सत्यमेव जयते

PARTICIPANT HANDBOOK

Electronics

Language: English

Electrician Domestic

N·S·D·C National Skill Development Corporation

Transforming the skill landscape

Orion Edutech®

ISO 9001:2015 CERTIFIED

Funded Partner of NSDC

ELECTRICIAN DOMESTIC

इलेक्ट्रीशियन डोमेस्टिक

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ISO 9001:2015 CERTIFIED
Funded Partner of NSDC

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Welcome Note

Dear Participant,

Welcome to the "**Electrician Domestic**" training programme. This PHB intends to facilitate the participants with detailed knowledge about the concept of electric and the related terms. After completion of the training, participants would be able to:

- Understand the various safety precautions and signs.
- Learn about the various fire extinguishers and their usage.
- Learn about general safety tools and equipment.
- Know about personal; protective equipment.
- Understanding with examples how to treat person with electric shock.
- Know the concept of Disaster Management.
- Learn about National Electrical Code.
- Understand the concept of electricity.
- Learn about cables and its types.
- Understand the structure of matter.
- Understand the uses of different electrical circuits.
- Understand the concept of Soldering.
- Know about the types of soldering and its use.
- Knowing the concept of Alternating Current.
- Understand the purpose of electrical earthing.
- Understand the types of earthing.
- Understand the signs and symbols and their meanings used for various electrical accessories.
- Understand the concept of domestic wiring.
- Learn about Megger Test.
- Know about the accessories required for wiring.
- Learn about the functions of fuse, MCB, ELCB.
- Understand the concept of battery.
- Know about battery maintenance.
- Learn the art of preparing Electrolyte. &
- Learn the difference between primary and secondary cell.

Read each module, log your key learning in the notes, and attempt the worksheet questions in the end.

General Instructions to Trainee

1. Greet your instructor and the other participants when you enter the class.
2. Always be punctual for every class.
3. Be regular. Candidates who fall short of the required attendance will not be certified.
4. Inform your instructor if, for any reason, you need to miss class.
5. Pay attention to what your instructor is saying or showing.
6. If you do not understand something, put up your hand and seek clarification.
7. Make sure you do all the exercises at the end of each module in this book. It will help you understand the concepts better.
8. Practice any new skills you have learnt as many times as possible. Seek the help of your Trainer or co-participant for practice.
9. Take all necessary precautions, as instructed by your Trainer, while working with electricity and with tools.
10. Make sure you are neatly attired and presentable at all times.
11. Participate actively in all the activities, discussions and games during training.
12. Always take bath, wear clean clothes and comb your hair before you come to class.

The three most important words you must always remember and use in your daily conversation are PLEASE, THANK YOU and SORRY.

TABLE OF CONTENTS

CHAPTER - 1
SAFETY PRACTICES AGAINST FIRE

LEARNING OUTCOMES:

After attending the session, the trainees would be able to:

- Know about the safety rules
- Know about the Safety Precautions
- Understand about the different Safety Sign
- Learn the use of Fire Extinguishers and its types
- Know about the General Safety of Tools and Equipment
- Know how to treat an injured person victimized for getting electrical shock
- Learn about the Personal Protective Equipment

PRE-SESSION ACTIVITY

- The Trainer will show a video to the trainees. The video will be based on how one should be careful and ensure complete safety while working with electrical components.
- After the video ends, the Trainees will be asked questions as what they learnt from the video.

Discussion:

- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by discussing the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.
- The Trainer proceeds with the lesson after the Discussion.

1.1 Safety Rules

Fires in Electrical Circuits and Precautions:

While working with electrical tools and equipment, chances are that there might be short circuit, which might further lead to fire. So it is important for you to know which electrical component holds what percentage of fire.

According to the National Fire Protection Association,

- Lamps, light fixtures and light bulbs and fixed wiring have the largest share among the major types of electrical distribution equipment.
- Cords and plugs account for the largest share of civilian deaths.
- Many avoidable electrical fires can be traced to misuse of electric cords, such as overloading circuits, poor maintenance, and running cords under rugs or in high traffic areas.
- In urban areas, faulty wiring accounts for 33% of residential electrical fires.
- Fifteen percent of residential electrical fires start in the bedroom. Replace worn, old, or damaged appliance cords right away.

1.2 Safety Precautions

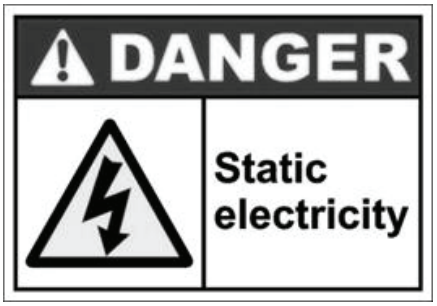
- Repair or replace the frayed cords on all electrical devices.
- Never have extention cords across doorways or under the carpets.
- Wall sockets and extension-cord receptacles with plastic safety covers are highly recommended in homes with small children.
- Have additional circuits or outlets added by qualified electricians to avoid extension cords.
- Always follow manufacturer's instructional manuals.
- Never overload the outlets.
- Always plug in one high-wattage outlet at a time.
- If you feel that switches have become hot, shut them off.
- When possible use cube tapes
- Have smoke alarms installed to avoid accidents

DO YOU KNOW?

Electrical appliances should never be stored in cramped areas and must have enough space for breathing.

1.3 Safety Signs

Safety Signs are crucial in any work environment. The primary importance of displaying Safety Signs is to prevent injury and ensure that all staff and visitors are well aware of the possible dangers and hazards in certain situations and/or environments.



Exercise

State if the following statements are True or False:

1. Lamps, light fixtures and light bulbs and fixed wiring have the smallest share among the major types of electrical distribution equipment. [T/F]
2. Cords and plugs account for the largest share of civilian deaths. [T/F]
3. In rural areas, faulty wiring accounts for 33% of residential electrical fires. [T/F]
4. When possible use cube tapes [T/F]
5. Always follow manufacturer's instructional manuals. [T/F]

1.4 Fire Extinguishers and its types

According to the Fire Industry Association [FIA], a survey has highlighted that rather than declining in importance, portable fire extinguishers have an even more vital role to play as a first aid response to fire. 88 percent of fires are now reported to be tackled with portable fire extinguishers.

Here are different types of fire extinguishers:

- **Water Extinguisher**

- A water extinguisher should only be used on Class A fires [Combustibles such as wood, paper, cloth, trash, and plastics].
- If used on a Class B fire [flammable liquid of gas or paint; flammable gases, such as propane or butane], the discharge could help spread the flammable liquid or gas.
- If used on a Class C fire [electrical equipment such as motors or kitchen appliances], it could create a shock hazard.

➢ **Foam Extinguisher**

The foam extinguisher can only be used on Class A and Class B fires only. If used on Class C fires, it will create a shock hazard.

➢ **Carbon Dioxide**

- This type of fire extinguisher takes away the oxygen from a fire and removes the heat with a cold discharge.
- The Carbon Dioxide fire extinguisher should be used on Class B and C fires. It is not effective on Class A fires.

➢ **Dry Chemical**

- The Dry Chemical Extinguisher removes the chemical reaction of a fire. In this category, the multi-purpose Dry Chemical extinguisher is the most used fire extinguisher of all extinguishers because it is effective on Class A, Class B and Class C fires.
- This fire extinguisher creates a barrier between the oxygen and fuel elements on Class A fires.

➢ **Wet Chemical**

- The Wet Chemical Extinguisher extinguishes a fire by removing heat and preventing barriers between oxygen and fuel so that fire is not re-ignited.
- Wet Chemicals are Class K [examples: cooking oils, greases, animal fat, vegetable fat] Extinguishers.
- This extinguisher is a must-have if you are in the commercial cooking industry. Some Wet Chemical extinguishers can be used on Class A Fires as well.

