguard are always connected in series. In automatic home

heating equipment, a power source is coupled in series with thermostats, electromagnetic coils, safety cutouts, and other parts. Fuses and the devices they protect are connected in series.

Disadvantages of Series Circuit

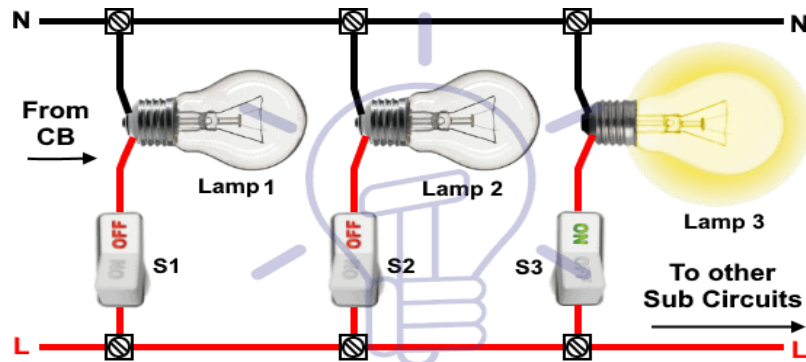
- There is only one path for current to flow in the circuit, thus if one lamp breaks, fails, or is removed, the circuit will be broken and all the other lamps will stop working.
- The brightness of each lamp in a series lighting circuit will decrease as more are added.
- If more loads (such as air conditioners, electric heaters, or light bulbs) need to be added to the series circuit, a high supply voltage is required.
- When more loads is added to the circuit, the overall series circuit resistance rises (and the current falls).

Advantages of Series Connection

- In series wiring, a smaller wire cable is needed.
- Connecting fuses and circuit breakers in series with other appliances is how we protect the circuit.
- When more loads are added to a series circuit, the high resistance prevents the circuit from easily going overboard.
- The life span of battery in series circuit is more as compared to parallel.
- Compared to parallel series-parallel wiring, this is the simplest method of electrical wiring, and faults can be found and fixed with ease.

2.4 Parallel circuit

The resistors or loads are said to be connected in parallel when one of their ends has a common point or junction and the other ends are also connected to a common point or junction. Parallel circuits are the name given to these circuits.



Lamps In Parallel

Unlike these circuit connections, the total (effective) resistance in a parallel circuit is determined by the reciprocal of each individual resistance. Thus, when many resistances are coupled in parallel, the reciprocal of the effective resistance is given by the arithmetic or algebraic sum of the reciprocal of the individual resistance.

$$1/R_{\text{eff}} \text{ or } 1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots 1/R_n.$$

All of the circuits' branches experience the same voltage when connected in parallel. There are distinct currents in each resistor.

Application of Parallel Connection

Parallel circuit connections are quite common. In order for each lamp, light bulb, and electrical device to function independently, they are connected in parallel in our homes. Individual bulbs or loads must be wired in parallel for us to have control over them.

Advantages of Parallel Circuit

- Each connected electrical device and appliance are independent from others.
- If the cable breaks or a light is removed, all related loads and circuits will remain intact.
- The brightness of the parallel lighting circuits won't decrease if more bulbs are added.
- As long as the circuit is not overloaded, additional light fixtures and load points can be added in parallel circuits based on future needs.
- When high current-rating equipment, such air conditioners and electric heaters, are employed, adding more devices and components will reduce the circuit's overall resistance rather than raise it.
- Parallel wiring is more reliable, safe and simple to use.

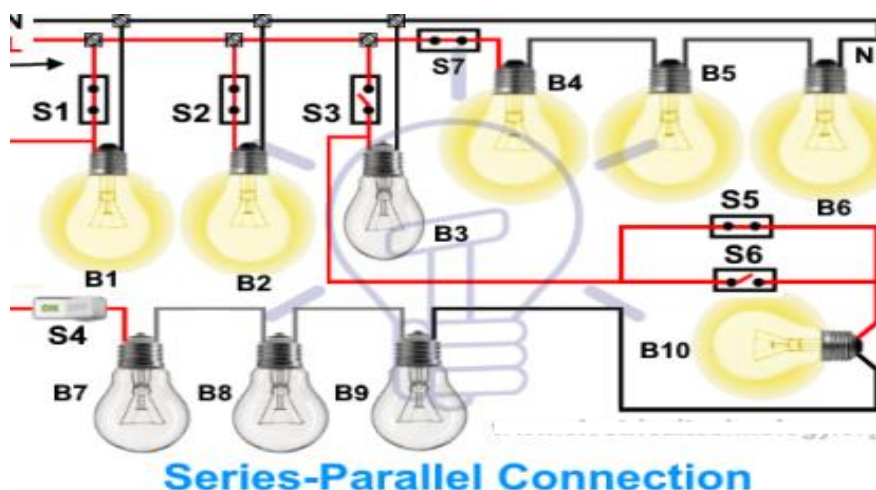
Disadvantages of Parallel Connections

- In parallel lighting wiring circuits, larger cables and wires are employed.
- When more light bulbs are connected to the parallel circuit, more current is required.
- During DC installation, the battery drains more quickly.
- Compared to series wiring, the design of parallel wiring is more intricate.

2.5 Series-Parallel Connections & Circuits

The circuit in the following figure is series-parallel, meaning it is neither series nor parallel. The switches (S1, S2, and S3) are linked in series with the first three bulbs (B1, B2, and B3), which are connected in parallel. While the switches (S5 & S6) are connected in parallel to Bulb (B10), B7, B8, B9, and B10 are in series with each other and parallel to the first three bulbs (B1, B2, & B3). Additionally, switches (S7) and bulbs (B4, B5, and B6) are in parallel with B1, B2, and B3 and shortly, but in series with each other.

Since the circuit combines series and parallel, we are unable to use Ohm's Law to simply calculate the current, voltage, resistance, and power. Several theorems, including Norton's, Thevenin's, the maximum power transfer theorem, and others, must be applied in order to obtain all of those quantities; alternatively, the circuit can be simplified into straightforward series and parallel circuits. These days, this wiring technique is most frequently used in household electrical installations.



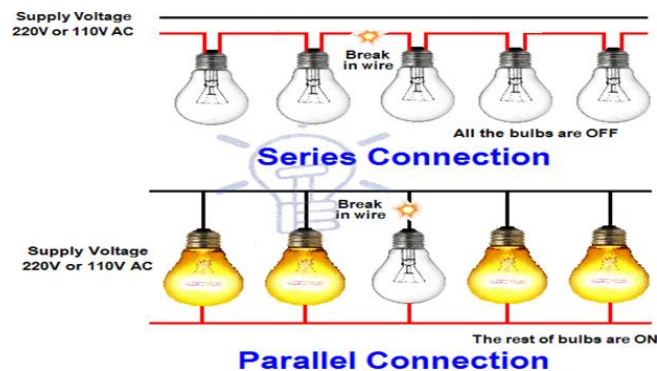
Comparison Between Series and Parallel Connection

Below in the given table, the main differences between series and parallel connections are shown.

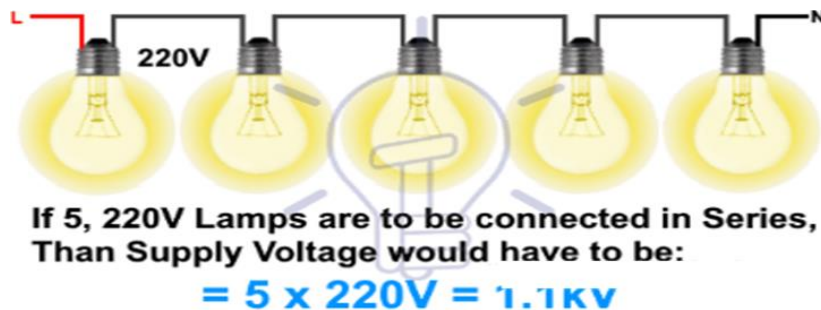
S No.	Series Circuit	Parallel Circuit
Current(I)	Every point in a series circuit has the same current: $I_1=I_2=I_3=...I_n$	In a series circuit, the current is additive: $I_1+I_2+I_3+...I_n$
Voltage(V)	$V_1+V_2+V_3+...V_n$ is the voltage are additive in a series circuit.	Each parallel circuit point has the same voltage: $V_1 = V_2 = V_3 = V_n$
Resistance (R) & to Find (R)	In a series circuit, resistance is additive: $R_1 + R_2 + R_3 +... R_n = R_{eff} = R_T$	As the circuit's load increases, resistance is split. The formula $1/R_T=1/R_1+1/R_2+1/R_3...1/R_n$ $I=G_1+G_2+G_3+...G_n$
To Find Current (I)	$I=V_1/R_1=V_2/R_2=V_3/R_3=V_n/R_n$	$I=V_1/R_1+V_2/R_2+V_3/R_3+V_n/R_n$
To Find Voltage (V)	$V = I_1R_1+I_2R_2+I_3R_3+ ...I_nR_n$	$V=I_1R_1=I_2R_2=I_3R_3=...I_nR_n$
To Find Electric Power (P)	$P=I_1^2R_1+I_2^2R_2+...I_n^2R_n$ (or) $P=V_1I_1+V_2I_2+...V_nI_n$	$P=V_1^2/R_1+V_2^2/R_2+...V_n^2/R_n$ (or) $P=I_1^2R_1+I_2^2R_2+...I_n^2R_n$
Current & Voltage Divider Rule	$V_1 = V_T(R_1/R_T)$ $V_2=V_T(R_2/R_T)$	$I_1=IT(G_1/G_T)$, $I_2 =IT(G_2/G_T)$
Paths off low of Electric Current	Only one path	Two or more paths
If breaks occur in the circuit	Whole circuit is useless	The rest of the circuit will still work
Battery Status	Battery Discharge slowly(Ah Rating of Battery)	Battery Discharge Quickly (Battery Ah Time & Currents)
Applications	Used to protect the circuit while connecting fuses and circuit breakers in series with the connected appliances	Used in most of house hold electrical wiring installations.

Advantages of Parallel Circuit Connection over Series Circuit Connection

An all-or-nothing connection is what a series circuit connection is. This implies that all of the appliances will malfunction if one does. Thus, only when we wish to protect a device is this kind of connection appropriate. The appliance it protects is unharmed when a fuse burns out, usually as a result of excessive current, because the current no longer reaches it.



A parallel circuit connection offers the option of separate switches for every load and appliance, in contrast to a series connection, which is all or nothing. Compared to series connections, parallel connections provide greater resistance to the flow of current.



Disadvantages of Series connections

When two resistors with resistances of 100 and 150 ohms are linked in parallel, the electric current will be less affected than when two resistors with resistances of 50 and 40 ohms are connected in series. A parallel connection is essential for electronic devices.

A power bank's cells are all connected in parallel, extending the lifespan of electrical energy. Since internal resistance has a greater effect in series than in parallel, part of the energy would be lost when these cells were joined in series in order to overcome the higher internal resistance.

2.6 Transmission loss (TL)

It generally refers to the cumulative loss of waveform energy when a wave moves outward from a source, through a certain area, or via a specific kind of structure. It is a phrase that is often used in optics, acoustics, twisted pair systems (PTSN, Ethernet, etc.), and radio communication. TL measurements are crucial in the manufacturing of acoustic equipment like sonars and silencers.

Definition

Measurement of transmission loss can be in terms of decibels. Mathematically, transmission loss is measured in dB scale and in general it can be defined using the following formula:

$$TL = 10 \log_{10} \left(\frac{D}{B} \right)$$

Where,

- D is the power of incident wave coming towards a defined area (or structure);
- B is the power of transmitted wave going away from the defined area (or structure).

Applications

Transmission loss may refer to a more specific concept in one of the fields below:

- In electrical engineering, transmission loss refers to the reduction in electrical power along an electrical cable. The term "in telephony" has its origins.
- The acoustic characteristics of a system that resembles a silencer are described by gearbox loss in duct acoustics.
- In room acoustics, transmission loss refers to the reduction in sound intensity caused by a wall or other structure at a specific frequency.



Fig. 2 Transformer

- In underwater acoustics, transmission loss refers to the reduction in sound intensity caused by a bubble curtain or other damping structure at a specific frequency. The phrase can also

be used to describe propagation loss, which is the difference between the sound pressure level at the receiver and the source level and is a measurement of the decrease in sound intensity between the two. The effective transfer of electricity from one circuit to another depends on transformers, which are static devices. The voltage that enters the input, or primary end, of a transformer is changed as power passes through it to meet the precise requirement at the output, or secondary end. The voltage level at the output is increased in a step-up transformer and decreased in a step-down transformer. The design and application of step-up and step-down transformers, as well as some of the laws controlling electrical transmission, are covered in this article.

Types of transmission losses

- Transmission loss types in fiber: Absorption loss, scattering loss, dispersion loss, radiation loss, and coupling loss are all included in optical communication.
- In twisted pair transmission systems, the kinds of transmission loss include radiation loss, dielectric loss, and conductor loss.

Step-up and Step-down transformers

A step-down transformer lowers the input voltage at the load, whereas a step-up transformer raises the input voltage and sends it to the load. Although effective power transmission necessitates high voltage, consumers must use the power at a lower level for safety.

A step-up transformer is needed to convert low voltage to high for gearbox. Step-up transformers are not worth much in some countries. For instance, India's power generation level is 11 kV. Therefore, step-up transformers at the generating stations are necessary. To put it briefly, a step-up transformer increases the voltage

High voltage power is converted to low voltage via step-down transformers. As a result, the power level at home or at work is appropriate for the needs of every device connected to the power systems. Home power circuit's use between 230 and 110 volts, however some features only need 16 volts. Therefore, step-down transformers are required in order to drop the voltage to a lower power level.

Furthermore, distinct circuits in electrical systems found in homes and businesses typically have a common frequency. However, the voltage requirements vary frequently. Therefore, smaller step-up or step-down transformers are used in many household appliances. Step-up and step-down transformers can be single-phase or three-phase,

depending on the type of power source. They are built in a variety of configurations and have different functions, depending on the needs of each particular situation.

Transformer working principle

A transformer consists of two sets of wires (see Figure 2):

- The main winding (A): gathers energy
- Secondary winding (B): supplies electricity

The primary and secondary windings are twisted together on a magnetic iron circuit core, but they are not in contact with each other, as shown in Figure 2. To lessen core loss, the core is composed of a soft magnetic material that is bonded together via laminations (shown as C in Figure 2). The energy loss within the core brought on by an alternating magnetic flux is known as core loss. The core material's ability to function is eventually destroyed by an unstable magnetic field.

When the primary winding (marked A in Figure 2) is connected to a power source, current flows through the coil and a magnetic field is produced. A section of this magnetic field attaches to the secondary windings (shown as B in Figure 2) via mutual induction, producing voltage and current flow at the secondary (load) side.

The number of turns in the secondary winding in relation to those on the main side determines the voltage generated at the load side. The voltage transformation is given by,

$$V1/V2=N1/N2=I2/I1$$

- V1: Voltage applied to the transformer primary winding
- V2: Voltage produced at the secondary(load)winding of the transformer
- N1: The principal winding's number of turns
- N2: The secondary winding's number of turns
- I2: The secondary windings' current flow
- The major windings are receiving current.

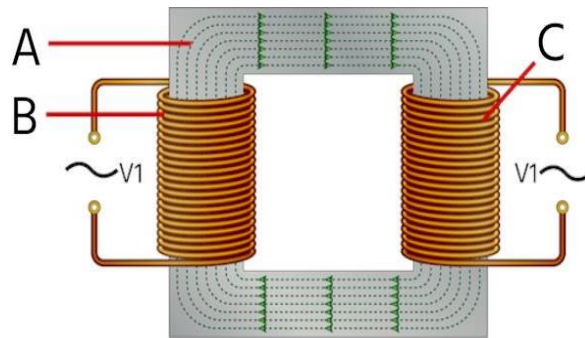


Figure 2.1: Construction of a transformer showing primary windings (A), secondary Windings (B), and magnetic core (C)

The principle of step-up transformer operation

A step-up transformer increases the voltage at the secondary windings relative to the main side. According to the voltage transformation equation, N_2 must be bigger than N_1 in order for V_2 to be greater than V_1 (see Figure 3). In a step-up transformer, thus,

- $N_2 > N_1$
- $V_2 > V_1$
- $I_2 < I_1$

A step-up transformer always steps down the current (while stepping up the voltage) at the secondary side compared to the primary side. Equal power at the transformer's primary and secondary sides is the cause of this. The capacity of the current that the transformer coils are intended to carry determines their thickness.

A step-up transformer's primary winding is composed of thick insulated copper wire, while the secondary side is composed of thin insulated copper wire, due to the fact that the primary side carries higher current. The product of voltage and current as kVA (kilo-volt amperes) is typically used to rate a transformer. For additional information on the power involved with a transformer, see our article on transformer calculator.

Example

If a 1:10 transformer is applied 10V at the primary winding,

- $N_1 = 1$
- $N_2 = 10$
- $V_1 = 10V$

Therefore, $V_2 = (N_2/N_1) \times V_1 = 100V$

The voltage at the secondary side of the transformer is ten times that applied at the primary side.

Advantages

- Easy maintenance
- High efficiency
- Quick start
- Power transmitter

Disadvantages

- Requires a cooling system
- Works only on alternating current (AC) signals
- Huge size

2.7 The idea of step-down transformer operation

A step-down transformer reduces the voltage at the secondary windings relative to the main side. The voltage transformation equation states that for V_2 to be less than V_1 , N_2 must be less than N_1 . Thus, in a step-down transformer, $N_2 < N_1$, $V_2 < V_1$, $I_2 > I_1$

A step-down transformer always increases the current (while decreasing the voltage) at the secondary side relative to the primary side. Because the secondary side of a step-down transformer carries more current, the secondary winding is made of thick insulated copper wire, whereas the primary side is made of thin insulated copper wire. Step-down transformers are commonly used in low voltage transformers for landscape lighting applications.

Example

When 10V is delivered to the primary winding of a 100:1 transformer, $N_1 = 100$, $N_2 = 1$.

$V_1 = 10V$, $V_2 = (N_2/N_1) \times V_1 = 0.1V$, therefore

The voltage on the secondary side of the transformer is 100 times lower than the voltage applied on the main side.

Advantages

- High durability and reliability.
- Less cost.
- High efficiency.
- Offers various voltage supply for typical household uses.

Drawbacks

- Needs a lot of upkeep
- Only AC is used.

Transformer operation reversibility

Step-up and step-down power transformation activities can be performed using the same transformer. The transformer acts differently depending on how it is connected to the circuit. The transformer functions as a step-up version if the input supply is finished on the low-voltage winding. The transformer can function as a step-down version of the input supply if it is connected to the high-voltage winding.

Uses

Transformers that step up

For users with particular power requirements, such as power plant applications, microwaves, and X-ray machine operation, step-up transformers with thick-insulated copper wire primary side windings are required to raise the voltage to 11,000 volts or higher. Step-up transformers are employed to boost electronic devices and distribute electrical energy in high-power transmission lines.

Transformers that step down

- Common household devices like CD players, televisions, and doorbells all employ step-down transformers.
- Voltage stabilizers
- Inverters
- Power distribution networks
- Mobile phone charges
- Transmission lines

2.8 How to Select Quality Cables and Wires?

Choosing cables and wires of good quality is crucial. Replacing the connections and wires after installation would be a difficult undertaking in the event of any flaws or quality problems. The high voltage would be too much for cheap cables and wires to handle, which could result in fire, short circuits, frequent power outages, or other issues.

Norden is aware of this reality and has made an effort to determine the quality of every batch of cables and wires that come from our production facilities. To rule out the

potential of abnormalities or production errors, the cables are inspected by the Quality Assurance specialists at every stage of manufacturing.

We have been providing wires, cables, systems, and electrical components to businesses, residential communities, industries, and private residences. Our overall approach has been essential in helping our product become the best in its field.

Selecting Quality Cables and Wires

For the purchase of cables and wires for your facility, you may be directed to a competent individual with electrical wiring and installation experience. Before choosing the components, they had to look at the ratings and do a visual inspection. The points to check in the case of confirming the quality of cables and wires include:

Voltage – The cable's voltage would be indicated on the cable drum. Following post-manufacturing testing at the factory, the makers confirm. You can determine whether or not the wire or cable is suitable for your systems by looking at the insulation standard details. It may be better to use a cable with ratings higher than the anticipated system voltage. Never accept someone whose voltage and insulation ratings are lower than what is necessary.

Flexibility - A wire with more annealed conductors is more flexible. Unquestionably, a flexible cable is superior to a solid one. It would make cable installation simple, practical, and efficient. Because the cables are flexible enough to bend, turn, and lie according to the systems' design, electricians can finish the job more quickly. Compared to flexible cables, solid conductor cables may be less expensive. Nevertheless, using flexible cables is more affordable.

Power Handling Capacity -The cable's power handling capacity should satisfy your needs, whether they are commercial, domestic, or industrial. It can become problematic if an A Cable has a lower power handling capacity than required. Compared to CAT cables, COX and single pair cables with a single pair gearbox will have a lower power handling capacity.

Durability and Strength -The electrical engineer or technician's perspective should be used to gauge the cables' strength and endurance. The area where the cables would be used should serve as the basis for the inspection. For instance, as required by the environment, the cable used in an industrial unit or factory should have properties that are resistant to heat and

chemicals. Conversely, the wires that would be placed outdoors should be able to endure bad weather, including sand, dust, storms, sunlight, rain, and dampness.

The Ability to Handle Overheating - Heavy electrical overload might lead to overheating of the cables. Wires and cables should manage excessive electricity and not be a fire hazard.

Quality of the Conducting Material Used -There are copper and aluminum cables and wires on the market. It has been demonstrated that copper wires function better than aluminum due to their higher conductivity. Nevertheless, copper wires are not recommended for longer-distance electrical transmission. Aluminum is a preferable choice in this situation because of the cost of cabling to such a distance. Based on the current requirements, the electrical supervisor and technician should choose the conducting material.

Insulation on the Cables and Wires – The insulation applied to the cables and wires needs to be appropriate for the industry in which it is used as well as the ambient temperature within the building. Depending on the local temperature, the insulation on the wires used in factories and production facilities should be fire-resistant or flame-tardant. Compared to FRPVC, FRPVC cables are more suitable in commercial and industrial settings.

Cables are an essential electrical component used in mechanical equipment, construction, etc. As an essential part of power transmission and control, cables are widely used in a range of industrial production, railway, petrochemical, shipbuilding, urban construction, and other fields. Depending on the number of conductors cables fall into one of two categories: single-core or multi-core. This post will go into great detail on the differences between single-core and multi-core cables.

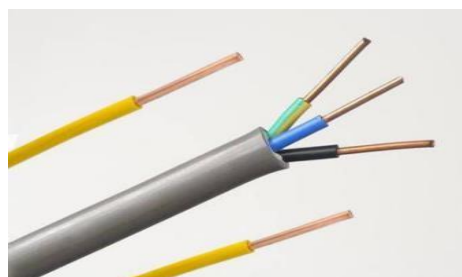


Fig 2.3 Cables

Fundamental Ideas of Cables

An apparatus consisting of two or more wires is called a cable; it usually includes a metallic conductor, insulating material, and a cable sheath. Single-core and multi-core cables are the two categories of cables. High voltage power transmission frequently uses single core cables, which only feature one metal conductor. Typically utilized in low voltage control or communication systems, multicore cables feature two or more conductors.

Definition of single core cable

A cable with just one conductor is called a single core cable. Its primary characteristics are its excellent with stand voltage capability, strong insulation performance, and suitability for high voltage and big current transmission. Single-core cables generate significantly less electromagnetic interference than multi-core cables since they only contain one conductor, which is crucial for applications requiring a high level of precision. Additionally, the single-core cable's tiny outer diameter and strong anti-corrosion properties make it ideal for installation in confined locations.

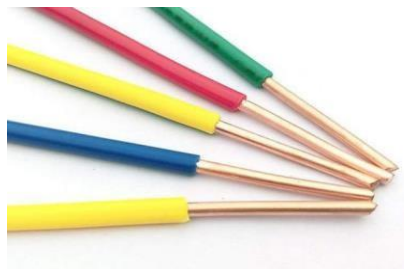


Fig 2.4 Single Core Cables

Definition of multi-core cable



Fig 2.5 Multi Core Cables

A cable with several conductors is called a multi-conductor cable. Its primary characteristic is its ability to simultaneously transfer various electrical or power signals, making it appropriate for communication and low-voltage control systems, such as data

transmission and phone lines, etc. Multi-core cables can be further divided into other types, such as twisted pair, coaxial, and shielded cables, for a range of application scenarios. Although the impact of electromagnetic interference can be effectively reduced by using appropriate shielding materials, mutual electromagnetic interference is increased by the large number of conductors in multi-core cables.

Comparing single-core vs multi-core cables:

Conductor count: While single-core cables only have one conductor, multi-core cables have many.

Scope of application: Single-core cables are appropriate for applications requiring the transmission of high voltage and high current, such as in the chemical, metallurgical, and oil refining industries, among others. In addition to being useful multi-core cables can also be used to power electrical equipment in buildings and send signals to mechanical and robotic devices, as well as for communication, data transmission, control systems, and railway signal transmission.

Anti-interference ability: High insulation performance, voltage tolerance, and minimal electromagnetic interference are all attributes of single-core cables. In addition to transmitting many signals simultaneously, the multi-core cable can also withstand some degree of external electromagnetic interference.

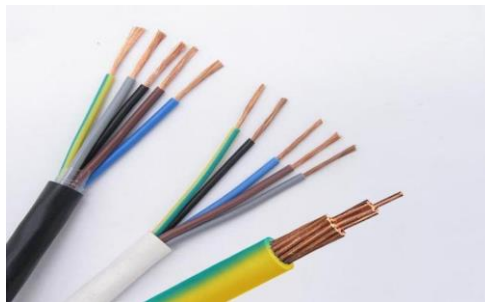


Fig 2.6 single-core vs multi-core cables

Application scenarios of single-core cables and multi-core cables

Single-core cables are commonly used in high-voltage power transmission systems, transformer wiring, oil refining, chemical, metallurgical, and other industries that need to transfer high-voltage and high-current circumstances. Furthermore, the single-core cable performs better against corrosion and is appropriate for outdoor use. Data transfer, control systems, railway signal transmission, and communication are just a few of the many uses for multi-core cables. They can also be used to send messages to mechanical and robotic systems and power electrical equipment inside structures.

Benefits and drawbacks of both single-core and multi-core cables

There are benefits and drawbacks to both single-core and multi-core cables. A single-core cable's advantages include strong voltage resistance and insulation performance, as well as relatively low electromagnetic interference. However, because it only has one conductor, it is unable to convey multiple signals. Although their resistance to electromagnetic interference is weak, multi-core cables have the advantage of being able to transfer numerous signals simultaneously, making them appropriate for sophisticated control systems and data transmission scenarios.

How to choose single-core cable and multi-core cable

The cable's purpose: The first step in selecting an appropriate cable is to think about its intended use. A single-core cable is advised if there is a scenario requiring the transmission of high voltage and high current; a multi-core cable is advised if various signals must be transmitted and the cable must be able to tolerate certain electromagnetic interference.

Cable quality: The safety and service life of cables are significantly impacted by their quality. It is advised to select a product with a certified brand and to carefully inspect that the ground connection, insulation, and cable interface are in good shape.

Cable length: Whether or not the cable length is suitable has a significant impact on the transmission effect and cable safety. Too-long cables raise the resistance of the cable itself, increasing power loss, while too-short cables may not be able to provide power to the desired device. Therefore, it is recommended to take exact dimensions in accordance with actual needs while buying cables.

Environmental climate: The cable's service life and safety are also impacted by the environmental climate. To ensure its safety and stability in certain unique application conditions, such as humid or hot environments, the appropriate cable must be used.

3.1 DIFFERENT TYPES OF SWITCHES

Define Switch

An electrical component called a switch is used to turn on and off many devices, such as fans, lights, washing machines, televisions, and more. The circuit is open and there is no current flow while the switch is off. The switch should be on since the current will flow when the circuit is closed. In an electrical circuit, switches often come in two varieties:

Electrical switches: These work under the influence of semiconductors

Mechanical switches: These are categorized into several categories based on the poles (number of input circuits available to the switch) and throws (number of paths for the passage of current available to the switch), and they require manual contact with the switch to operate.



Fig 2.7 Types of Switches

Types of Electrical Switches

i. Bipolar Transistors

A transistor functions similarly to a typical switch. Switching applications do not employ the transistor's active area. The transistor is on when it is operating in the saturation zone and off when it is operating in the cut-off region. Base current must be given to NPN and PNP transistors in order for them to function as switches when turned on.

ii. Power Diode

The power diode's manufacturing involves silicon. The power diode functions as a switch on when its PN junction is forward biased and as a switch off when it is reverse biased.

iii. MOSFET

Metal Oxide Semiconductor Field Effect Transistor, or MOSFET for short, is a unipolar switching device. It has three terminals: the gate (input), the source (common), and the drain (output). The input voltage and resistance across the source and drain can be adjusted to determine the device's on and off states because it is voltage regulated.

iv. SCR

The three terminals of an SCR (Silicon Controlled Rectifier) are the anode, cathode, and gate. The gadget is unidirectional. It is controlled by controlling the gate input and biasing the anode and cathode.

Single Pole Single Throw

With one input terminal (named the pole) and one output terminal (called throw), this is the most basic type of switch. This switch is utilised in a single closed path or loop.

Single Pole Double Throw

It can be used as a selector switch, allowing us to supply current to two loops, and it has one input terminal and two output terminals.

Double Pole Single Throw

These are used to control the two circuits at the same time. It features two terminals for input and two for output. The two switches in these circuits are linked by a single lever and function simultaneously.

Double Pole Double Throw

Two input terminals (poles) and four output terminals (throw) make up this arrangement, with two terminals for each pole. In this, two input terminals (poles) are connected to one pair of outputs (throw).

Two Pole Six Throw

Each pole has six output terminals (throw) and one input terminal (pole). There are twelve output terminals in all. This is used to switch features for the circuit's identical input terminals.

1.1.2 Types of Mechanical Switches

Further Momentary control switches can be divided as:

- Push-button
- Pressure switch
- Temperature switch
- Toggle switch
- Rotary switch

Push Button Switch

It closes the circuit to current flow when it is pressed. The contact breaks and the current flow is halted when the switch's pressure is released.

Pressure Switch

By doing this, pressure can be raised or lowered from a fixed point. It is used in businesses to detect the pressure of air, water, or oil and is composed of a C-shaped diaphragm.

Temperature Switch

This is made up of a resistance temperature sensor that measures temperature and is controlled by the temperature reading.

Toggle Switch

This is utilized in the home and has a lever that can be adjusted up and down to turn it on and off.

Rotary Switch

This switch, which is utilized in band selectors, range selectors, and channel selectors, is essentially self-explanatory. Here, one line is connected to one of several lines using a switch.