- **Clean Agent**
  - The Clean Agent Extinguisher uses both halon and halocarbon by interrupting the chemical reaction component of a fire. The extinguisher is mainly used on Class B and C fires.
  - Larger Clean Agent extinguishers can be used on Class A, Class B, and Class C fires.

- **Dry Powder**
  - Similar to the dry chemical extinguisher, dry powder separates fuel from oxygen or removes the heat element of a fire.
  - Dry powder extinguishers are used on Class D [combustible metal fires] only. They will not be effective on any other fire class.

- **Water Mist**
  - The water mist extinguisher extinguishes a fire by taking away the heat element of a fire.
  - You should mainly use this extinguisher for Class A fires but it is safe to use the water mist extinguisher for Class C fires as well..

- **Cartridge Operated Dry Chemical**

This extinguisher helps extinguish a fire by interrupting the chemical reaction of a fire and works by creating a barrier between oxygen and fuel on Class A fires.

1.5 General Safety of Tools and Equipment

Electrical work can't be done without the right tools. As basic tools have been improved over the years and new specialized tools are developed, the list of tool choices for electricians has expanded to a good extent.

Here is a list of tools:

Tools	Functions
Pliers 	A small tool with two handles for holding or pulling small things like nails, or for cutting wire.
Screwdrivers 	A screwdriver is a tool, manual or powered, for turning, driving or removing screws. A typical simple screwdriver has a handle and a shaft, and a tip that the user inserts into the screw head to turn it.
Wire strippers 	A wire stripper is a small, hand-held device used to strip the electrical insulation from electric wires.
Fishing tools 	Tape materials are suited to any type of job. Fish pole wire-installation tools facilitate wire pulling in drop ceilings, down walls or under raised floors.
Measuring devices 	Laser measuring tools are becoming more popular, but no electrician's tool belt is without a basic tape for simple measurements. Those with rare earth magnetic tips that stick to iron and steel surfaces permit fast, one-person measurements.
Labelling machines 	Properly labelling work at installation saves time when making moves, adds and changes, and handheld labelling tools speed up this important step.
Power drills and drivers 	Every electrician uses drills, but the type of tool needed varies with the application-what is essential for one worker isn't necessarily needed by another. The power required depends on the material being drilled.

Power saws 	A power-saw makes use of a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour.

1.6 How to treat a person who has been injured by an electrical shock?

Electrical shocks always needs emergency medical attention, even if the person seems to be fine afterwards:

a. Separate the Person from Current's Source

To turn off power:

- Unplug an appliance if plug is undamaged or shut off power via circuit breaker, fuse box, or outside switch.

If you can't turn off power:

- Stand on something dry and non-conductive, for example dry newspapers, telephone book, or wooden board.
- Try to separate the person from current using non-conductive object such as wooden or plastic broom handle, chair, or rubber doormat.

If high voltage lines are involved:

- The local power company must shut them off.
- Do not try to separate the person from current if you feel a tingling sensation in your legs and lower body. Hop on one foot to a safe place where you can wait for lines to be disconnected.
- If a power line falls on a car, instruct the passengers to stay inside unless explosion or fire threatens.

b. Do Cardiopulmonary Resuscitation, if Necessary

When you can safely touch the person, do Cardiopulmonary Resuscitation if the person is not breathing or does not have a pulse.

c. Check for Other Injuries

- If the person is bleeding, apply pressure and elevate the wound if it's in an arm or leg.
- There may be a fracture if the shock caused the person to fall.

d. Follow Up

- A doctor will check the person for burns, fractures, dislocations, and other injuries.
- An ECG, blood tests, urine test, CT scan, or MRI may be necessary.
- The person may be admitted to the hospital or a burn center.

e. Call up for 108 for Emergency Disaster Management.

1.7 Personal Protective Equipment

PPE or Personal Protective Equipment protects the user against health or safety risks at work. It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. It also includes respiratory protective equipment.

What can be done to ensure proper use of Personal Protective Equipment?

- It is important that all personal protective equipment are safely designed and constructed
- To encourage the workers, equipment should fit comfortable
- When engineering, work practice, and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment to their workers and ensure its proper use.

1.8 National Electrical Code

The National Electrical Code describes the laid down norms of several Indian Standards dealing with all the aspects which are related to the practice od electrical installation. Several product standards also exist and compliance with relevant Indian Standards is desirable. Therefore we would recommend that every single part or section of the code must be read along with the relevant Indian Standards. Few examples of Indian Standards are:

732 : 1989 Code of practice for electrical wiring installations

1255 : 1983 Code of practice for installation and maintenance of power cables upto and including 33 kV rating

1646 : 1997 Code of practice for fire safety of buildings [general]: Electrical Installations

3043 : 1987 Code of practice for earthing

4051 : 1967 Code of practice for installation and maintenance of electrical equipment in mines

5571 : 2000 Guide for selection of electrical equipment for hazardous areas

Exercise

Fill in the Blanks

- It is important that all personal protective equipment are safely _____.
- Stand on something dry and non-conductive, for example _____.
- _____ shocks always needs emergency medical attention
- A _____ makes use of a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour.

NOTES

POST-SESSION ACTIVITY

- The Trainees will prepare a chart paper project, illustrating the different hand tools used by electricians. One who does so in the best manner will be recognised.
- The Trainees will make a PPT on the different types of fire extinguishers used in different sections.

SUMMARIZATION

- Lamps, light fixtures and light bulbs [28%] and fixed wiring [22%] account for the largest share of fires among major types of electrical distribution equipment.
- The Water and Foam extinguisher eliminates a fire by allowing water to take away the heat component of a fire while foam separates oxygen from the fire.
- Laser measuring tools are becoming more popular, but no electrician's tool belt is without a basic tape for simple measurements. Those with rare earth magnetic tips that stick to iron and steel surfaces permit fast, one-person measurements.
- Fifteen percent of residential electrical fires start in the bedroom. Replace worn, old, or damaged appliance cords right away.

Test yourself

A. Match the following:

1.	Labelling machines	**I.**	A small tool with two handles for holding or pulling small things like nails, or for cutting wire.
2.	Screwdrivers	**II.**	A tool for removing the insulation from electric wires.
3.	Pliers	**III.**	Properly labelling work at installation saves time when making moves, adds and changes, and handheld labelling tools speed up this important step.
4.	Power saws	**IV.**	It makes use of a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour.
5.	Wire strippers	**V.**	A tool, manual or powered, for turning, driving or removing screws.

B. Fill in the blanks:

1. _____ Extinguisher eliminates a fire by allowing water to take away the heat component of a fire while foam separates oxygen from the fire.
2. _____account for the largest share of civilian deaths.
3. _____ Extinguisher extinguishes a fire by removing heat and preventing barriers between oxygen and fuel so a fire cannot be re-ignited.
4. _____makes use of a toothed or abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour.
5. _____is a small tool with two handles for holding or pulling small things like nails, or for cutting wire.

NOTES 

CHAPTER - 2
INTRODUCTION TO ELECTRICITY

RECALL SESSION: 

In the previous chapter, we studied about:

- The safety rules
- The Safety Precautions
- The different Safety Sign
- The use of Fire Extinguishers and its types
- The General Safety of Tools and Equipment
- How to treat an injured person victimized for getting electrical shock
- The Personal Protective Equipment

LEARNING OUTCOMES: 

After attending the session, the trainees would be able to:

- Understand the basic concept of electricity
- Understand the structure of matter
- Know Cables and its Specifications
- Understand types of Wires joints and uses
- Understand Polarity and its test in DC

PRE-SESSION ACTIVITY

- The trainer will show a PPT presentation to the trainees. The PPT will contain several slides on diverse electrical components including wire joints and cables.
- The trainer will then ask the trainees if they have any experience working with these electrical components.

Discussion:

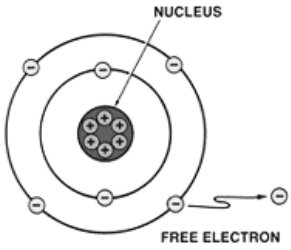
- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by rectifying the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.
- The Trainer proceeds with the lesson after the Discussion.