3.2 TWO-WAY SWITCH

Because a two-way switch may be operated from either switch separately, you can use the other switch to control the light regardless of whether it is in the ON or OFF position. A two-way switching connection can be made using either the 2-wire control or the 3-wire control mode. Single Pole Double through (SPDT) switches are two-way switches that are used in electrical and do-it-yourself projects. The following idea can be used for anything, from simple do-it-yourself projects to intricate electrical wiring jobs.

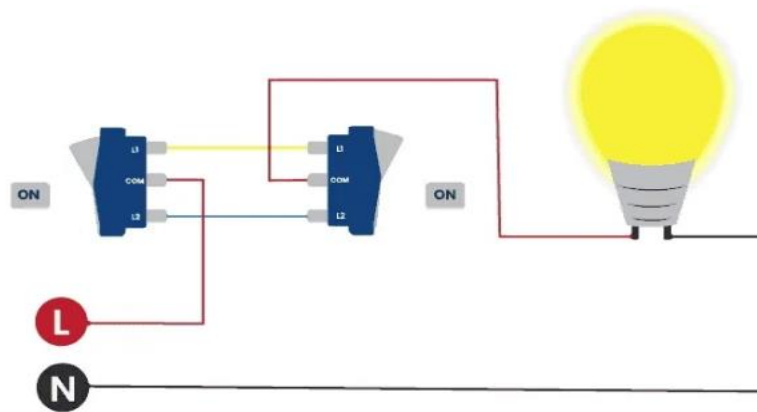


Fig 2.8 Two-Way Switch

Required Components for Two-Way Switch Connection Experiment

- 2-way switches x 2
- Bulb x 1
- AC supply x 1
- Connecting wires

The old approach was the first to establish a two-way switching link. Choose three wire control techniques if you're installing a new one. The phase/live is connected to the common of the first 2-way switch, as can be seen in the 2-way switch schematic below. The first switch's PIN1 and PIN2 are linked to the second switch's PIN1 and PIN2, respectively. The second switch's common terminal is linked to one end of the light bulb, while the AC power supply's neutral line is attached to the other end. The condition of getting Output in ON condition is the same as the Ex-nor gate truth table which is given below:

Switch 1 (SW1)	Switch 2 (SW2)	Lamp state (L1)
OFF	OFF	ON
ON	OFF	OFF
ON	ON	ON
OFF	ON	OFF

Applications of Two-Way Switch:

- Staircases: For managing lighting from the stairwell's top and bottom.
- Incorrect Tripping of Safety/Circuit Protection Equipment: Assists in resetting circuits that have tripped in various places. The ability to conveniently manage lighting or other

equipment from many entrances is made possible by large rooms with multiple entry/exit gates.

- Managing the air conditioner Fans and lights are examples of appliances that may be operated from two locations, such as a room's entrance and exit.

3.3 ROLE OF SOCKETS

Mechanical, Electrical and Functional Specifications for sockets/connectors

A hollow component or portion that can contain and receive object electricity. An apparatus designed to mechanically support an electric light bulb and electrically attach it to circuit cables. Alternatively known as a wall socket a wall-mounted socket that accepts a plug that connects electrically to supply wiring. The fixed item into which the plug is plugged is called a socket, and it is often fixed to a wall or floor.

The 13-amp three pin plug is the most widely used plug type in the UK. These rectangular pins are compatible with the 13-amp socket's three pins. A 5-amp socket is one of several other sockets that are typically used to connect lights to lighting circuits.

Every type of socket and connection has a standard mechanical specification that details its mechanical characteristics, such as its size, shape, and pin count. The functions of each pin (such as transmit, receive, ground, clock, etc.) and the appropriate voltage or signal value to be applied to that pin are also specified in an electrical specification for each type of socket or connector. For instance, to transmit a digital 1 bit in a particular socket, pin number 4 might need to be set to +0.85V for 5 ms.

Furthermore, there is a functional specification for every type of socket or connector that outlines the methods necessary to send and receive data through these connections. For instance, before sending data over serial cables, the DTE pin must be activated. Likewise, prior to receiving data from the cable, the DCD (data carrier detect) pin must be activated.

3.4 What are Electric Plugs?

The devices that provide and draw current from a container to the circuits of electrical equipment are called electrical plugs, sometimes referred to as power plugs. A typical electric plug's plastic case supports its prongs or pins. An electrical connection between an appliance and the main power supply is made by inserting prongs into the holes of outlets or receptacles.

Types of Electric Plugs

At least fifteen common types of electric plugs are presently on the market. Let's examine a few of the most popular electric plugs:

- **Type A**

Type A plugs are ungrounded plugs that have two parallel, flat prongs. These plugs have specifications of 125V for voltage and 15A for current. Type A plugs are compatible with Type A and Type B sockets.

- **Type E**

Type E electrical plugs are made up of two spherical pins. They have a female interface or hole that accepts the earthing pin from the socket, measuring 14 mm in length and 4.8 mm in diameter. It is located beneath the plug pins. Polarity reversal is prevented by Type E plugs' asymmetric pin arrangement.

- **Type C**

Type C plugs are the most widely used electrical plugs in the world. It is an ungrounded, unpolarized plug with two spherical pins.

- **Type F**

The pin sizes of Type F plugs are almost the same as those of Type E plugs, with the exception of their irregularly shaped pins. In Type F plugs, a female earthing contact is swapped out for two earthing clips. These plugs also have two plastic slots on the left and right sides to provide even more stability when used as a massive built-in plug.

- **Type B**

Type B plugs are identified as grounded plugs and are frequently referred to as three-pin plugs. They consist of two parallel flat prongs and a spherical grounding pin. The current and voltage ratings for Type B electrical plugs are 15A and 125V, respectively.

- **Type G**

Type G connectors, which have an inbuilt fuse, are made up of three rectangular pins placed in a triangle. Type G plugs come with 3A or 13A fuse ratings. Heavy-duty appliances usually use Type G plugs because of their greater current rating. Because of this, Type G plug and socket arrangements are regarded as among of the safest for both the user and the equipment. The fact that Type G plugs are only compatible with Type G sockets—which further implies that they cannot be utilised with other socket types—is their sole drawback.

•Type K

Type K electrical connectors consist of two circular pins, including a U-shaped earthing pin.

These plugs have a different earthing connection configuration and gender than Type E plugs. Type K plugs has an integrated 16A current rating and are designed to avoid polarity reversal.

•Type D

Type D electrical plugs are made up of three circular pins stacked in a triangle. Because of their asymmetrical pin arrangement, Type D plugs are protected against polarity reversal.

Uses of Electric Plug

An electric plug's primary purpose is to pull power so that different appliances can operate.

In addition, an electric plug can be used for the following purposes:

- A wide range of devices, including as TVs, washing machines, microwaves, and refrigerators, are connected by electric plugs to power sources for electricity.
- Speakers, DVD players, game consoles, televisions, and other home entertainment devices are powered by plugs.
- To maintain suitable indoor temperatures, fans, air conditioners, heaters, and other climate control devices are powered by electrical plugs.
- Electric plugs are used to power medical equipment that runs on electricity, such as oxygen concentrators, CPAP machines, and electric wheelchairs.
- Electric plugs are frequently used in factories, workshops, and construction sites because power tools, machinery, and other equipment there need a constant supply of electricity.
- Plugs are required when utilizing wall sockets or power strips to charge portable electronics like laptops, tablets, smart phones, and other gadgets. Electric vehicle owners use charging plugs to recharge their cars' batteries by plugging them into home or station charging outlets

Benefits of Electric Plug

Here are some of the significant benefits of an electric plug:

- Many products may be easily moved and used anywhere there is an electric socket, providing freedom and mobility, provided there is a power source nearby.
- Electric plugs help lower energy consumption and encourage energy conservation by enabling equipment to be used only when necessary and by making it easy to cut power

when not in use.

- One of the biggest benefits of an electric plug is that it lowers overall energy usage and utility prices, which benefits customers by promoting the use of energy-efficient appliances and gadgets.
- By promoting the use of energy-efficient equipment and reducing energy waste, electric plugs can help reduce the environmental effects of electricity production and consumption. Initiatives for sustainability may benefit from this.
- A variety of electrical gadgets and equipment can function without complicated installations thanks to the ease and convenience of electric plugs, which make it easy to access power sources.
- Electric plugs provide safety features including grounding, over current prevention, and insulation to reduce the potential for electrical hazards and ensure the safe operation of connected devices.
- From little electronic devices to large household appliances, electric plugs come in a wide range of sizes and forms to fit a number of devices and equipment.

The electric socket is the conduit that allows electricity to enter electrical devices and machinery. One of the most important components for conducting electricity is an electric socket. While the sizes and shapes of different electrical outlets may vary across different countries, their basic functions are always the same. The maximum current that sockets can withstand, or their voltage capability, is another characteristic that distinguishes them.

3.5 Types of Electric Sockets

Among the wide spectrum of electric sockets, here are some of the widely popular sockets used in the world:

- **Two Pin Electrical Outlet**

2-prong/pin outlets, which are only intended for ungrounded circuits, are commonly found in homes. They are still mostly utilized for low-power household products that require low voltage or low current.

- **Three Pin Electrical Outlet**

The 3-prong/pin electrical socket is the current standard for outlets in homes and offices. It is becoming commonplace to utilize these outlets in place of the 2-prong outlet for routine,

light electrical use at home. Compared to two-pin outlets, these three-pin grounded outlets are far safer.

- **AFCI Outlets**

The purpose of AFCI outlets is to stop arcing and the possibly harmful effects of the extreme heat that the arc produces. The AFCI outlet detects arcing and promptly deactivates the outlet via an inbuilt breaker.

- **GFCI Outlets**

GFCI outlets are used in places like laundry rooms, restrooms, kitchens, basements and outdoor spaces where water is always present. The GFCI outlet functions in a very simple way. When an internal breaker trips due to a short circuit or overload, the electrical supply to the affected outlet is immediately cut off, preventing any potentially dangerous situations. It keeps people safe from electrical shocks and shields residents from electrical risks.

Uses of Electric Sockets

An electric socket's main purpose is to supply electricity to different purposes. Furthermore, electrical outlets have several purposes:

- Providing electricity for CPAP machines, electric wheelchairs, and home healthcare equipment.
- Connecting Internet of Things (IoT) devices, like smart plugs and switches, for automation and control.
- Providing electricity for the tools, machinery, and equipment used by manufacturing facilities and businesses.
- Garages and workshops can be used for power tools like routers, saws, drills, and sanders.
- Supplying energy for essential household equipment including refrigerators, washing machines, and dishwashers.
- Providing power for emergency lights, radios, and communication equipment during blackouts.

3.6 METER INSTALLATION

Self-contained

Self-contained meter installations, which are meters that are installed directly into the meter socket or base in series with the customer's electrical service, are commonly used by

smaller residential and commercial electrical services. Because all of the customer's power passes straight through the meter, self-contained installations are also occasionally referred to as series installations. In this instance, measuring the customer's usage properly doesn't require any additional auxiliary equipment.

Since the meter is installed in series with the customer's service, when it is removed from a self-contained installation, the electrical service is turned off. Utility companies. Before smart meters were invented, it was necessary to send someone to a customer's home to disconnect them. This required hiding the hole in the meter base and taking out the self-contained meter. Reinstalling the meter in the meter base was necessary to restart the service when an overdue payment was made or a new customer moved into the building. Disconnecting and reconnecting can be done remotely using a smart meter.

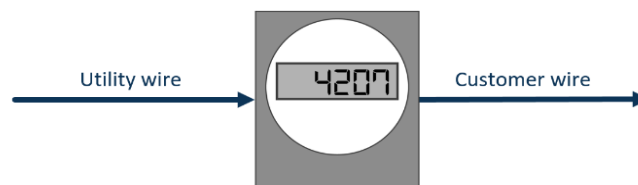


Fig 2.9 self-contained meter installation

For single-phase services with 200 amps or less, three-phase services with 320 amps or less, and single-phase voltages with 240 V or less and three-phase voltages with 600 V or less, self-contained systems are frequently used.

Transformer-rated

To accurately and reliably assess the electrical consumption of customers whose loads exceed the rating of ordinary meters, additional auxiliary equipment is required. This situation often affects substations and generating switchyards, which are components of the distribution and transmission network, as well as large commercial and industrial clients. Because the customer's usage is too high to harm the meter, the meter is not linked in series with the service in a transformer-rated installation.

Because the meter cannot handle all of the amps or electricity, a separate transformer is required to measure the customer's usage. These instrument transformers include both current transformers (CTs) and potential transformers (PTs).

The purpose of the instrument transformer is to reduce the voltage or current of the power as it flows through the meter. The meter then calculates actual power demand or usage using

ratios. For example, if an instrument transformer decreased the current or voltage flowing through it to 10% of the actual flow, the meter would multiply the reading by 10 to get an accurate number.

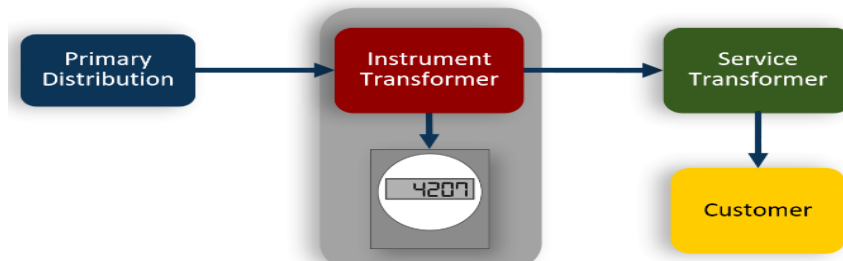


Fig 3.0 transformer-rated meter installation

In a transformer-rated installation, the meter and associated auxiliary equipment are often positioned in a special cabinet near the service transformer. A transformer-rated service, as opposed to a self-contained system, will keep the customer's electricity flowing even if the meter is disconnected. Therefore, this installation requires a lock-out device so that the utility may lock off service when the meter is removed.

3.7 SWITCH BOARD:

A "switch board" is a device (like a telephone exchange) that has a panel with electric switches designed so that several circuits can be connected, combined, and managed.

Switchboards are used to safely distribute electricity throughout commercial and industrial buildings. The switchboard of an electrical distribution system divides a power supply into branch circuits and contains a fuse or circuit breaker for the protection of each circuit in a single enclosure. Switchboards with a maximum voltage rating of 600 Vac/Vdc and a maximum bus rating of 6000 A typically meet UL891 and NEMA Standard PB2.

Types of switch boards:

Although there are many different kinds of low voltage switchboards, the three most popular ones are remote power panels (RPPs), sub-distribution boards (SDBs), and main distribution boards (MDBs).

Which Type of Switch is Better

Single-pole switches are suitable for controlling a single light or fixture, whereas three-way or four-way switches work best in larger areas with several entry points.

3.8 ELECTRIC BELL

An electric bell is a gadget that produces an audible ringing sound when electricity is passed through it. Electric bells, which were originally used as signaling devices or doorbells, often contain a push button adjacent to an entrance door. These days, they are used in a wide range of signaling applications, including alarm bells, timers, robots, and game scorekeepers.

Electromagnet

A soft metal core that conducts a current is looped around the input jack of an electromagnet; a type of magnet used in electric bells. Thus, this magnetic field is produced by passing an electric current over the surface of the metal core. Iron rods are commonly used as metal cores in electromagnet construction. Soft iron rods are typically used for an electromagnet's core for two reasons: first, they strengthen the magnetic field of the electromagnet; second, when the copper wire wrapped over the core is not in use, it demagnetizes readily, enabling an electric bell to operate without a hitch. For this reason, electric bells require an electromagnet.

Working of Electric Bell

The electric bell operates on the basis of the electromagnet principle, which is the magnetic influence of current.