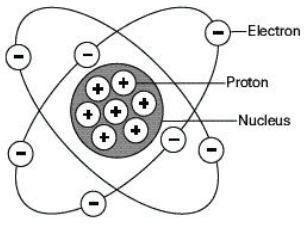
2.1 Basic Concept of Electricity

Electricity is the flow of electrons from one place to another. Electrons can flow through any material, but it becomes more easily in some compared to others. It's easy flow is called resistance. This resistance of a material is measured in Ohms.

Electron Theory

Electron theory states that all matters comprised molecules, which in turn comprised atoms, which are again comprised protons, neutrons and electrons. A molecule is the smallest part of matter which can exist by itself and contains one or more atoms.





Free Electron

Some materials, such as metals, are good conductors of electricity; these possess free or valence electrons that do not remain permanently associated with the atoms of a solid but instead form an electron "cloud" or gas around the peripheries of the atoms and are free to move through the solid.

DO YOU KNOW?

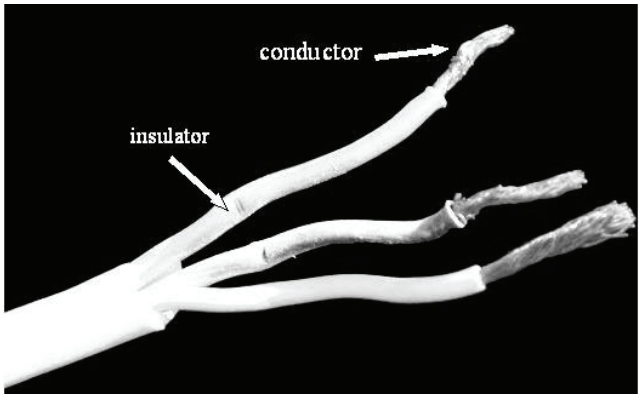
Electricity travels at 6,696,000 miles per hour.

2.2 Structure of Matter

The matter is divided into molecules, which in turn are divided into atoms. These atoms are composed of two parts: nucleus and periphery. In the nucleus of the atom, there are positive charged protons and neutrons, which as its name suggests, have no electric charge or are neutral.

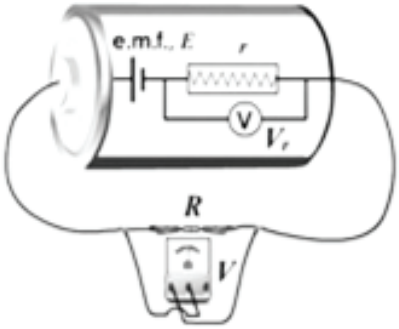
Matter can be broken down into:

- **Conductors:** In a conductor, electric current can flow freely. Metals such as copper typify conductors, while most non-metallic solids are said to be good insulators, having extremely high resistance to the flow of charge through them.
- **Semi-conductors**: A semiconductor is a type of material that has an electrical resistance which is between the resistance typical of metals and the resistance typical of insulators, so it kind of, or “semi”-conducts electricity.
- **Insulators**: Insulator can mean not only the material but things that are made of that material. They are made of various materials such as: glass, silicone, rubber, plastic, oil, wood, dry cotton, quartz, ceramic etc. The type of insulator will depend on the uses. Insulators have high electrical resistivity and low conductivity.

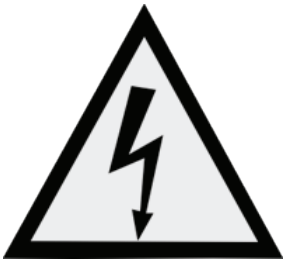


Some more Important Terms:

EMF: Making electrons flow through a resistance requires an attractive force to pull them. This force, called Electro-Motive Force or EMF, is measured in volts.



Volt: The volt is the derived unit for electric potential, electric potential difference, and electromotive force.



Power: As electrons flow through a resistance, it performs a certain amount of work. It may be in the form of heat or a magnetic field or motion, but it does something. This work is called Power, and is measured in Watts.

2.3 Cables and its Specifications

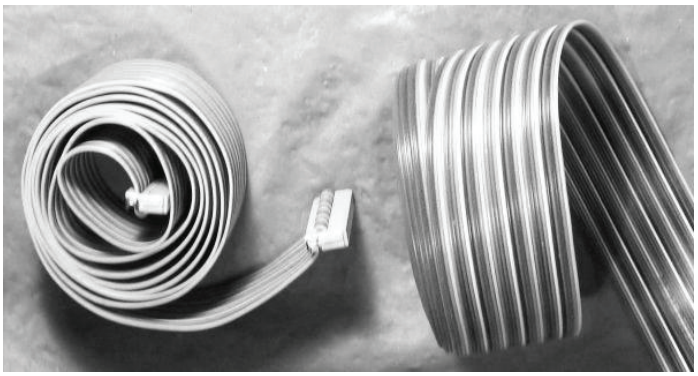
All electrical cables consist of at least two conducting wires and an outer protective jacket. For medium to high power cables that carry high voltages, the conducting wires within the outer protective jacket may individually be enclosed in insulating sheaths. Electrical conductors are commonly made of copper. Synthetic polymers make the outer jacket and protective, insulating material.

2.3.1 Coaxial Cable

- A coaxial electrical cable has a copper-plated core, surrounded by a dielectric insulator. A woven shield of copper surrounds the insulating layer, which is finally wound by an outmost plastic sheath.
- Coaxial cables differ in size, performance, flexibility, power handling capabilities and cost.
- They are used to connect home audio and video equipment, television networks and components of a local area network. Hard line, leaky cable, RG/6, twin-axial, biaxial and semi-rigid are types of coaxial cables.

2.3.2 Ribbon Cable

- A ribbon electrical cable [also called multi-wire planar electrical cable or flat twin cables] is made up of multiple insulated wires running parallel to each other.
- These parallel wires allow the simultaneous transmission of multiple signals of data. According to “Optical Communications Essentials,” a typical ribbon cable consists of four to 12 wires. It is commonly used to interconnect network devices.
- Ribbon cables also connect the motherboard with other core CPU [central processing unit] components..

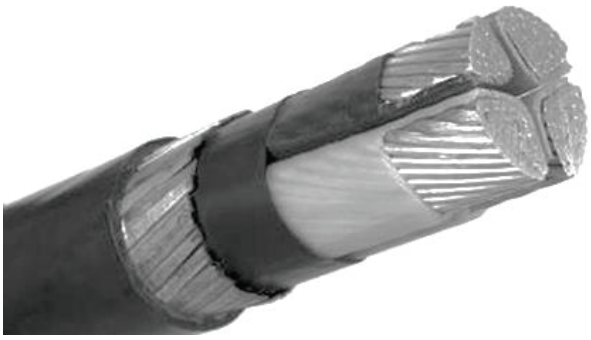


2.3.3 Twisted Pair Cable

- A twisted pair electrical cable consists of pairs of insulated copper wires [that are colour coded], which are twisted around each other.
- The diameter of each wire ranges from 0.4 to 0.8 mm, and the number of pairs vary in different types of twisted pair cables. The greater the number of pairs, the higher the resistance of the cable will be to external noise and cross-talk.
- Twisted pair cables are easy to install, flexible and inexpensive. They are used for telephone cabling and to wire local area networks.

2.3.4 Shielded Cable

- A shielded electrical cable is made of one or more insulated wires that are collectively enclosed by an aluminium Mylar foil or woven braid shielding.
- The shielding prevents the cable from external radio and power frequency interference, allowing the signal transmission to proceed smoothly. High-voltage power cables are commonly shielded.



Exercise

Fill in the Blanks:

1. _____ theory states that all matters comprised molecules, which in turn comprised atoms
2. In a _____, electric current can flow freely.
3. A semiconductor is a type of material that has an _____ resistance

NOTES

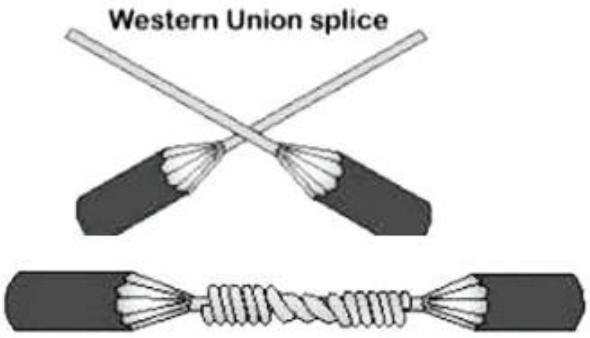
2.4 Types of Wire Joints and Uses

Knowing the different types and uses of electrical wire joints is critical to home repair and electrical maintenance. Joining wires incorrectly or without proper insulation can make the joint overheat, resulting in a potentially deadly fire.

To complete any electrical joint, the practitioner must seal the exposed wires with electrical tape or another type of insulation. There are many types of electrical joints, but several are considered fundamental archetypes. These types of joints include the Western Union splice, tap splice and fixture splice.

2.4.1 Western Union Splice

The Western Union Splice is relatively simple and is one of the most common types of joints. This type of joint is used to connect two of the same conductor — repairing a severed wire, for example.

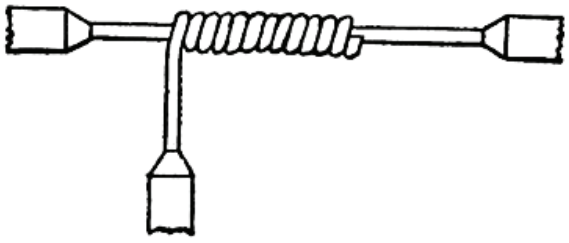


Uses:

- To make a Western Union splice, strip 5 inches of insulation from both conductors. Hold them in an “X” shape, leaving 1 or 2 inches of exposed wire for each conductor above the intersection.
- Wrap one of the exposed wires around the base of the other, then do the same with the remaining wire and conductor.

2.4.2 Tap Splice

- A tap splice connects a loose wire to a conductor in a perpendicular shape. This joint resembles a “T” shape, with the connecting wire intersecting the running one.
- Tap splices allow loose wires to tap the electrical flow of an active wire.

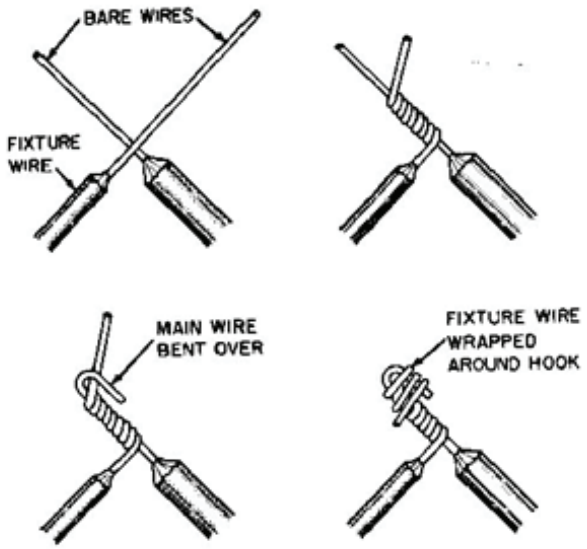


Uses:

- A tap splice requires you to strip 4 inches of insulation from the connecting cord, and 2 inches from the running wire. Hold the two together like a “T” and wrap the exposed wire of the connecting cord around the running wire once.
- Continue to wrap the wire in the opposite direction of the first coil. This results in one loop on one side of the “T” intersection, with the remaining loops [at least five] on the other side.

2.4.3 Fixture Splice

A fixture splice is mostly used to connect different-sized conductors, particularly those in electrical fixtures. This type of splice requires a pair of pliers or a similar tool.



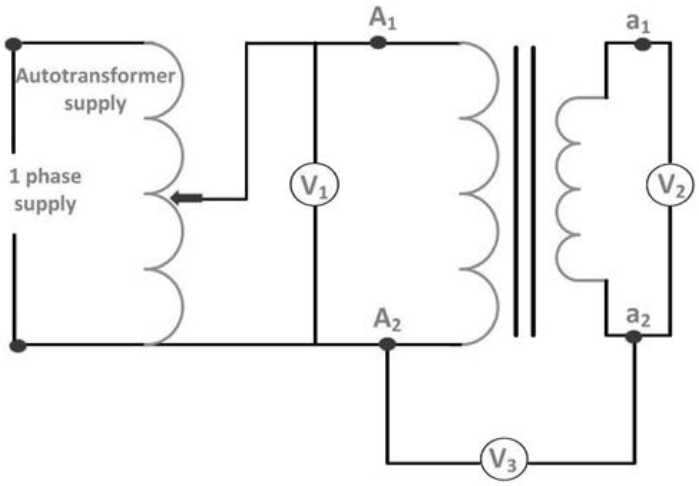
Uses:

- To fashion a fixture splice, remove 4 to 5 inches of insulation from both of the wires. Clean them by scraping residue and remaining insulation from the conductor.
- Hold one of the exposed wires right at the base of the other. Roughly half of the exposed conductor should be on each side of the intersection.
- Grasp the intersection with the pliers and turn both wires simultaneously. Bend the coil towards the wires to complete the joint.

2.5 Polarity Test in DC

2.5.1 What is Polarity?

Polarity means the direction of the induced voltages in the primary and the secondary winding of the transformer. If the two transformers are connected in parallel, then the polarity should be known for the proper connection of the transformer.



2.5.2 What is meant by Polarity test?

Polarity in electrical terms refers to the Positive or Negative conductors within a DC circuit, or to the Line and Neutral conductor within an AC circuit.

2.5.3 How to test polarity in DC?

- Use a small DC motor.
- 'Calibrate' on a source of known polarity and mark the motor tab that gives clockwise rotation when positive.
- Use a small electrolytic capacitor of higher voltage as the supply. If you connected it with the right polarity nothing will happen.

2.6 Few Importance Definitions:

1. **Capacitor:** A capacitor has two conductors which is separated by an insulator and is known as a dielectric.

2. **Capacitive Reactance:** An opposition to the change of voltage across and element is known as capacitive reactance. It is inversely proportional to the single frequency or angular frequency, denoted by ω and the capacitance.

3. **Inductive Reactance:** The variable opposition to current flow in an inductor is related to the amount of the inductance. The larger the value of inductance the greater the back emf effect produced. The opposition to current flow through an inductor is proportional to both the amount of inductance and to the frequency of the current in the inductor. This opposition to current flow is called Inductive Reactance denoted by [X_L].

4. **Impedance [Z]:** The opposition to current flowing through a coil in an AC circuit is determined by the AC resistance which is also known as Impedance [Z], of the circuit.

5. **Power Factor [pf]:** The ratio of the real power flowing to the load to the apparent power in circuit of an AC electrical power is known as the power factor [p.f.]. The dimensionless number for power factor is in the closed interval of -1 to 1.

POST-SESSION ACTIVITY

- The Trainees will be divided in groups of 4. Each group will be provided with chart papers having diagrams on wire joints. Trainees from each group will be asked to identify the joints and write down their functions. The group which does this best will be recognized.
- The trainer will take the trainees to the laboratory where they will be provided with a set of cables. Each trainee will be asked to choose a cable from the lot and describe it accordingly.

SUMMARIZATION

- Electrons can flow through any material, but does so more easily in some than in others.
- Electron theory states all matter is comprised of molecules, which in turn are comprised of atoms, which are again comprised of protons, neutrons and electrons.
- In a conductor, electric current can flow freely, in an insulator it cannot.
- Insulator can mean not only the material but things that are made of that material.
- All electrical cables consist of at least two conducting wires and an outer protective jacket.
- Knowing the different types and uses of electrical wire joints is critical to home repair and electrical maintenance. Joining wires incorrectly or without proper insulation can make the joint overheat, resulting in a potentially deadly fire.
- Polarity in electrical terms refers to the Positive or Negative conductors within a DC circuit, or to the Line and Neutral conductor within an AC circuit.