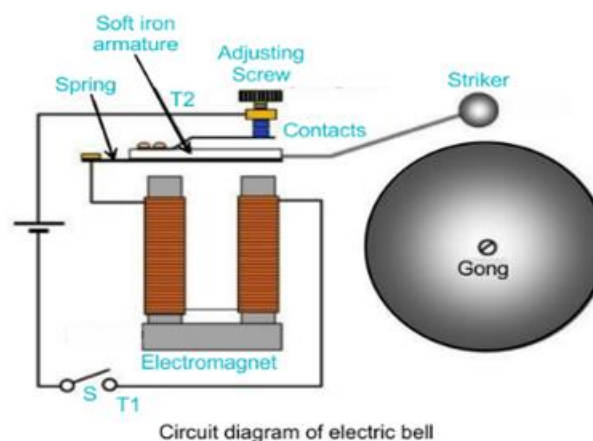


Fig 3.1 Electric Bell

Coils of wire strung around iron rods protect the electromagnet of an electric bell. An electric current flowing through the coils causes the bell to strike, and the electromagnet creates a magnetic field that pulls the impeller towards it. When electric current flows via coils, the iron rods of the electromagnetic force acquire magnetic properties. The iron rod is drawn towards the clapper by the iron piece that is fastened to it. When the clapper strikes the bell, it rings or makes a sound.

- **Electromagnet:** An electromagnet is a magnet that is powered by electricity. In contrast to a magnet, the amount of electricity that flows through an electromagnet may be altered to alter its power. When the current flow is halted, the magnetic property is lost.
- **Armature:** An electric bell is made up of a U-shaped electromagnet in front of a ferromagnetic strip or armature that is held in position by a spring. The armature serves a purpose and collaborates with the interrupter, as the electromagnetic theory illustrates.
- **Spring:** Consequently, the spring is attached to an adjustable screw.
- **Armature rod:** The motion of the armature can initiate movement of the iron hammer attached to it.
- **Hammer:** An iron hammer is used to strike the electric bell's striking head. A hammer attached to a spring on one end and an iron ball on the other strikes the gong.
- **Gong:** The gong is the main element that generates sound when it makes direct contact with the striker.

Importance of Electromagnet in Electric Bell

An electric bell is an electro-mechanical device that is powered by an electromagnet. An electric bell operates according to the theory of electromagnetism, which is the magnetic influence of current. According to the electromagnetism phenomena, magnetic fields are linked to moving electric charges. Electric bells are most frequently found in our homes, workplaces, and buildings. In order to offer an alert in the event of a fire, they are included into business fire alarm systems.

Application of Electric Bells

The electric bell has the following applications:

1. Our houses, buildings, or offices are where we most frequently use electric bells.
2. To alert us in the event that a thief tries to break in, electric bells are also used as a component of robber alarm systems.

3. They are utilized in industrial sectors as a component of smoke detectors to emit an alert in case of a fire. Buzzers, hard drives, speakers, and many other gadgets have electric bells.
4. Industrial settings also make use of them.

3.9 INDICATOR

What is an electrical indicator?

An electric current flow indicator detects when an electrical current passes through a device and shows a visible response to demonstrate that the equipment is functioning correctly. The first and second inputs of the current flow indicator's voltage and current regulation circuit are connected to the first and second conductors, respectively. Machine tools, switch cabinets, power distribution cabinets, and ships are common places to find indicator lamps, also referred to as indicator lights. An indicator light, sometimes referred to as a pilot lamp, is used to indicate whether a system is operating or if the power is on.

The light information functions of the indicator light.

1. Attract the operator's attention or give them guidance on how to do a specific operation.
2. Signal the execution or completion of a particular command, state, condition, or evolution type.

Color	Meaning	Explanation	Typical application
Red	Abnormal situation or alarm	Keep an eye out for possible danger and take appropriate action.	When the temperature rises above the designated (or safe) level, the protective device cuts off the crucial component of the apparatus.
Yellow	Caveat	Variables getting close to their limit values or state changes	Overload is permitted for a specific amount of time, and the temperature deviates from the typical value.
Green	Preparation and safety	Conditions for safe operation indicator that the equipment is prepared for operation	operation of the cooling system
Blue	Special	Any function not included i	The position of the

	instructions	n red, yellow, and green	selector switch is as indicated.
White	General signal	Anything that isn't covered by red, yellow, and green like a particular action is considered nor	

3.10 What is an Air Conditioning?

Working Principle of Air Conditioning

Like a pump, an air conditioner draws heat from a space and sends it outside. It is composed of a heat exchanger coil, compressor, and a mechanism that runs on refrigerant gas. The absorption of heat during the change from a liquid to a gas is a basic physics theory that supports the operation of air conditioning equipment. In actuality, air conditioners move heat from a room's inside to its exterior.

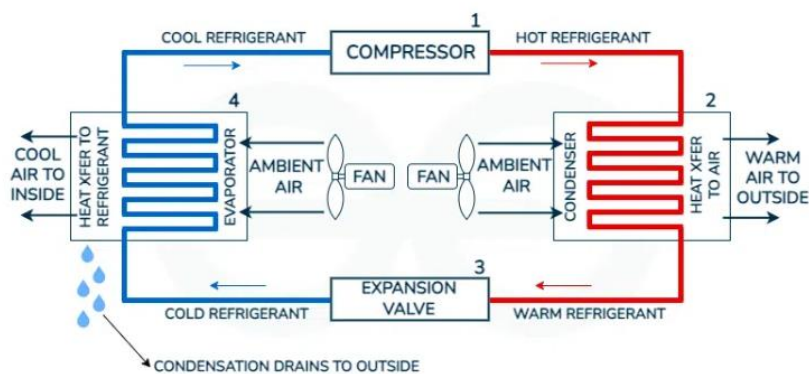


Fig 3.2 Working of Air Conditioning

- The refrigerant begins as a low-temperature, low-pressure liquid in the home's evaporator coil. The heat from the ambient air is absorbed here. Meanwhile, the refrigerant transforms from a liquid to a low-pressure gas due to heat absorption. This gas is then delivered to the unit outside the house, where a compressor is used to increase the gas refrigerant's temperature and pressure. It is then moved to the condensation coil, which discharges the heat that was previously trapped inside your house into the atmosphere. A fan pushes air across the condenser for cooling and turning the refrigerant into a high-pressure liquid.
- The refrigerant is then reintroduced into the house via the expansion valve to complete the cycle. Consequently, your home's heat (hot air) is transferred outdoors to aid in cooling.

Components of Air Conditioning Systems

- Compression, condensation, expansion, and evaporation are the cycle's four fundamental processes. The diagram that follows shows the cycle.

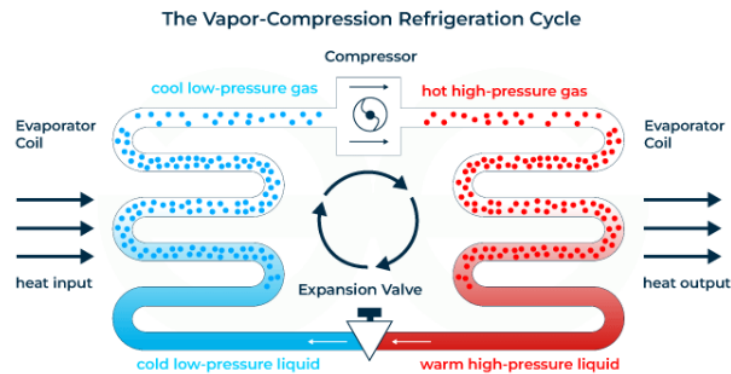


Fig 3.3 Working of Air Conditioning

- The compression process functions similarly to the cycle's engine. The compressor starts compressing the superheated refrigerant vapour after drawing it via the suction pipe. Compressed vapour's energy, temperature, and pressure all increase quickly. On the other hand, the particular volume was significantly lower. At this point in the cycle, the refrigerant vapour's temperature and energy are at their maximum points. During this procedure, extremely hot, high-pressure vapour is produced.
- **Condensation process:** This is where the condenser's function is crucial; it condenses the refrigerant, or transforms gas into liquid. When exterior air passes through the coil of the condenser, which is filled with hot, gaseous refrigerant, it is done. It causes heat to be transferred from the refrigerant to the cooled outdoor air, which is where too much heat is diffused into the atmosphere. Heat transmission to the air and piping surface area are increased by the condenser coils that pass through the condenser. Refrigerant changes from a vapour to a hot liquid due to the high pressure and temperature drop.
- The expansion mechanism is reached by the refrigerant in a heated, high-pressure state. By acting as a catalyst, the expansion device quickly lowers the refrigerant pressure, making it easier for it to boil in the evaporator. Reducing refrigerant pressure is the expansion device's primary function. The refrigerant turns into a mixture of cold liquid and vapour due to the rapid drop in pressure at the expansion mechanism.

- **Evaporation process** – The refrigerant begins to pass through the evaporator when it turns into a cold liquid and gas mixture (vapour). The refrigerant begins to flow through the evaporator once it has cooled to a cold liquid and gas mixture. By boiling (or evaporating) the refrigerant that passes through it, the evaporator cools the surrounding air. This happens when cold refrigerant travels through the evaporator coil and warm air passes over it.

The refrigerant receives heat from the air and instantly cools it before releasing it into space. To maximise heat transfer from the refrigerant to the surrounding air, the evaporator coil, like the condenser coil, loops around the evaporator. The low-pressure fluid refrigerant is rapidly boiled by the heated air directed towards the evaporator and then flows as a cool gas or vapour to the compressor.

3.11 Types of Air Conditioning

There are some list of Air Conditioning given below:

Geothermal heat pumps, window air conditioners, central air conditioners, portable air conditioners, and hybrid air conditioners, Evaporator coolers, floor-mounted air conditioners, ductless mini-split systems, package terminal air conditioners (PTAC), and smart air conditioners.

Refrigeration

Refrigeration is the process of extracting heat from a material, system, or place in order to chill it. Usually, a process of evaporation and condensation in the form of refrigerant fluid accomplishes this. Perishables must be stored in a refrigerator to maintain pleasant indoor temperatures and support a variety of industrial operations. A refrigerator, one of the most widely used kitchen appliances, preserves food and beverages by using the chilling principle. It is made up of various essential parts.

- **Compressor:** By compressing the refrigerant gas, this component raises its temperature and pressure.
- **Condenser:** After being pushed into the condenser coils, the hot, high-pressure refrigerant gas releases heat into the surrounding air and condenses back into a liquid under pressure.
- **Expansion valve:** As the liquid refrigerant enters an evaporator, it passes via an expansion valve, which lowers its temperature and pressure.

- **Evaporator:** Inside the refrigerator, low-pressure, relatively low-temperature liquid refrigerant evaporates to a gaseous condition, absorbing heat from the inside and further cooling it.
- **Refrigerant:** Heat is transferred from the refrigerator's interior to the exterior by this fluid, which circulates continuously throughout the system. The system's evaporation and condensation move heat from the refrigerator's inside to the exterior, keeping the interior temperature relatively low.

By altering compressor operation, which controls flow rate and, consequently, cold output, the refrigerator's temperature can be changed. In a nutshell, refrigeration is a process that uses a refrigerator as an appliance to store food and beverages while removing heat from the air or item to chill it down. The act or process of drawing heat from materials and/or space to lower their temperature is known as refrigeration.

This process is achieved through the use of a refrigeration cycle, which typically involves the following components: the compressor, condenser expansion valve and evaporator. Here's a simple diagram illustrating the refrigeration cycle:

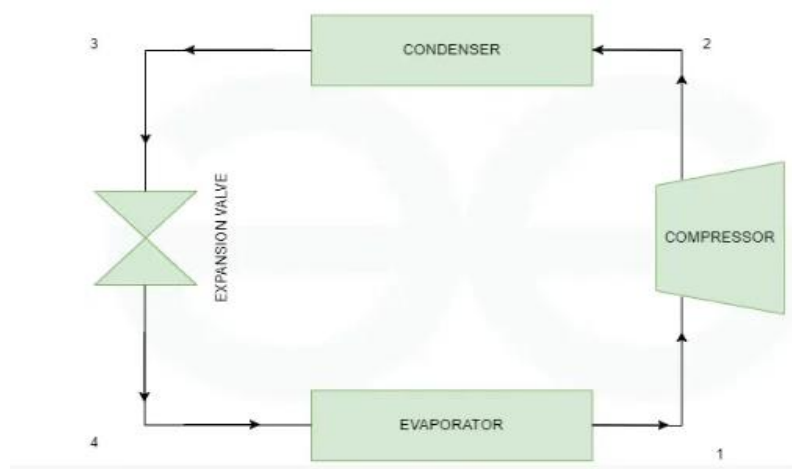


Fig 3.4 Working of Refrigerator

Working of Refrigerator

- An acting variable that raises the refrigerant's temperature and pressure is the compressor.
- The heated and high-pressure refrigerants pass through the condenser coils, where they turn into liquid and release heat into the atmosphere. The liquid refrigerant then enters the expansion valve, where it loses pressure.
 - The low-pressure, cold liquid refrigerant passes through the wine refrigerator's evaporator coils and vaporizes as a result of internal heat absorption. This process then continues as the gas refrigerant is drawn back to a point of compression.
- The recurrent processes of expansion, evaporation, condensation, and compression

2.2.2 Application of Refrigeration and Air Conditioning

1. Food Preservation and Storage

- How refrigeration is used in the food business Among the uses are bulk handling facilities for the freezing, chilling, and cold storage of end goods, additives, and raw materials.
- Walk-in refrigerators, freezers, and ice makers can be found in public spaces like cafeterias, restaurants, and other commercial kitchens.

2. HVAC Systems for Buildings

This is why houses and other locations, such as workplaces or commercial spaces, as well as other establishments like schools, employ air conditioning and heating.

- Consistent comfort heating and cooling to regulate the indoor air's humidity level.
- Indoor ventilation that will eliminate pollutants and supply enough fresh air.
- The development of contemporary HVAC technologies, such as VRF systems and certain thermostats, has resulted in energy conservation.

3. Medical and Pharmaceutical Applications

- Laboratory equipment, such as ultra-low temperature freezers and cryogenic storage systems used for research or clinical trials;
- Cryogenics is essential for storing vaccines, medications, and biological materials appropriately at required temperatures to prevent product inactivation or spoiling.

4. Data Center Cooling

- In order to remove heat produced by computer servers and other electronic equipment and maintain ideal operating conditions, air conditioning systems are necessary in data centres and server rooms.
- The requirement for appropriate humidity and temperature control to prevent the equipment from becoming excessively hot and damaging.

5. Industrial Processes

Different industrial applications use refrigeration like:

- Businesses that used petrochemicals in distillation columns, cooling reactors, and other associated machinery.
- Lancing hot/cold rolling mills, mould casting, and stamping are used to regulate temperatures during heat treatment procedures in welding and machining.
- Pharmaceutical manufacturing to prepare active ingredients for medications and store them at regulated temperatures.

Advantages and Disadvantages of Refrigeration and Air Conditioning

Air conditioning and refrigeration systems have certain disadvantages in addition to their many benefits. Let's examine these technologies' benefits and drawbacks:

Advantages

- A cozy indoor atmosphere.
- Perishable Goods Preservation
- Controlling the temperature in industrial processes, energy efficiency, and cooling data centres

Disadvantages

- Impact on the Environment;
- Energy Use and Maintenance Needs
- Initial Expense
- Aesthetic and Noise Factors

3.12 How Do Washing Machines Work?

In summary, washing machines function by filling with water, sloshing your clothing in soapy water, then spinning and rinsing to partially dry them. The washing machine features an inner and an outer drum to do this.