Test yourself

1. Complete the following sentences.

a. Electro-motive force is _____

_____.

b. In a conductor, electric current can _____

_____.

c. To complete any electrical joint, the practitioner must _____

_____.

d. A ribbon electrical cable is made up of _____

_____.

e. Polarity in electrical terms refers to _____

_____.

2. State whether the following statements are True or False:

a. A molecule is the smallest part of matter which can exist by itself and contains one or more atoms. [ ]

b. A tap splice separates a loose wire from a conductor in a perpendicular shape A circuit is a closed loop that allows charge to move from one place to another. [ ]

c. Polarity means the direction of the induced voltages in the primary and the secondary winding of the transformer. [ ]

d. A fixture splice is mostly used to connect same-sized conductors. [ ]

NOTES 

CHAPTER - 3
SIMPLE ELECTRICAL CIRCUITS AND LAWS

RECALL SESSION: 

In the previous chapter, we studied about:

- The basic concept of electricity
- The structure of matter
- Cables and its Specifications
- Types of Wires joints and uses
- Polarity and its test in DC

LEARNING OUTCOMES: 

After attending the session, the trainees would be able to:

- Learn and understand Ohm's laws
- Understand different Simple Electrical circuits
- Learn about the resistors
- Understand the law of resistance
- Learn and understand Kirchhoff's law
- Understand the effect of temperature on resistance

PRE-SESSION ACTIVITY

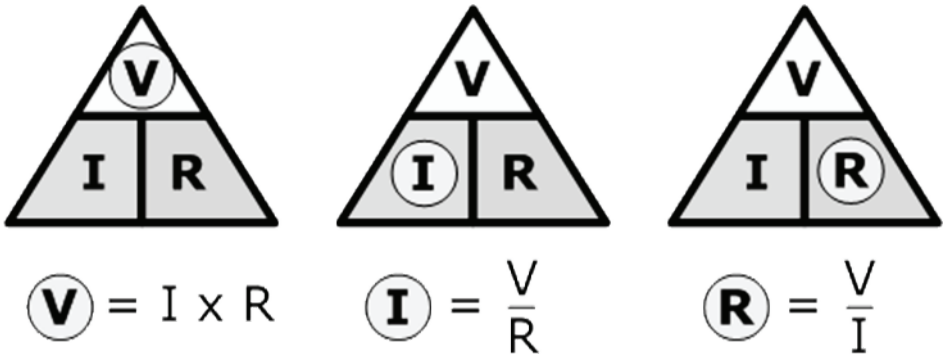
- The trainer will arrange for a guest lecture session for the trainees

Discussion:

- The Trainer will ask the trainees to discuss all the important points that they have gathered from the **"Guest Lecture Session"**.
- Once that is done, the trainer will divide the trainees into groups and share all the points.
- The trainer will then correct all the points that need to be memorized.

3.1 Ohm's Law

- Ohm's Law is a law stating that electric current is proportional to voltage and inversely proportional to resistance.
- The potential difference [voltage] across an ideal conductor is proportional to the current through it. The constant of proportionality is called the "resistance", R. 2.
- Material that obeys Ohm's Law is called "ohmic" or "linear" because the potential difference across it varies linearly with the current.



DO YOU KNOW?

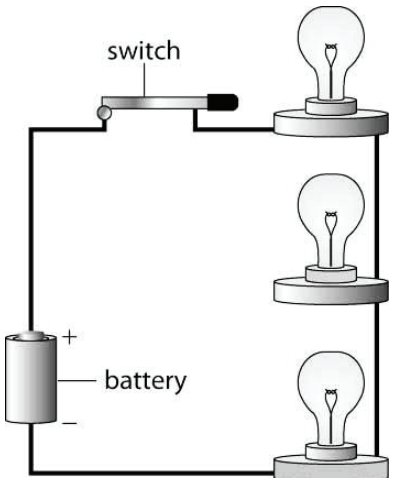
Ohm's law first appeared in the famous book 'Die galvanischeKette, mathematischbear beitet (tr., The Galvanic Circuit Investigated Mathematically) (1827) in which he gave his complete theory of electricity.

3.2 Simple Electrical Circuits

- A simple electric circuit contains a power source [battery], wires, and a resistor [light bulb].
- In a circuit, electrons flow from the battery, through the wires, and into the light bulb.
- In other words, it is the path that an electric current travels on, and a simple circuit contains three components necessary to have a functioning electric circuit, namely, a source of voltage, a conductive path, and a resistor.

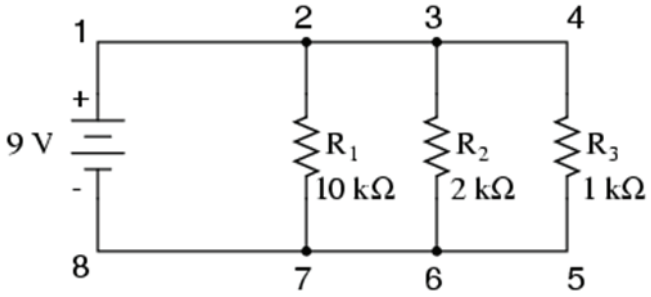
3.2.1 Series Circuit

In a series circuit, the current through each of the components is the same, and the voltage across the circuit is the sum of the voltages across each component.



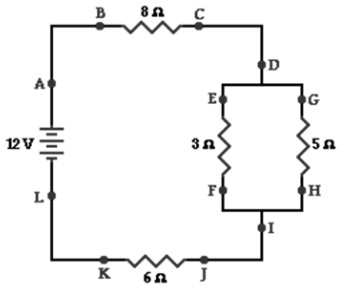
3.2.2 Parallel Circuit

- A parallel circuit has two or more paths for current to flow through. Voltage is the same across each component of the parallel circuit.
- The sum of the currents through each path is equal to the total current that flows from the source.



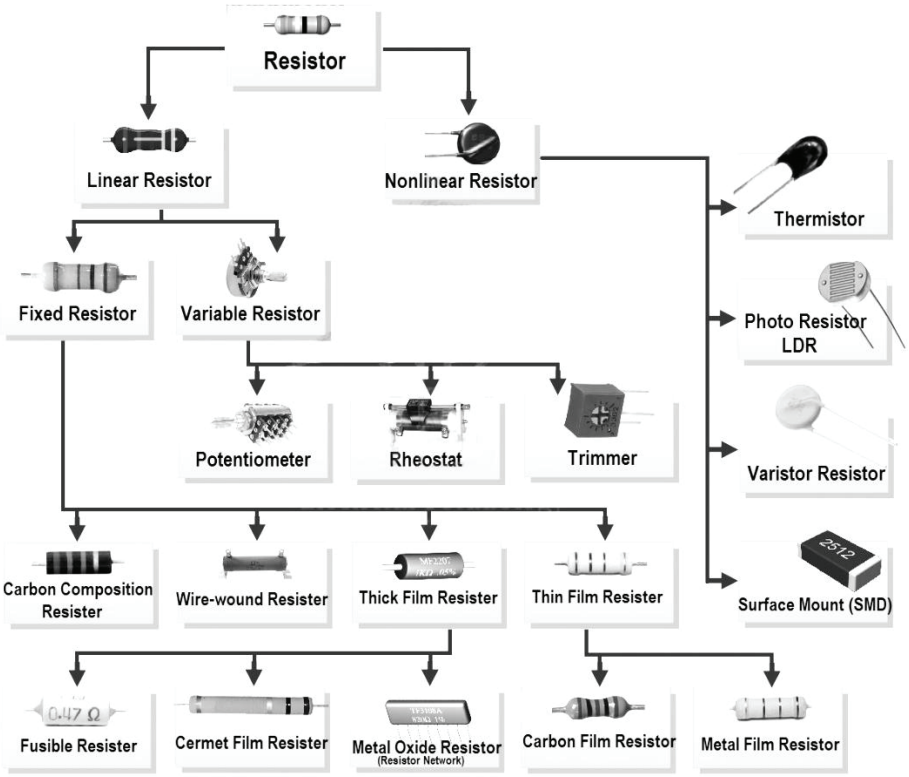
3.2.3 Combination Circuit

- It involves the dual use of series and parallel connections in a circuit known as compound circuits or combination circuits. The circuit depicted at the right is an example of the use of both series and parallel connections within the same circuit.
- In this case, light bulbs A and B are connected by parallel connections and light bulbs C and D are connected by series connections. This is an example of a combination circuit.



3.3 Resistors

- A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.
- There are different types of resistors in the electronic circuits. Depending upon the manufacture and contraction the resistance has different properties. It makes the difference in their applications.



The resistors are available in different sizes and shapes in the market. The different types of resistor are discussed in the following section.

- Linear resistors.
- Non-linear resistors.

Linear Resistors

The resistor values are changed with the help of the temperature and applied voltages are called linear resistors. If the resistance of the current value is directly proportional to the applied voltage is called the linear resistance.

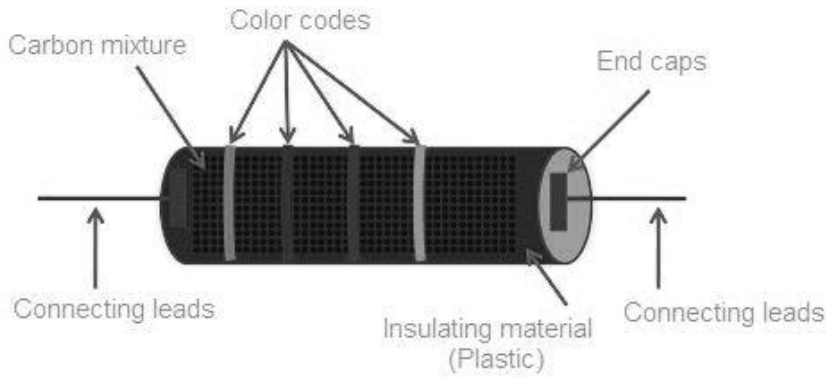
- Fixed resistors
- Variable resistor

1. Fixed Resistor

The name itself says that fixed resistor. So the values of the specific resistor cannot change in the fixed resistor. There are different types of Fixed resistors:.

Carbon Composition Resistor

- The carbon composition resistor is made from the mixer of granulated or graphite, insulation filter and a resin binder.
- The actual resistance of the resistor is determined by the ratio of the insulation material. The shape of the insulating binder is in the shape of roads and there are two metal caps at both the end of the roads.
- At both ends of the resistor it has two wire conductors for easy to connectivity in the circuit design.
- There are different colours which are printed on the resistor to find the value of it and the road is covered with the plastic coat.

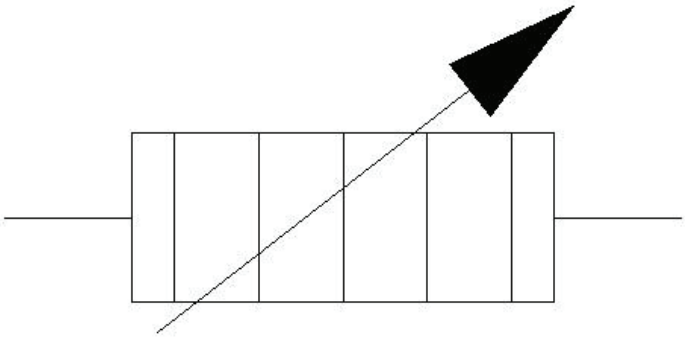


Applications

- The composition resistor is used in the high energy pulses.
- It has a relatively small size.
- High voltage power supplies
- Welding
- High power

Carbon Pile

- This type of resistor is prepared with the stack of compressed disk between two metal plates which are in contact.
- These resistors are integrated in automatic voltage regulators and it controls the field current to maintain the constant voltage. The symbol of the carbon pile resistor is shown below.



Applications

- These are used in the speed control small controls small motor in home appliances.
- This type of resistors is available in carbon microphone.
- Carbon pile resistors are used in the adjustable load resistors if it requires like radio transmitter or automatic batteries.

Carbon Film

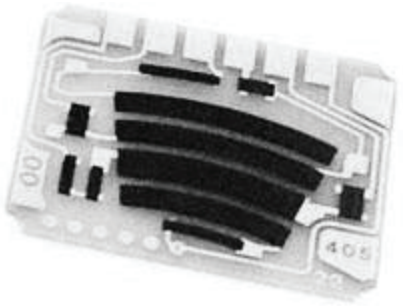
- The carbon film resistor is formed by cracking the hydrocarbon in a ceramic former and the temperature coefficient is from the -100 to -900 ppm/°C.
- The carbon film resistors are not being used in the market AS the superior resistors are available.
- These resistors are obtainable in small wattage levels. The symbol of the carbon film resistor is shown below.

Applications:

The carbon film resistors are available in High plus stability.

Printed Carbon Resistor

- This type of resistors is used on the printed circuit boards.
- They are mostly common in hybrid PCB modules.
- The tolerance of these resistors is large and it is in the order of 30%. The symbol of this resistor is shown below.

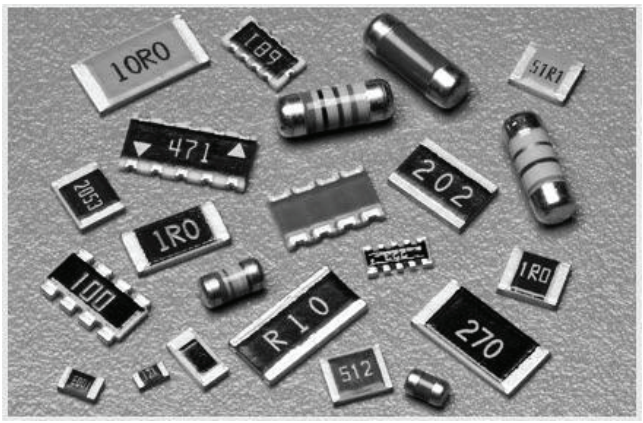


Applications:

- This type of resistors is used in the standard fiberglass in PCB's.
- It has non critical pull up resistor.

Thick and Thin Film:

- This type of resistors is in surface mount device.
- The thick film is 1000 times thicker than the thin films with resistive elements.
- The thin film resistors are prepared by a method of vacuum deposition and the resistive material are through the insulating substrate.
- The old process of making the printed circuit board is in film etched.
- The surface is covered with a photosensitive material and a pattern film, irradiated with ultraviolet light and exposed to the sensitive coating.
- Thick film resistor is manufactured by using the screen and a stencil printing process.



Applications:

- Thin film is usually used in precision applications.
- High tolerance is a feature of thin film resistance.
- Thin film resistors have low inductance and capacitors.
- The thick film resistors are used in case of high tolerance.
- The thick film resistors are available in low price and it can handle low power.
- Thick films have wide range of resistors.

Metal Film Resistor:

- Metal film resistors and carbon film resistor have similar construction. Instead of carbon there are a mixture of nickel, chromium, metal glaze and metal oxides.
- The temperature coefficient of metal film resistor is very low and the value is +-2ppm/C. The symbol of metal film resistor is shown below.

Applications

- The tolerance of metal film resistor has good characteristics.
- The low voltage coefficient of this resistor has high linearity and low noise.
- In bridge circuit and active filter this film resistors are used.

Metal Oxide Film Resistors

- Metal oxides help in the preparation of metal oxide film resistor and they are fixed from the axial resistors.
- The chemical deposition methods are produced with the help of metal oxide resistor.
- The pure metal gases like high temperature and low pressure involve in the deposition process.

Applications

- The application of metal oxide film resistors is mostly similar to the metal film resistor.
- The metal oxide film and metal film are the predominant resistors.