Water can enter and exit through the holes in the inner drum, which is the one you can see. Additionally, it contains paddles for moving clothing. While the inner drum rotates, the outside drum—which is invisible—is meant to hold water. The outside drum is waterproof, in contrast to the inside drum.

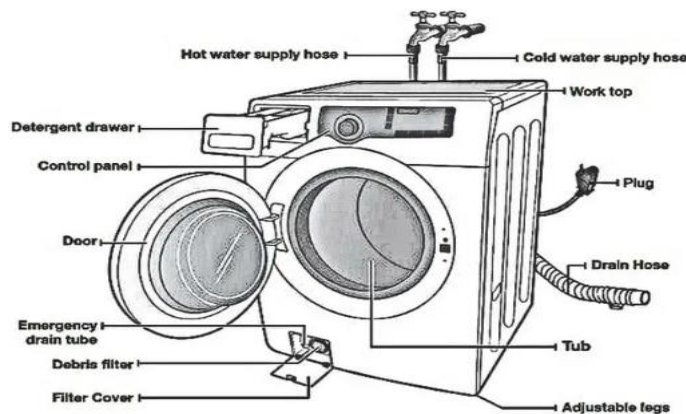


Fig 3.5 Working of Washing Machines

The motor that drives the pump, agitator, and inner drum; a thermostat that regulates the water's temperature; a pump that extracts water after your clothes are clean; a programmer that electronically regulates the cycles of washing, rinsing, and spinning; two pipes that allow clean water to enter; and one pipe that allows dirty water to exit.

Why Do Washing Machines Break Down?

A washing machine can malfunction for two main causes. First, it isn't being used or maintained appropriately. Sometimes, by reading your user manual and doing some troubleshooting, you can resolve these issues. The second is that one of its primary components malfunctions.

1. The motor goes bad:

Overuse might cause the engine in your washing machine to fail. The motor may overheat and malfunction in certain circumstances. The motor may start to function again if you let your machine to cool down, but you should still call a repairman because this is

typically an indication that your motor is failing. The coupler, which is composed of rubber or plastic and links the motor to the machine's gearbox, may also fail, causing the motor to malfunction.

2. The pump breaks:

Because your pump is made of plastic, it may break occasionally. Additionally, the pump may leak, allowing water to spill onto the floor. Lastly, your pump may be blocked in some way, which would prevent it from moving water.

3. The belt wears out or slips loose:

The washing tub will not move if your belt fails. Frequently, belts will just deteriorate and come free.

4. The gaskets fail:

Water cannot sleep or escape because of the gasket. You'll need to hire a repairman when water starts to leak due to the gasket wearing out.

Working of Top Loading Washing Machine

The inside wash tub is where the washing process starts. It involves soaking the garments in a solution of water and detergent. The detergent comprises of numerous enzymes which operate on clothes to clean them. In the inner wash tub, the cloths are tossed and positioned on either side of the agitator.

The activity of enzymes on clothing is enhanced by an agitator. A plastic cylinder in the middle of the inner tube is called an agitator. An agitator is typically finned. Its finned structure helps it do its job. To ensure that the clothes and detergent mix thoroughly, an agitator's job is to move the clothes up, down, and back and forth. The agitator also moves the inside wash tub. For a particular amount of time, this motion is repeated. The agitator ensures this by washing the garments. The wash cycle is the name given to this cycle.

The timer helps with manually setting the clothing' wash time. Depending on how many clothes are in the washing machine in automated mode, the time is automatically set. A strong electric motor moves the inner tub and agitator on a regular basis during the wash cycle. In actuality, the engine speeds up the washing process.

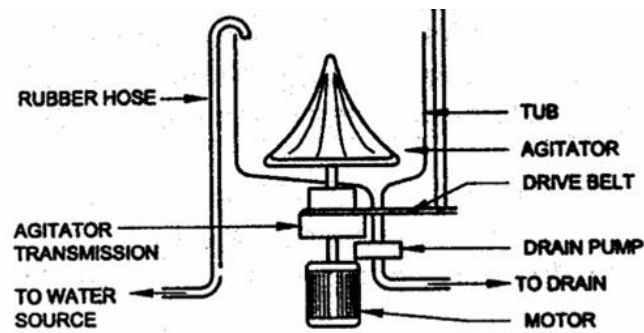


Fig 3.6 Simple structure of Top loading washing machine

There are several perforations in the inner tube. Centrifugal force extracts wash water from the clothing and forces it through these holes to the stationary outer tub. From here, the water is pushed out via the drain tube. The inner tube is again filled with clean water when the wash water has departed. Once more, the agitator tumbles the garments. Known as the rinse cycle, this is the second cycle. This cycle's goal is to release the detergent particles that have become lodged in the cleaned fabric. The machine drains out water once more at the end of the rinse.

Another electric motor kicks in when the water has been drained out. At a very high speed, it stirs the inner tube. Remaining water is spun out of the fabric by the centripetal force and expelled through the drain tube. This procedure has a time limit. The clothes becomes only wet instead of soaked. The third cycle, known as the spin cycle, aims to extract as much water as possible from the damp clothing. Draining is done through the drain tubes in each phase. The cloth has been thoroughly cleaned and let to air dry.

Advantages of Washing Machine

- 1) Time is saved by washing machines
- 2) Washing machines are easy to operate and keep clean.
- 3) Extended Clothes Life
- 4) Not Too Much Water
- 5) Durable
- 6) Easy Drying for Clothes.

3.13 MICROWAVES

Powerful microwaves are produced and permitted to land on food items. The meal is cooked by these waves, which uniformly heat the molecules in the food particles.

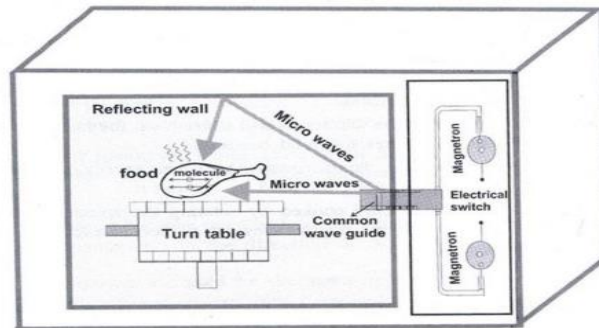


Fig 3.7 Microwaves

To effectively focus microwaves onto the food particles, the food container is composed of reflective metal walls that resemble mirrors. To cook the meal uniformly, the food is rotated using a rotating spinning device known as a "turn table." The microwaves are transferred from the magnetron to the food compartment via a common wave guiding route. For safety, sturdy metal enclosures completely enclose the entire arrangement. Modern microwave ovens also come with a timer display so that users can select different settings for cooking different foods, such as grills and tandoors

WORKING

- The electricity is turned on, and the food to be cooked is set out on the turn table. Electrical energy is transformed into powerful radio waves, or microwaves, by the magnetron.
- Through a tube known as a common wave guide, the magnetron directs these microwaves into the food compartment. The microwave then bounces back and forth between the reflective metal walls before reaching the food.
- This Micro wave penetrates inside the food and makes the molecules in the food to vibrate.
- The vibrations will generate heat, and as the molecules vibrate more quickly, the food gets hotter. In this manner, the energy from the microwaves is transferred to the food's molecules, heating it and cooking it.
- The food is cooked evenly by slowly turning the table or spinning it so that the microwaves reach every part of it.

ADVANTAGES:

- It is compact and portable; it cooks food quickly and easily and efficiently.
- A microwave can enter food more deeply than two centimeters.
- Microwave ovens are less expensive.

DISADVANTAGES

Since microwaves are harmful, leaks should be avoided.

- The door's lock should always be thoroughly inspected.
- Cell phones should not be used in locations where microwave ovens are used for cooking.
- Food that is cooked or heated unevenly is unhealthy.

3.14 GEYSER

- Water heater is also called as geyser when the electricity is used as source of heating using the electric resistance rod.

How does an Electric Geyser heat up water?

- The geyser uses electric resistance to transform electrical energy into thermal energy.
- The heat is transferred to the water in the bucket or geyser.
- The water forms a convection flow after heating.
- Water geysers, sometimes referred to as hot water heaters or just heaters, are appliances that heat water for cooking, cleaning, and bathing, among other household uses.

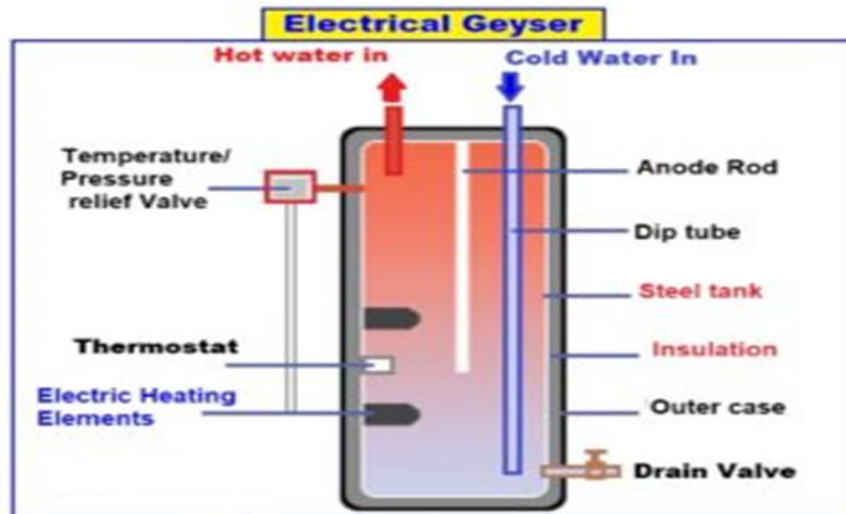


Fig 3.8 Electric Geyser

- The most popular kind of water geyser is the storage tank heater, which heats water in an insulated tank and keeps the water at that temperature until it is needed. These devices have become an essential component of contemporary homes, offering a steady supply of hot water at the touch of a tap.
- The size of the tank, which is usually mounted on a building's wall or roof, can vary from 20 to 80 gallons, depending on the needs of the household. Typically, the tank is composed of glass-lined steel or stainless steel, which helps to prolong the heater's life and prevent corrosion.

Main Benefits a water Geyser

- The convenience of having a steady flow of hot water is one of the key advantages of owning a water geyser; it removes the need to wait for water to heat up in a pot or on the stove and enables several people to use hot water at once without having to wait.
- Furthermore, a lot of contemporary water geysers have a number of features including temperature control, energy-saving settings, and safety features like automated shut-off.
- But it's crucial to remember that water geysers may be costly to buy and install, and they use a lot of energy. As a result, picking a water geyser that is effective and fits the needs of the home is crucial. When making a purchase, factors including the type of fuel source, the size of the tank, and the heating element type should all be taken into account.

What are Parts of Electric Geyser?

A water tank with two pipes attached makes up the electric geyser:

- The cold-water inlet pipe
- The hot water outlet pipe

Thermostats regulate the heating components installed in the water tank, preventing the water from rising above a predetermined temperature. Typically, the tank is encased in a metal casing and covered with insulating mater

Important Points to take care of during the geyser installation:

Make sure the bathroom's geyser unit has enough room; make sure it is the right height above the floor; and make sure the water supply is constant.

- The geyser unit needs to be positioned at the proper elevation above the ground.
- A sturdy wall construction.
- Water pipes were unblocked.
- Secure electrical connections.

3.15 What is Jet Pump?

Water delivery, irrigation, and pressure boosting are just a few of the uses for a jet pump, which is a multipurpose and effective water pump. Because of its dependability and very low maintenance needs, a jet pump is a popular pump type among both businesses and households.

How Does a Jet Pump Work?

- The fundamental idea behind how a jet pump works is fluid dynamics. It takes water from a well, tank, or other water sources by using a venturi nozzle to create a stream of water that creates suction. A drop in pressure caused by the water jet's acceleration through the venturi enables the water to be pulled into the pump and subsequently propelled through the discharge pipe.
- The diffuser, venturi nozzle, and impeller are the main parts of a jet pumps. While the venturi nozzle speeds up water flow and produces suction, the impeller is in charge of producing the water jet. Lastly, by slowing down the water's flow, the diffuser transforms its kinetic energy into pressure energy, which can be utilized to raise or move the water.

Types of Jet Pumps

Shallow well jet pumps and deep well jet pumps are the two primary varieties of jet pumps. Every kind is made for certain uses and well depths.

1. **Shallow Well Jet Pumps:** Jet pumps for shallow wells are made for water sources that are up to 25 feet deep. These pumps just have one pipe that connects to the water supply and one impeller. Typically, shallow well jet pumps are utilized for irrigation and water delivery in homes.
2. **Deep Well Jet Pumps:** Water can be extracted using deep well jet pumps from sources up to 150 feet deep. Water is drawn from the well by one pipe and returned to the well via the venturi nozzle by the other pipe in this two-pipe system. Compared to their shallow well counterparts, deep well jet pumps are more complicated, but they can deliver water for larger properties and commercial uses.

Applications of Jet Pumps

- Water treatment
- pressure boosting
- irrigation
- Residential water supply and industrial application.

4.1 Conversion of Electrical Energy

Numerous additional types of energy can be created from electrical energy, such as:

- **Light:** Electrical energy is transformed into light energy by a light bulb.
- **Thermal energy:** Electrical energy is transformed into thermal (heat) energy by an electric heater.
- **Mechanical energy:** Electrical energy is transformed into mechanical energy by an electric motor so that work can be done.
- **Sound energy:** Electrical energy is transformed into sound energy by speakers.

4.2 Work Done

When charge moves through a circuit, work is done. Energy is exchanged when electrical work is done, as is the case with all "work." There are two methods by which we can compute the energy transmitted.

Using Power and Time

The energy transported per second is indicated by power. We must multiply power by the entire number of seconds in order to calculate the overall energy delivered over an extended period of time.

Power $\times$ Time equals energy transmitted.

$$E = Pt$$

Where:

- **E** is the **energy transferred** in joules(**J**)
- **P** is the **power** in watts(**W**)
- **T** is the **time** in seconds(**S**)

4.3 Power Rating

An appliance's power rating indicates how much electricity it needs to run normally. It specifies the amount of grid energy that is being transferred to power the instrument or device. This number is typically located in the handbook that is included with the appliance or electrical gadget. The maximum power at which the unit can function safely is also indicated by the power rating.

For instance, the power ratings of the majority of phone chargers range from 5 to 25 watts. This indicates that the gadgets can only use a maximum of 25 watts, or 25 joules per

second, of electricity from the mains. In contrast, the power rating of a standard electric kettle is 3. This is 120 times more than the power consumed by a phone charger.

Power Rating Formula

The nameplate of electrical and electronic devices indicates the power rating. Additional details include the maximum power rating at which the gadget or appliance may function safely, as well as the specifications of the plug and cable that can manage the electricity entering the machine. You can use the data to calculate the amount of energy that is exchanged in a circuit.

An appliance or device's power rating can be found using one of two formulas. The first one is as follows:

$$\mathbf{P = VI}$$

Power = Electric Potential x Current

The power, P, is measured in watts (W) with this method, the potential difference, V, between the energy transfer locations is measured in volts (V), and the current is measured in amperes (A). Accordingly, the energy transmitted when a current of one ampere (A) passes across a potential difference of one volt (V) is known as one watt of electric power.

The work or energy transferred by a piece of electrical equipment in a specific amount of time is employed in the other formula that determines an appliance's power rating.

$$\mathbf{P = W \text{ (or E) } / T}$$

Power = work done/time taken

Using this method, t is the time in seconds, and W is the work done or E, which is the energy transferred in joules. The power rating is expressed in watts. You can utilize megawatts or kilowatts for appliances or electrical devices with higher power consumption values.