Wire Wound Resistors

- This type of resistors is made up of the insulating the core to a resistive wire.
- The resistive wire is tungsten, manganese, nickel is allowed. These resistors are very costly and sensitive to test.
- This resistor is available in the range of 2 watt to 100 watt resistors.
- The wire wound resistors of Ohmic values are from the 1 ohm to 200l ohm.

Applications

- It has high security
- Accurate measurement and balance current control is required.

2. Variable Resistors

There are different types of variable resistors are following

- Adjustable resistor
- Potentiometers
- Resistance and decade boxes
- Special devices.

Adjustable Resistor

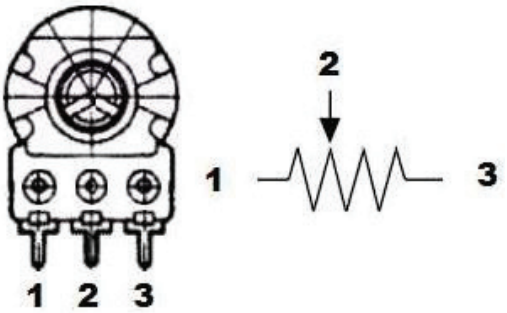
- The adjustable resistors are also known as a rheostat.
- These resistors are two or three terminal device and used for the current limiting purpose through the manual operations.
- The accessible range of these resistors is from 3 to 200 watts. The power rating is between the 5 to 50 watts.

Applications

- It is a power control device.
- Speed of motors.

Potentiometer Resistor

- The potentiometers resistor will have an additional screw and it has a better efficiency of operation.
- The potentiometer resistors are also known as trimmers.
- By changing the position of the screw by rotating through small screw driver then the value of resistor can be changed.
- These resistors are made of carbon composition, carbon film, and wire materials. The range of this resistor is from 50 ohms to 5mega ohm.



Applications

- These are used in wide range of industries.
- It can be used in control input and position measurement

Exercise

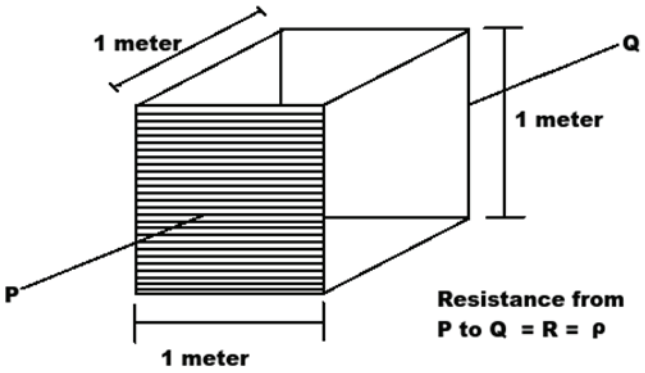
State if the following statements are True or False:

1. The tolerance of metal film resistor has good characteristics. [T/F]
2. The chemical deposition methods are produced with the help of iron oxide resistor. [T/F]
3. The wire wound resistors of Ohmic values are from the 5 ohm to 200l ohm. [T/F]
4. The potentiometer resistors are also known as trimmers. [T/F]

NOTES

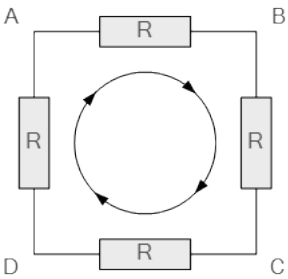
3.4 Laws of Resistance

The laws of resistance states that the Resistance “R” offered by a conductor depends upon following factors: The resistance of conductor is the obstruction posed by the conductor to the flow of current through it.



1. The Resistance “R” is directly proportional with its length “L”
2. The Resistance “R” is inversely proportional with its Cross Sectional Area: “A”
3. The Resistance “R” is dependent on the Nature of the material.
4. The Resistance “R” is dependent on the Temperature of the conductor.

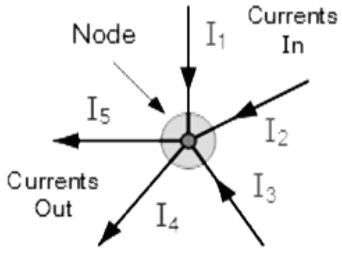
The sum of all the Voltage Drops around the loop is equal to Zero



$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$

3.5 Kirchhoff’s Law

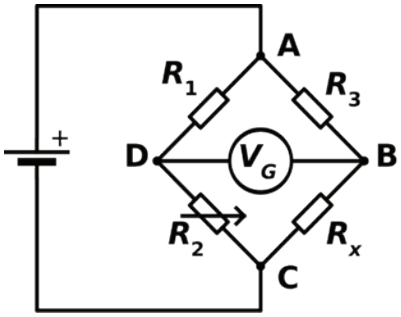
Currents Entering the Node
Equals
Currents Leaving the Node



$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$

3.5.1 Kirchhoff's Voltage Law

- Kirchhoff's Voltage Law or K.V.L. states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero.
- In other words, the algebraic sum of all voltages within the loop must be equal to zero.



3.5.2 Kirchhoff's Current Law

Kirchhoff's Current Law states that at any node [junction] in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.

3.5.3 Wheatstone bridge

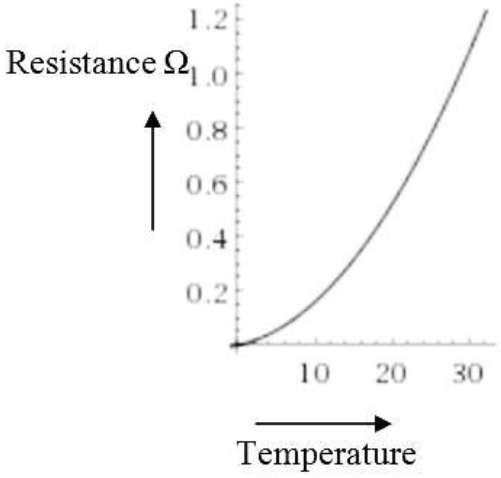
- A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component.
- One of the Wheatstone bridge's initial uses was for the purpose of soils analysis and comparison.

3.6 Effect of Temperature on Resistance

- The resistance of a conductor changes with the size and the chnaging temparature, as the temparature changes the dimensions of the conductor which in return expand or contracts.
- The conductors increase their resistance with the increase in temparature. However, insulators are liable to decrease their resistance with an increase in temperature.
- Materials used for practical insulators only exhibit a marked drop in their resistance at very high temperatures.
- Therefore, the changes in resistance cannot be explained be a change in dimensions due to thermal expansion or contraction.

Temperature and Atomic Structure

- The flow of current is actually the movement of electrons from one atom to another under the influence of an electric field.
- Electrons are very small negatively charged particles and will be repelled by a negative electric charge and attracted by a positive electric charge. Therefore if an electric potential is applied across a conductor [positive at one end, negative at the other] electrons will "migrate" from atom to atom towards the positive terminal.
- Only some electrons are free to migrate however. Others within each atom are held so tightly to their particular atom that even an electric field will not dislodge them.
- The current flowing in the material is therefore due to the movement of "free electrons" and the number of free electrons within any material compared with those tightly bound to their atoms is what governs whether a material is a good conductor [many free electrons] or a good insulator [hardly any free electrons].
- The effect of heat on the atomic structure of a material is to make the atoms vibrate, and the higher the temperature the more violently the atoms vibrate.
- In a conductor, which already has a large number of free electrons flowing through it, the vibration of the atoms causes many collisions between the free electrons and the captive electrons.
- Each collision uses up some energy from the free electron and is the basic cause of resistance. The more the atoms jostle around in the material, the more collisions are caused and hence the greater the resistance to current flow.
- In an insulator however, there is a slightly different situation. There are so few free electrons that hardly any current can flow. Almost all the electrons are tightly bound within their particular atom.
- Heating an insulating material vibrates the atoms, and if heated sufficiently, the atoms vibrate violently enough to actually shake some of their captive electrons free, creating free electrons to become carriers of current. Therefore at high temperatures, the resistance of an insulator can fall, and in some insulating materials, quite dramatically.
- In a material where the resistance increases with an increase in temperature, the material is said to have a positive temperature coefficient.
- When resistance falls with an increase in temperature, the material is said to have a negative temperature coefficient.
- Conductors have a positive temperature coefficient, whilst [at high temperatures] insulators have a negative temperature coefficient.
- Different materials within either group have different temperature coefficients. Materials chosen for the construction of the resistors used in electronic circuits are carefully selected conductors that have a very low positive temperature coefficient.