Efficiency = useful work output / total input energy transfer

You will receive a decimal result that is less than or equal to one when calculating efficiency. A great approach to express this value is with a percentage. To find the so-called percentage efficiency, multiply the efficiency by 100%. A gadget is 100% efficient if it transforms all of the power that is supplied into usable power. A 30% efficiency rate, on the other hand, indicates that only 30% of the power input is transformed into work or useful energy by the device.

The conventional filament light bulb is a prime illustration of an inefficient equipment. Although the electric filament bulb is meant to provide light, 95% of the energy that enters the device is transformed into heat energy, which is then wasted.

Power Rating Calculation

Let's examine how particular appliances or gadgets relate to the power rating formula. The samples we provided at the beginning of the essay will be used for this. These are the electric kettle and cell phone charger. We will use the power rating formula to calculate how much energy a 3-watt phone charger would need to transfer compared to a 3000-watt kettle that can boil a litre of water in five minutes.

Step 1

Find the specified values

T (kettle) = 5 minutes; P (kettle) = 3000 W

P (charging unit) = 3 W T =?

Step 2

Convert the values in step two.

5 minutes is equal to $5 \times 60 = 300$ seconds.

Step 3

Rearrange the power equation to determine the energy transferred to the kettle.

900,000 joules = 900 kilojoules (kJ) = P = E/t E (kettle) = P (kettle) x t E (kettle) = 3000 W x 300 seconds

E (kettle) = 3000 W x 300 seconds = 900,000 joules = 900 kilojoules (kJ)

Step 4

Calculate the time it takes for a phone charger to transfer the same energy as the kettle

$P = E/t$

$T (\text{charger}) = E (\text{charger}) / P (\text{charger})$

$T (\text{charger}) = (900 \times 10^3 \text{ joules}) / 3 \text{ watts} = 300,000 \text{ seconds}$

Step 5

Convert the time from seconds into minutes

$300,000 \text{ seconds} / 60 \text{ seconds/minute} = 5,000 \text{ minutes}$

According to this power rating calculation, a kettle can transfer the same amount of energy in five minutes, but a phone charger will need five thousand minutes to do the same.

Power Ratings of Common Appliances

An appliance's power rating, which is measured in watts (W), is directly correlated with how much energy it uses. An appliance with a 2000 W power rating, for instance, will use 2000 joules per second. Because of this, you may use the power rating of your electrical and electronic gadgets to estimate how many watt hours they require. To determine the size of your solar energy system or the amount of power it should produce each day, you will need the information if you plan to install solar panels.

Most devices and appliances have a power rating that can be found on the equipment or in the handbook. To determine its watt-hour consumption, find its rated power. Remember, though, that not all appliances are always in use. Some only run for a few minutes every day. For instance, you only spend a very small portion of an hour using garage openers. A 500-watt lawnmower may seem like a lot of power, but if you only use it once a week, that's 71 Watt-hours a day.

Furthermore, some appliances like refrigerators seem to run constantly. Actually, they only run for 12 to 15 hours every day (turning on and off as needed). The same is true of air conditioners. As a result, they don't always utilize the most energy.

Be mindful of phantom loads as well. Phantom loads, sometimes referred to as vampire power or ghost loads, are the energy used by plugged-in equipment. These appliances or gadgets usually take very little current typically less than one watt. But because they're operating around the clock, that sum builds up sometimes by as much as 100 watt-hours in a single day. TVs, printers, and microwaves are a few examples of devices that require energy even when they are not in use.

Let's look at the power rating of common appliances, devices, and equipment.

Appliance/Equipment	Watts (Power rating)
Freezer	1240 W
Refrigerator	1411 W
Air Conditioner (room)	1000 W
Air Conditioner (central)	2000 to 5000 W
Fan (box)	200 W
Fan (ceiling)	120 W
Fan (table)	10 to 25 W

Laptop computer	20 to 75 W
Desktop PC	80 to 200 W
Printer	100 W
LCD monitor	100 W
Heater (engine block)	150 to 1000 W
Heater (portable)	1200 W
Heater (waterbed)	400 W
Coffee machine	1000 W
Dishwasher	1200 to 1500 W
Electric kettle	1200 W
Microwave	600 to 1500 W
Electric oven	1200 W
Hot plate	1200 W
Toaster	800 to 1500 W
Clothes washer	800 W
TV (LCD)	150 W
TV (plasma)	200 W
Stereo	10 to 30 W
Vacuum cleaner (portable)	150 W
CFL bulb (40 watt equivalent)	11 W
CFL bulb (60 watt equivalent)	18 W
CFL bulb (75 watt equivalent)	20 W
LED bulb (40 watt equivalent)	10 W
LED bulb (60 watt equivalent)	13 W
LED bulb (75 watt equivalent)	18 W
LED bulb (100 watt equivalent)	23 W
Weed Eater	500 W
Hedge trimmer	450 W

4.4 Energy consumption

Energy consumption determines how much of it is used. It is the precise use of energy for a predetermined amount. This relates to how much energy is used by any living creature or how much electricity is generated by power plants. The two types of energy use differ from one another. Since the term "joules" is used to scale energy as a standard unit of measurement, it is frequently measured in gigajoules per year. The energy calculation formula is designed to determine how much energy is utilised over a specific amount of time.

The formula for Energy Consumption

The energy consumption for a specific time period is determined using the energy formula. The number of power units used in a specific time period is multiplied to determine the amount of energy consumed. The following is the formula for energy consumption:

$$E = P*(t/100)$$

The measured Joules or kWh is denoted by the letter E in this expression.

P stands for power used in watts per unit.

It stands for the amount of time that power is used.

Therefore, this formula can be used to determine energy usage.

Energy consumption is categorized according to a number of factors, some of which are included below:

1. Global energy supply: as the name implies, there is a lot to learn about in the world. As a result, there is a large supply of energy that must be specified by elements such as the preparation and production of fuel for power worldwide, energy consumption, and energy utilized for transportation.

2. Global energy consumption: the amount of energy used globally in relation to the amount of energy that is available for usage. This energy is computed at various demographic levels using the energy consumption formula, which is $E = P*(t/100)$.

3. Domestic energy consumption: This refers to the amount of energy required for household tasks or for household purposes. Typically, the number of households in the population with the specified demographics is multiplied by the energy consumption formula to determine the domestic energy consumption.

4. Electric energy consumption: This category specifically takes into account energy use in the form of electricity. It excludes all other forms of energy that are utilized to carry out tasks. Additionally, by calculating the power unit value based on the meter readings, the energy consumption formula can be applied here.

4.5 Electrical Energy Unit in kWh:

The kilowatt-hour (kWh), a non-SI unit of energy, is used to measure electrical energy. When one kilowatt of power is consumed for an hour, the energy consumption is one kilowatt-hour. The following information relates to kilowatt-hours:

- **Conversion**

One kilowatt-hour is equal to 3.6 mega joules in SI units.

- **Billing**

Kilowatt-hours are a common unit used by electric utilities to bill customers for electricity.

- **Calculation**

One kilowatt-hour is equal to 1,000 watts multiplied by 3,600 seconds, which is 3,600,000 watt-seconds or joules.

- **Cost**

Electricity providers charge customers based on how much electricity they use per kilowatt-hour, depending on the electricity unit price.

4.6 Calculation of EB Bill

Essential components of the TNEB electricity bill calculator you should know

To provide you with an accurate estimate, the TNEB bill calculator considers a number of factors:

Fixed charge: Depending on the connection type, a fixed fee that is applied to all users.

Energy charge: Determined by counting the units (kwh) used.

Meter rent: The cost of the electricity meter, if any.

Refunds or subsidies: Any government reimbursements or subsidies are also taken into account.

TNEB bill tariff 2024

Units	Subsidy	Unit Range		Unit cost
	(≤ 100 u)	From	To	
≤ 100	Rs. 4.50 × u	1	100	Rs. 0.00
≤ 200	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
≤ 400	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
≤ 500	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
		401	500	Rs. 6.00
≤600	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
		401	500	Rs. 6.00
		501	600	Rs. 8.00
≤ 600	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
		401	500	Rs. 6.00
		501	600	Rs. 8.00
		601	800	Rs. 9.00
≤ 1000	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
		401	500	Rs. 6.00
		501	600	Rs. 8.00
		601	800	Rs. 9.00
		801	1000	Rs. 10.00
< 1000	Rs. 450	1	100	Rs. 0.00
		101	200	Rs. 2.25
		201	400	Rs. 4.50
		401	500	Rs. 6.00
		501	600	Rs. 8.00
		601	800	Rs. 9.00
		801	1000	Rs. 10.00
		< 1000		Rs. 11.00

Conclusion

Every Tamil Nadu home has to have access to the TNEB eb bill calculator. It not only assists with estimating monthly electricity costs, but it also fosters a deeper comprehension of how energy use may affect your account.

4.7 Joule's Law of Heating

The rate at which resistance in a circuit transforms electric energy into thermal energy is described mathematically by Joule's law. James Prescott, an English physicist, found that the square of the current and the wire's electrical resistance determine how much heat is produced in a current-carrying conductor every second. Joules are used to describe the heat produced by the current flowing through an electric wire. Joule's law can be expressed mathematically as follows.

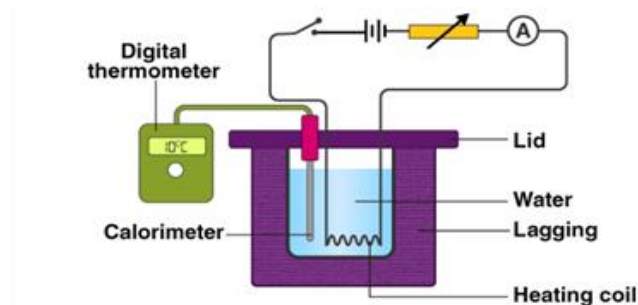


Figure 3.9 Joule's Law

Joule's first law

The relationship between the heat generated by an electric current passing through a conductor is demonstrated by the joule's first law.

$$Q = I^2 R T$$

Where,

- I denote electric current; Q denotes heat; and R denotes the conductor's electric resistance.
- T stands for time.
 - When the circuit current and current flow remain constant, the quantity of heat produced is proportional to the electrical resistance of the wire.
 - When the electrical resistance and current supply are both constant, the quantity of heat produced in a conductor carrying current is proportional to the square of the current flow across the circuit.
 - When resistance and current flow are held constant, the quantity of heat generated by the current flow is proportional to the flow duration.

4.8 Single-Phase Power Supply

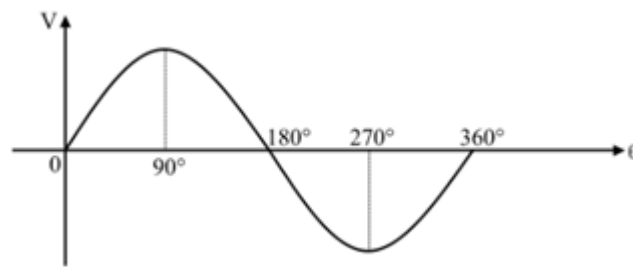


Figure 4.0 – Single phase

In our daily lives, we rely on alternating current (AC) power supplies for our electric needs. The kind of electric power source known as an alternating current (AC) supply is one in which the electric current's direction and magnitude fluctuate over time. Alternating sources, such as alternators, provide about 90% of the electric power that we consume in our homes, offices, and businesses.

Based on the number of phases in the supply system, the AC power supply can be classified into two types viz. –

- Single-Phase AC Supply
- Three-Phase AC Supply

Single-phase power supplies is a kind of AC power supply where only two conductors phase and neutral are used to distribute AC electricity. In actual operation, a sinusoidal AC power supply is employed; Figure displays the single-phase power supply's waveform. In the single-phase power supply, the voltage reaches its highest value at 90° during the positive half-cycle and 270° during the negative half-cycle.

In the 1-phase power supply, the phase wire carries the electric current from source to load while the neutral wire provides the return path to the current. In India, the RMS value of voltage in a single-phase supply is 230 V at 50 Hz frequency.

The main drawback of single-phase power supply is that the single-phase power is of pulsating nature, which causes the vibrations in the motors. However, almost all residential power supplies are single phase which are used to run electrical appliances such as fans, coolers, air conditioners, lamps, etc. The phase wire of a one-phase power supply transports

The electric current from the source to the load, and the neutral wire offers the current a way back. A single-phase supply in India has an RMS voltage of 230 V at a frequency of 50 Hz.

The primary disadvantage of single-phase power supplies is their pulsing nature, which creates vibrations in the motors. Nonetheless, practically all single-phase home power sources are utilized to power electrical devices like fans, air conditioners, coolers, lamps, and more.

4.9 Three-Phase Power Supply

A three-phase power supply is an electric power source that uses three-line conductors to distribute AC electricity to the load. Three-line conductors for three phases and perhaps a neutral is present in a three-phase power supply. The type of connection between the source and load windings determines whether a neutral wire is present in the three-phase power supply; for example, a neutral wire is present in a star connection but absent in a delta connection.

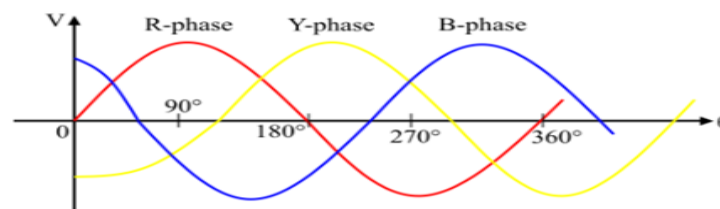


Figure 4.1 Three phase power supply

5.1 INSULATION FOR WIRES

Insulated wire or cable is encased in a non-conductive substance that resists electric current, protecting the wire and cable from harm.

An essential outer covering that is placed to cables and wires to shield them from the elements is wire insulation. At the same time, the jacket or insulation stops current from escaping from the wires into the environment. Wire insulation comes in a range of types and materials to satisfy the requirements of various wire materials, environments, and applications.

Materials Commonly Used for Wire Insulation

Wire insulation can be made of a variety of materials, such as plastic, rubber, and fluoro polymers, depending on the application.

- **Plastic:** Numerous beneficial properties, such as ductility, electrical resistance, UV resistance, and fire resistance, make plastics perfect for wire insulation. The following are common polymers used to insulate electrical wires:
- **Polyvinyl Chloride (PVC):** Because of its great durability and affordability, PVC is one of the most often used insulating materials. It is very resistant to fire and chemicals and it can withstand temperatures ranging from -55°C to 105°C without losing its resilience or shape.
- **Semi-Rigid PVC (SR-PVC):** In addition to being highly resistant to heat, water, acids, and alkalis, SR-PVC can tolerate abrasion.
- **Plenum Polyvinyl Chloride (Plenum PVC):** For usage in plenum spaces, Plenum PVC is designed to be more fire resistant.
- **Polyethylene (PE):** Compared to PVC, PE is tougher and denser. It is particularly resistant to cracking at temperatures between -65° C and 80° C and is extremely electrically insulating.
- **Polypropylene (PP):** Polypropylene has higher temperature resistance than PE, with operating temperatures between 30° C to 80° C.
- **Polyurethane (PUR):** PUR is very resistant to abrasion, chemicals, and water. It is also flexible. It works exceptionally well in maritime applications and at low temperatures between -62°C and 93°C.
- **Chlorinated Polyethylene (CPE):** CPE is a reasonably priced insulation that has outstanding resistance to heat, oil, and external factors.

- **Nylon:** usually applied over softer insulating materials as a supplementary insulator. A flexible protective layer with low water resistance is offered by nylon.
- **Rubber:** Particularly at lower temperatures, rubber materials are more flexible than plastic. The following rubber materials are used to insulate wires:
 - **Thermoplastic Rubber (TPR):** TPR is resistant to wear, UV rays, and a wide range of temperatures.
 - **Neoprene (Polychloroprene):** Superior abrasion and cut resistance, as well as resistance to oils and solvents, are all displayed by neoprene.
 - **Styrene Butadiene Rubber (SBR):** SBR is commonly used for MIL cables at temperatures between -55° C and 85° C since it is more temperature resistant than neoprene.
 - **Silicone:** Silicone is prized for its great flexibility, remarkable flame retardancy, and heat tolerance up to 180° C.
 - **Fiberglass:** Fiber glass can withstand temperatures as high as 482°C. It is also water and chemical resistant.
 - **Ethylene Propylene Rubber (EPR):** EPR is extremely resistant to electrical currents, alcohol, aqueous acids, alkalis, heat, and oxidation.
 - **Chloro sulfonated Polyethylene (CSPE):** CSPE functions at a wide range of temperatures and is ideal for low-voltage applications. It also offers strong resistance to chemicals and ultraviolet light.
 - **Ethylene Propylene Diene Monomer (EPDM):** EPDM functions at temperatures between -45°C and 177°C, has low conductivity, and is incredibly flexible.
- **Fluoro polymer**
 - The polymers known as fluoropolymers have exceptional resistance to solvents, acids, and bases. The following fluoropolymers are frequently used in electrical insulation:
 - **Perfluoro alkoxy (PFA):** PFA's low dissipation factor makes it a great choice for increased electrical efficiency. Although it is more expensive than alternative insulating solutions, it can tolerate temperatures ranging from -65° C to 250° C.
 - **Poly tetra fluoro ethylene (PTFE):** Outstanding resistance to heat, moisture, chemicals, and oil is provided by PTFE. It can withstand temperatures ranging from -73°C to 204°C with great flexibility.
 - **Fluorinated Ethylene Propylene (FEP):** FEP resists chemicals and UV rays and has outstanding electrical insulating qualities. It is incredibly flexible and durable.

- **Ethylene tetra fluoro ethylene (ETFE):** Superior resistance to chemicals, electrical current, and high-energy radiation is demonstrated by ETFE, which also has a high melting temperature and outstanding corrosion resistance.
- **Halar ethylene chloro tri fluoro ethylene (ECTFE):** ECTFE is a melt-processable polymer with exceptional strength, flexibility, and chemical resistance. It may also be extruded and braided for further abrasion resistance.
- **Polyvinylidene Fluoride (PVDF):** PVDF is a cost-effective insulation that satisfies UL 910 requirements for plenum cables and is lightweight, flexible, and flame resistant.

Wire Insulation Applications

The type of material used for wire insulation is largely determined by the application for which it is used.

Plastic wire insulation is used for:

- Medical applications
- Food & beverage industry
- Military purposes
- Industrial power plants
- Interior spaces either beneath raised floors or above dropped ceilings
- Marine and low-temperature environments
- Power & control cable applications
- CPE cable insulation displays

Rubber wire insulation is used for:

- Heat treating
- Glass and ceramic kilns
- Foundries
- Aluminum processing

Fluoro polymer wire insulation is used for:

- Military applications
- Automotive industry
- Household appliances.

5.2 Colour Specification for Mains, Return and Earth

Standard colour coding for electrical wires aids in classifying each wire's role inside the circuit. Red-green-black, or RGB, wires are used in India. These RGB wires all have distinct purposes.

Red – The phase in an electric circuit is indicated by a red wire. It is a live wire that cannot be linked to a black or red wire. Some switch leg types are red isused. Switch leg is the wire that emerges from a switch's bottom terminal and turns on when it is switched on. This is what switches the load on and off.

Black – In an electric circuit, a black wire indicates the neutral line. Inside an electric panel, the neutral wires are connected to the neutral busbar. Abusbaris are conductive metal bars used for distribution that draw in electric current. No wire of any other colour can be attached to a black wire. Because black wire is neural, it can conduct current and charge. It primarily transports the unbalanced load, or what is known as the turn current. Return current to the electrical board or panel and return current to the electricity/current not in use.

Green – In an electric circuit, a green wire indicates grounding. There should only be one green wire that can be linked to another green wire.

Generally speaking, grounding cables are not intended for fans or lighting. Green wires are typically utilized for socket applications. A socket may be used for a microwave, TV, AC, geyser, etc. Switches typically only have two wires: phase and neutral.

In a flat or room additionally, there could be sockets for us. All of these sockets' grounding wires are connected to a single point/grounding terminal in the residence. This grounding terminal is a copper rod or screw that is attached to one side of the distribution box (DB). The cable travels from the DB to the ground bus bar via the society meter box. The copperplate is the ground bus barista inserted deep down inside the ground. This is called as earthing in common language. The function of green wire is to provide a path to ground for circuit's electric current. Especially times when a live wire inside the circuit happens to touch metal or other conductive metal. In case of this occurrence, green wire could be carrying major current and therefore it should also be handled with care.

Single Phase 230VAC

- **RED**=Phase, Hotor Line, (L)
- **BLACK**=Neutral(N)
- **YELLOW/ GREEN**=Earth Conductor “Protective earth”(PE)

Three Phase 415+AC

- **RED**=Phase1or Line,(L1)
- **YELLOW**=Phase2 or Line2,(L2)
- **BLUE**=Phase3 or Line3, (L3)
- **BLACK**=Common Neutral(N) (Used in Two Lines System Only)
- **YELLOW/ GREEN**=Earth Conductor “Protective earth”(PE)

In the event of an electric fault, the earth cable is a wire inside the electrical circuit that offers a secure route to the ground for excess current. Ground wire is the same as earth cable.

	Single Phase	Three Phase
Phase Conductor (Line)	 Red or  Yellow or  Blue	 Line 1 Red  Line 2 Yellow  Line 3 Blue
Neutral Conductor	 Black	
Protective Conductor (Earth)	 Green-and-Yellow	

The purpose of the earth cable includes:

1. To ensure the safety of electrical equipment and power plants.
2. Turning off the electricity when the current flow is irregular
3. Lightning strikes can be neutralized.

When a live wire comes into contact with the metal casing of electrical equipment, electric shock may result. This is why the earth cable is so important.

Earth cables have the following characteristics:

- They have a low resistance
- Good electrical conductivity
- Excellent corrosion resistance
- Good equipotential bonding characteristics
- Durable
- Ability to with stand high fault current.

5.3 White wires or Gray wires

Electricity is returned to the breaker box via these lines. To finish the circuit, they basically send electricity back to a grounded area of an electrical panel from a hotwire.

Function of Fuse

A fuse is a tool used in electrical engineering that protects a working electrical circuit against over current. Here is a list of some of the fuse's primary purposes.

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

Information like the ampere rating, voltage-rating, and interruption rating are carried via the marking on the fuse.

Types of Fuses

- AC fuses
- DC fuses

Definition of Circuit Breaker

A circuit breaker is a switching device that acts as a switch to safeguard the electrical system from damage by interrupting the defective current.

Working Principle of Circuit Breaker

There are two essential contacts in a circuit breaker, and they are:

- Fixed contacts
- Moving contacts

The contacts come into contact with one another and transfer the current when the circuit is closed, which is a typical state. Current-carrying contacts, referred to as electrodes under a closed-circuit breaker, interact with one another under the force of a spring. Through the opening or closing of the circuit breaker's arms, the system is switched and maintained. Applying pressure to the trigger opens the circuit breaker. The breaker's trip coil is activated when an improper current flows through any component of the system; this causes the coils to move apart and open the circuit.

Fuse:

An electrical safety device known as a fuse is used to cut off an electrical circuit when the current within it becomes excessive.

Circuit Breaker:

- A circuit breaker is an electrical switch that operates automatically and is intended to prevent damage to an electrical circuit caused by an excess of current that could result from an overload or short circuit. A circuit breakers primary job is to stop current flow when a defect is identified.
- Circuit breakers are used in heavy machinery or electronic equipment that needs a lot of current, whereas fuses are used in devices that need relatively little current.
- These days, circuit breakers are used in the majority of homes because of their many benefits. Because of their compact size and ease of use, fuses are frequently utilized in motor protection circuits.

Fuse vs Circuit Breakers

Fuse	Circuit Breaker
Works on the thermal and electrical properties of the conducting materials	Works on the switching principle and electromagnetism
It doesn't give any indication of overloads	It gives an indication of over loads
Fuse can only be used once	A circuit breaker can be used many numbers of times
Provides protection against power over loads	Provides protection against power over loads and short circuits
It detects and interrupts faulty circuit conditions	It performs the interruption process only. Faults are detected by a relay system.
Low breaking capacity compared to the circuit breaker	High breaking capacity
Automatic operation	Can either be automatic or manually operated
Operating time off use is 0.002 seconds	Operating time of the circuit breaker is 0.02–0.05 seconds
Low Cost	High Cost

5.4 MCB– Miniature Circuit Break

When selecting electrical gadgets or appliances, safety comes first. An overload or short circuit results from damage caused by power fluctuations or excessive current flow. Therefore, it is imperative to include a safety feature that protects electrical equipment and circuits against over current. One of the most widely utilized tools for circuit protection in the early days was the fuse. When an overflow of current happens, a metal wire or strip inside a fuse burns, stopping or interrupting the current.

Miniature Circuit Breaker

- Have you ever considered the consequences of a short circuit or overflow of current on your home appliances, like your refrigerator, oven, washing machine, fan, and many more? If appropriate circuit breakers are not fitted in these devices, they burn and cause fire incidents. A safety item having an electro-mechanical mode of operation is a miniature circuit breaker.

- An MCB is an automated switch that activates when the circuit experiences an excessive amount of current. It doesn't require a manual replacement to be reclosed. The type of MCB will determine whether a fuse needs to be changed or rewired after it has been operated. Fuse is hence referred to be one of the sacrificial devices. This is the primary justification for using MCBs in most circuits instead of fuses. Additionally, the MCB's switches immediately cut off when there is a circuit failure, making it simple to identify the device's issue.
- Managing The MCB swiftly recovers the supply and is comparatively safe. Miniature circuit breakers, or MCBs, need less maintenance and can be reset rapidly. MCBs guard against solenoid short circuit current and overload current by operating on a bi-metal concept.

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: When the current is two to three times the actual current rating, the circuit is cut off. Because MCBs, or miniature circuit breakers, are extremely sensitive to short circuits, they are used in the production of semiconductors.

B Type MCB: It is used for cable protection and trips the circuit when the current is three to five times the flow rate.

C Type MCB: It is used in both commercial and residential appliances, such as transformers, fluorescent lighting circuits, and IT equipment, such as PCs, servers, and printers. It trips the circuit when the current exceeds 5–10 times the real current flow.

D Type MCB: When the current surpasses 10–20 times the current flow and presents excessive resistance, the circuit trips. Motors are one application for it.

K Type MCB: can tolerate up to 8–12 times the current flow and is used in heavy-duty equipment such as X-ray machines, compressors, and winding motors.

Working Principle of MCB

When electricity overflows through miniature circuit breakers (MCBs), the bimetallic strip becomes hot and bends, deflecting the current. A latch is released when the bi-metallic strip deflects. By halting the circuit's current flow, the latch turns off the MCB. This procedure helps protect the equipment or appliances from the risks of over current or overload. The MCB needs to be manually turned on in order to restore the current flow.

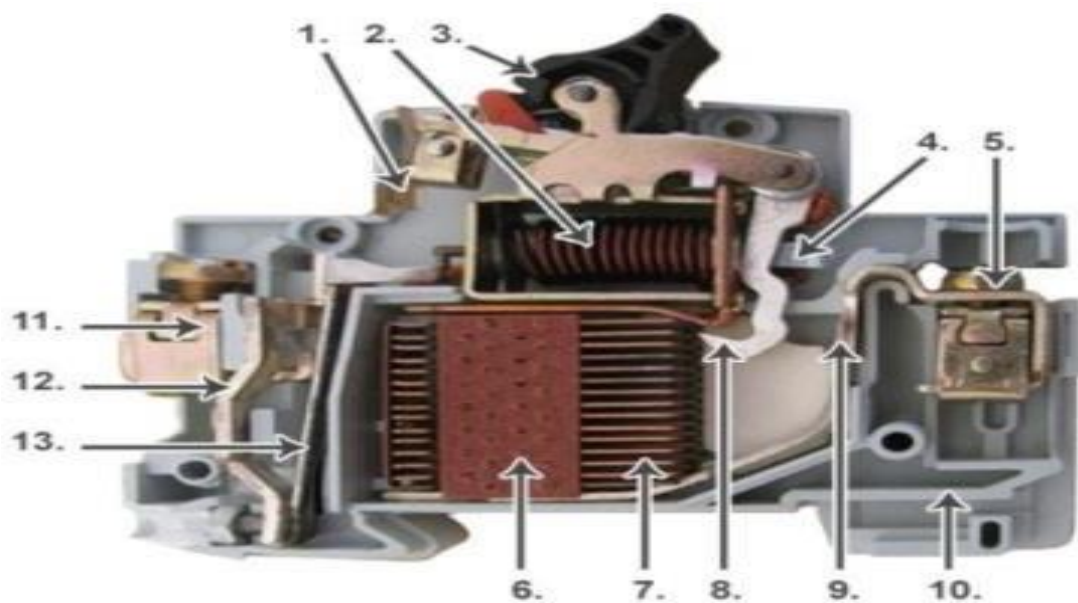
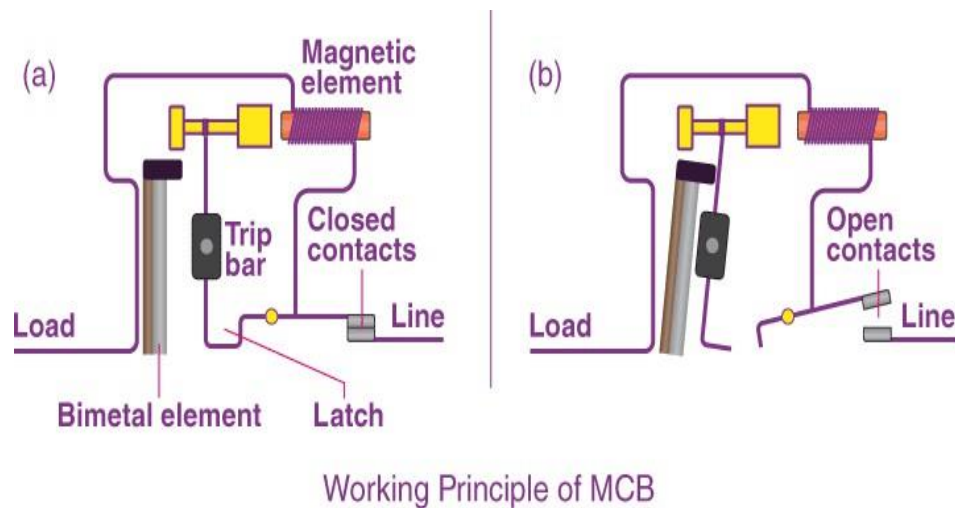


Fig 5.4 working real-time MCB.

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. DinRail Holder
11. Outgoing Terminal
12. Bi-metallic Strip Carrier
13. Bi-metallic Strip



When a short circuit occurs, the current increases abruptly and in an unanticipated manner, which causes the solenoid-connected plunger to move electromechanically. By striking the trip lever and opening the circuit breaker connections, the plunger triggers the latch mechanism's automatic release.

An MCB is a straightforward, user-friendly device that requires no maintenance. MCB replacement is simple. The trip unit is the essential component that powers the MCB, or miniature circuit breaker. The circuit's magnetic guards against short-circuit current, while the bi-metal in the MCB circuit guards against overload current.

Uses of MCB

- The majority of electrical appliances used in homes or businesses contain MCBs, which are essential for the safe and effective operation of electric devices. Lights, heaters, and fans are examples of household appliances that need MCBs to continuously inspect and safeguard the connection.

5.5 Types, Working, and Application of Earth Leakage Circuit Breaker (ELCB)

ELCB or Earth Leakage Circuit Breaker is a safeguard that guards against earth leakage. The earth leakage circuit breaker was originally a voltage detecting device, but it is now a current sensing device. The original ELCBs are still called ELCBs, but they are no longer in use. The current ELCBs are now called RCCBs or RCDs.

Earth Leakage

Earth leakage is the term used to describe the unintentional flow of electrical current from the live conductor to the earth. Electrical shock could result from it passing through a person's body or between their inadequate insulation. If the leakage current is more than 30mA, the resultant electrical shock could be lethal. Consequently, when such current leakage is discovered, protection devices are utilized to cut off the power source.

Causes of Earth Leakage

There are several causes of earth leaking. Broken conductors or damaged live conductor insulation may be the cause. It may also happen if the equipment is not correctly grounded and the live conductor comes into touch with the equipment body. Current can flow from a person's body to the earth when they touch the equipment or conductor.

Earth Leakage Circuit Breaker

One kind of circuit breaker used to guard against leakage current is the Earth Leakage Circuit Breaker, or ELCB. When it detects the leakage current, it cuts the circuit and cuts off the load's power supply. Electrical shocks from the earth leak have the potential to be lethal. The primary purpose of an ELCB is to prevent electrical shock. They don't provide short circuit or overload protection. As a result, they need to be connected in series with a small circuit breaker.

Function of ELCB

The primary purpose of the ELCB safety device is to guard against electrical shock. It keeps track of any leakage current that leaves the circuit via an unforeseen route. It is unable to guard against short circuit current or overloading.

Operation of ELCB

In a typical scenario, the source current enters the load through the live wire and exits the load through the neutral wire. Actually, the amounts of the two currents are equal. There is an imbalance between the live and neutral wires if the electricity flows through any

unforeseen channels. A current transformer is used by the ELCB to detect the imbalance, and an electromagnetic relay is used to break the connections.

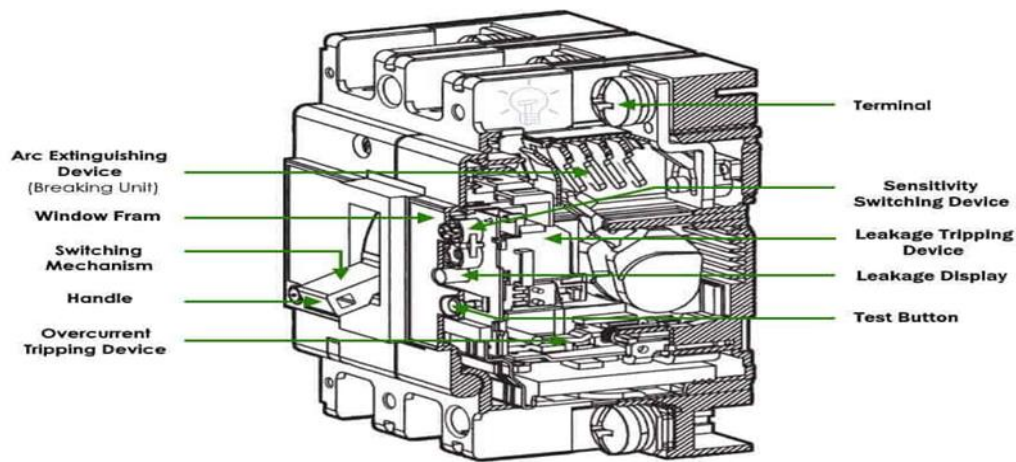


Fig 5.5.1 working real-time ELCB.

Types of ELCBs

There are two types of ELCB classified based on its operation principle;

- Voltage ELCB
- Current ELCB

Although both varieties of ELCBs are capable of detecting leakage current, they differ in terms of sensitivity and protection degree. The current ELCB was developed after the voltage ELCB. Current ELCB is superior to voltage-based ELCB. As a result, the current ELCB is now called RCCB or RCD, and the voltage ELCB is now called ELCB to prevent misunderstanding.

Voltage ELCB

Voltage The voltage level between the equipment's body and the earth is what the ELCB uses to function. The circuit is immediately broken by using the voltage differential to identify the leakage current.

On both the supply and load sides, it has neutral connections as well as terminals for both phases. It contains two additional terminals that link to the earth and the equipment's body. When current leaks, these terminals—which are really attached to the electromagnetic relay—are essential for cutting the circuit.

Working Principle

The equipment's body is linked to one of the relay coil's terminals, while the other terminal is directly connected to the ground. The coil is able to detect the voltage differential between the equipment's body and the earth. There will be a voltage differential between the coil's terminals if the live wire breaks or its insulation fails and it comes into contact with the equipment's body. Consequently, the coil becomes energized and electricity begins to flow through it. Electromagnetic force is generated by the relay. The relay generates enough force to pull the latch when the current reaches a predetermined threshold. By doing this, the latch break unlocks the connections, cuts off the equipment's power source, and guards against electrical shock.

Since the relay only functions when the leakage current passes through it, the earth connection is therefore required. Since the electricity must pass via the relay in order to break the circuit, it won't do so if it leaks through any other portions of the circuit and travels down any other undesired path.

Advantages

- It helps in protection against electrical shocks.
- They are less sensitive and do not trip unnecessarily.
- They are less expensive.

Disadvantages

- It cannot sense the current leakage from phase to any other earthed body.
- It cannot prevent electrical shock in case of touching the phase conductor directly.
- It only trips when the leakage current flows through the earth conductor.
- It requires an extra connection with the body of the equipment and earth.
- It is less sensitive and cannot detect low leakage current.
- Electrical equipment that normally leaks voltage might trip ELCB unnecessarily.

It is outdated and has significantly more drawbacks than benefits. Thus, replace any old voltage ELCBs that you may have put in your house with current ELCBs or RCCBs. They offer the best defense against any type of leakage current and are more dependable and effective.

5.6 Types based on Poles

According to the poles of circuit breakers, the ELCB is classified into three types.

- **2-Pole ELCB:** In a single-phase system, it serves as protection. It features two outgoing and two ingoing terminals with neutral and phase connectors.
- **3-Pole ELCB:** It is used for protection in a three-wire three-phase system. It contains three terminals for inbound and outbound traffic.
- **4-Pole ELCB:** It is used for protection in a four-wire three-phase system.

Short-Circuit & Over loading

A short circuit is a circuit that permits electricity to flow through a random path with little resistance. The electrical equipment's insulation is harmed by the high current caused by the short circuit. It mostly happens when the insulation between the conductors deteriorates or when the two wires come into contact with one another.

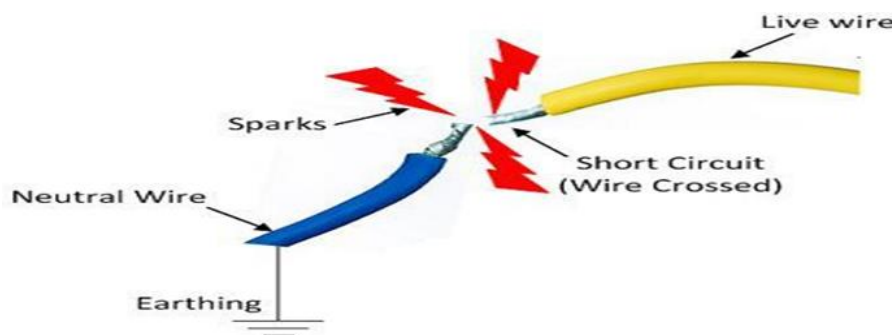


Fig 5.6.1 Short Circuit

The short-circuit current's magnitude increases by thousands of times compared to the typical current. When there is a short circuit, high magnitude current flows across the network and the voltage at the fault point drops to zero. The power system is negatively impacted by the short circuit in a number of ways.

1. The power system experiences a strong current due to the short circuit, which generates excessive heat and ultimately triggers an explosion or fire.
2. The arc created by the short circuit seriously damages the power system component.
3. The short circuit affects the stability of the network which upsets the continuity of the supply. The synchronous generator, synchronous motor, and synchronous condensers are the primary sources of short circuit power.

Overloaded: The overload indicates that the power system network is subjected to more than the desired load. Although it can't be zero, the voltage at the overloads is reduced to a very low value. While still high, the current in the overloaded state is far less than the short circuit current. Overloading raises the temperature in joules, which damages electrical equipment by causing burns. An overload will result, for instance, if an 800-watt load is placed across an inverter with a 400 watt rating.

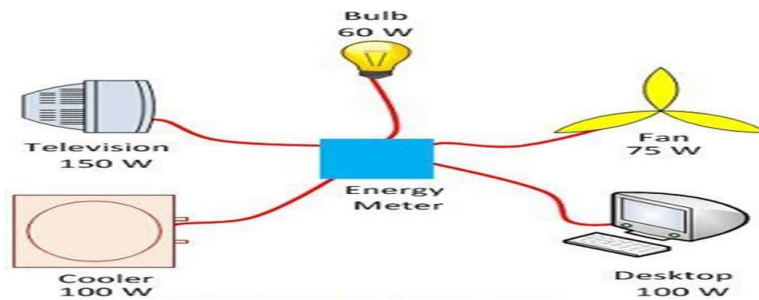


Fig 5.6.2 overloaded Condition

Basis For Comparison	Short Circuit	Overload
Meaning	The network's malfunctioning point experiences a short circuit when the voltage drops to zero and an erratic high current flow through it.	An overload occurs when the system is subjected to a load that exceeds the intended value.
Voltage	Zero	Although it can't be zero, the voltage drops.
Current	High	Low as compared to short circuit.
Occur	It occurs when the neutral and live wire touch each other.	It occurs when a large number of devices are joint in a single socket.

Tips to avoid Electrical shock

Your body's physiological response to an electrical current flowing through it is known as electrical shock, or simply electric shock. Ten to twenty milliamperes (mA) can generate muscle contractions so intense that you are unable to release the electrical wire or other current source, while currents as low as one milliamper (mA) to 0.001 amp can cause a tingling sensation. Ventricular fibrillation, a potentially fatal irregular heartbeat, can be brought on by currents greater than 100 mA.

Steps To Prevent Electric Shock

There are a number of crucial electrical safety procedures to adhere to. In order to reduce the risk of electrical shock, it is first and foremost imperative that electrical equipment not come into touch with damp surfaces. Second, to avoid damage, pull the plug instead of the cord to ensure safe usage while unplugging. Electrical cords must also be installed and arranged correctly to prevent trip hazards and other damage. Finally, to guarantee appropriate administration and utilization of electrical power, it's critical to comprehend your switchboard.

To prevent electric shock incidents, individuals should take the following vital steps:

1. Before working on any electrical appliances or equipment, turn off the power sources. By taking this little precaution, the risk of electric shock can be greatly decreased and unintentional contact with live electrical circuits can be avoided.
2. In locations with water, use Ground Fault Circuit Interrupters (GFCIs). In order to prevent electric shock, GFCIs are made to recognize electrical current imbalances and swiftly cut off the power. They are frequently utilized in outdoor spaces, kitchens, and bathrooms where there is a greater chance of coming into touch with water.
3. Keep electrical appliances away from water sources. Water is an excellent conductor of electricity, and any contact between electrical devices and water can create dangerous situations
4. To prevent any risks, regularly check electrical wires and replace any that are frayed or damaged right away.
5. When using extension cords, exercise caution. Extension cord overloading can cause overheating and possible electrical risks. Avoid using numerous power strips or adapters linked to a single outlet and abide by the manufacturer's recommendations about the

maximum load capacity of extension cords.

6. Keep in mind that by doing these things, you can greatly lower the chance of electric shock events and increase safety.

First Aid for Electric Shock

Electric shock can be a life-threatening situation that requires immediate attention. Here are the steps to follow:

- **Priorities safety:** Before providing any assistance, switch off the electrical or relocate the victim away from it with a non-conductive object. Keep in mind that if the sufferer is still in contact with the electrical source, you should never touch them directly.
- **Assess Responsiveness and Breathing:** Take a cautious approach to the victim to see whether they are conscious.

To see how responsive they are, speak quietly. Call for help and make sure their respiration is normal if they don't respond.

- **Contact Emergency Services:** Contact emergency services right away if the person passes out or if their heartbeat or breathing becomes. If necessary, do cardiopulmonary resuscitation (CPR) if the sufferer is unconscious and not breathing regularly. Aim for 100–120 chest compressions per minute, and after every 30 compressions, perform two rescue breaths.

- **Address Burns and Injuries:** Burns and other injuries are frequently caused by electric shocks. Cover any electrical burns with a clean cloth or sterile gauze bandage after cooling the area with running water for approximately 20 minutes. Towels and blankets can adhere to the burned skin, so never use them. Any bleeding wounds should be elevated and pressured.

Post-Incident Care

- Even if you survive an electric shock, the threat is still present. Injuries and effects may be concealed and not immediately apparent.
- **The Value of a Medical Assessment Even When the Victim Feels Alright:** Internal injuries may be present even if the person seems to be unhurt. Seeing a doctor is essential.
- **Electrical shock's potential long-term effects include:** The effects of electric shock might endure a lifetime. Some victims may suffer from anxiety and despair, acquire cataracts, or endure persistent discomfort.

- **Rehabilitation and Follow-Up Care:** Depending on the severity of the shock, the victim may require further care, including physical therapy, wound care, and mental health support. Recovery will take time and patience, and a customized rehabilitation plan will be developed.

Tips for Prevention

Prevention is always preferable to cure when it comes to electrical safety. An electrical shock can be avoided by following these important safety precautions.

1) Safety Procedures for Electrical Shock Prevention

The following are a few easy yet powerful ways to prevent electrical shocks:

- **Use Ground Fault Circuit Interrupters (GFCIs):** GFCIs ought to be placed in places like bathrooms, kitchens, and outdoor outlets where water and electricity might come into contact. If they detect an electrical imbalance, they automatically cut off electricity.
- **Prevent Circuit Overloading:** Steer clear of overloading power strips or outlets. To avoid overheating and fires, only use one high-wattage device per outlet.
- Examine appliances and electrical cords:** Check appliances and cords for cracks, frays, and other damage on a regular basis. Any damaged equipment should be replaced or repaired right away.
- **Keep Electrical Devices Away from Water:** Avoid using electrical devices near water and keep them away from swimming pools, sinks, and bathtubs.
- **Install Appropriate Lighting:** To avoid mishaps, make sure outside spaces where electrical equipment may be utilized at night are adequately illuminated.

2) Importance of Regular Maintenance of Electrical Systems

- For electrical systems to operate safely, routine maintenance is essential. To find any risks, obsolete wiring, or malfunctioning equipment, schedule routine inspections by a certified electrician.
- If your electrical systems are inadequate or outdated, think about updating them to satisfy modern power requirements and safety regulations.
- Make sure GFCIs and smoke alarms are operating correctly by testing them on a regular basis. Don't forget to swap out batteries when necessary.

3) Educating Family Members and Coworkers on Electrical Safety

You can educate your family members and coworkers by doing the following:

- Provide coworkers and family members with electrical safety training. Talk about the

dangers of electricity and the significance of adhering to safety procedures.

- Teach everyone how to call for assistance and administer basic first aid in the event of an electrical shock.