- In use, resistors made from such materials will have only very slight increases in resistivity, and therefore their resistance. Using such materials for the manufacture of resistors creates components whose value changes only slightly over a given range of temperature.

POST-SESSION ACTIVITY

- The Trainees will be divided into two groups. The trainer will bring two chart papers. One chart paper will have a diagram on Ohm's Law and the other one will have a diagram on the Laws of Resistance. Both the group of trainees will be asked to explain their chart paper contents.
- The Trainer will take the Trainees to a workshop where they will be provided different types of resistors. They will be asked to identify the types of resistors provided and state their specifications.

SUMMARIZATION

- Ohm's Law is a law stating that electric current is proportional to voltage and inversely proportional to resistance.
- In a series circuit, the current through each of the components is the same, and the voltage across the circuit is the sum of the voltages across each component.
- A parallel circuit has two or more paths for current to flow through.
- A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element.
- Kirchhoff's Voltage Law or KVL, states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero.
- Kirchhoff's Current Law states that at any node [junction] in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.
- Although the resistance of a conductor changes with the size of the conductor [e.g. thicker wires have less resistance to current flow than thinner wires], the resistance of a conductor also changes with changing temperature.

Test yourself

A. Fill in the blanks.

a) A _____circuit has two or more paths for current to flow through.

b) A _____ is a passive two-terminal electrical component that implements electrical resistance as a circuit element.

c) _____ _____ Law states that at any node [junction] in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.

d) The potentiometer resistors are also known as _____.

e) The thick film resistors are available in low price and it can handle_____ power.

B. State whether the following statements are True or False:

a) In a series circuit, the current through each of the components is the same. [ ]

b) The values of the specific resistor cannot change in the fixed resistor. [ ]

c) When resistance falls with an increase in temperature, the material is said to have a positive temperature coefficient. [ ]

d) The adjustable resistors are also known as a rheostat. [ ]

e) The flow of current is actually the movement of electrons from one atom to another under the influence of an electric field. [ ]

NOTES 

Worksheet -1

[20 Marks]

1. Answer any 4 from the following questions. **[1.5x4 = 6]**

a. What is Ohm's Law?

b. How to test polarity in DC?

c. State Kirchhoff's Voltage Law.

d. State two uses of Western Union Splice.

e. State the different types of fire extinguishers.

2. State whether the statements are true or false **[4x1 = 4]**

a. A twisted pair electrical cable consists of pairs of insulated copper wires. [ ]

b. In a conductor, electric current cannot flow freely, in an insulator it can. [ ]

c. The Clean Agent Extinguisher uses both halon and halocarbon by interrupting the chemical reaction component of a fire [ ]

d. The foam extinguisher can be used on Class A, Class B and Class C fires. [ ]

3. Complete the following sentences **[10x1 = 10]**

	Column - A		Column - B
A.	The potentiometers resistor will have an	**i.**	thin films with resistive elements.
B.	The thick film is 1000 times thicker than the	**ii.**	additional screw and it has a better efficiency of operation.
C.	Twisted pair cables are	**iii.**	electric potential difference, and electromotive force.
D.	The volt is the derived unit for electric potential,	**iv.**	removes the chemical reaction of a fire.
E.	A simple electric circuit contains	**v.**	has a copper-plated core, surrounded by a dielectric insulator.
F.	The Dry Chemical Extinguisher	**vi.**	easy to install, flexible and inexpensive.
G.	Lamps, light fixtures, and light bulbs [30%] account	**vii.**	for the largest share of civilian injuries.
H.	Carbon Dioxide fire extinguisher	**viii.**	a small, hand-held device used to strip the electrical insulation from electric wires.
I.	A wire stripper is	**ix.**	takes away the oxygen from a fire and removes the heat with a cold discharge.
J.	A coaxial electrical cable	**x.**	a power source [battery], wires, and a resistor [light bulb].

CHAPTER - 4
SOLDERING PRACTICE

RECALL SESSION:

In the previous chapter, we learnt about:

- Ohm's laws
- Different Simple Electrical circuits
- About the resistors
- The law of resistance
- Kirchhoff's law
- The effect of temperature on resistance

DO YOU KNOW?

Desoldering is as important as soldering.

LEARNING OUTCOMES:

By the end of this session, trainees would be able to:

- Understand soldering and its types
- Know various methods of soldering and required tools
- Learn the tips for soldering

PRE-SESSION ACTIVITY

- The trainer will show the trainees videos on soldering
- The trainer will also ask trainees to share their knowledge and experience on working with soldering tools.

Discussion:

- The Trainer will ask the trainees to jot down the important points that they have gathered from the video session.
- Once that is done, trainer will discuss the points with the trainees.
- The trainee with most number of correct points will be appreciated.

4.1 Soldering

- Soldering is the process of fixing one or more components as one by one by dissolving and running a solder in the joint.
- The solder metal has a lower melting temperature compared to the working piece. They are in electrical and electronic projects, plumbing, etc.
- Soldering process in various electrical and electronics projects is done by combining the components with the roots of the printed circuit board.
- The circuit performance depends on the perfect soldering.

4.1.1 Different Methods of Soldering

The methods of soldering process are classified into two - soft soldering and hard soldering.

Soft Soldering:

- Soft soldering is a process for fitting very minute compound parts possessing low liquefying temperature, which have been broken during the procedure of soldering is performed at high temperature.
- In this process, a tin-lead alloy is used as space filler metal. The liquefying temperature of the space filler alloy must not be less than 400oC / 752oF. A gas torch is used as a heat source, for the procedure.
- Some of the examples of this kind of soldering metals include: tin-zinc for bonding aluminium, tin-lead for general usage; zinc-aluminium for aluminium, cadmium-silver for power at high temperature; lead-silver for strength higher than room temperature, weakening confrontation, tin-silver & tin-bismuth for electrical products.

Hard Soldering:

In this type of soldering a solid solder unites two elements of metals by spreading out into the holes of the component that are unlocked due to high temperature. The space filler metal grips higher temperature more than 450oC/840oF.

It comprises of two elements:

- Silver soldering
- Brazing soldering

Silver Soldering

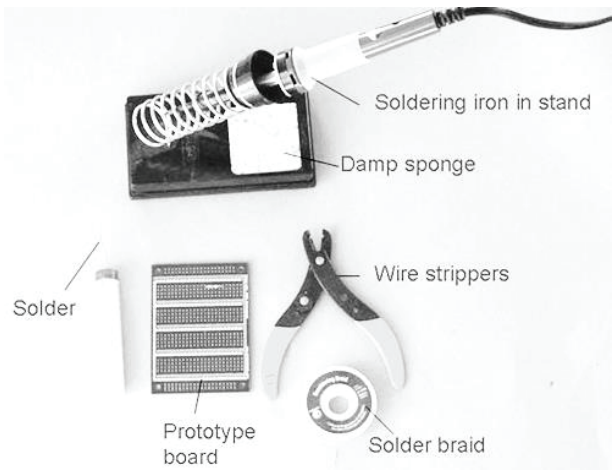
- It is an unsoiled method supportive to fabricate small components, carrying out abnormal maintenance and built-up tools. It makes use of an alloy containing silver as a space filler metal.
- Though silver provides a free running individuality, yet silver soldering is not suggested for space filling, and thus, different flux is recommended for accurate silver soldering.

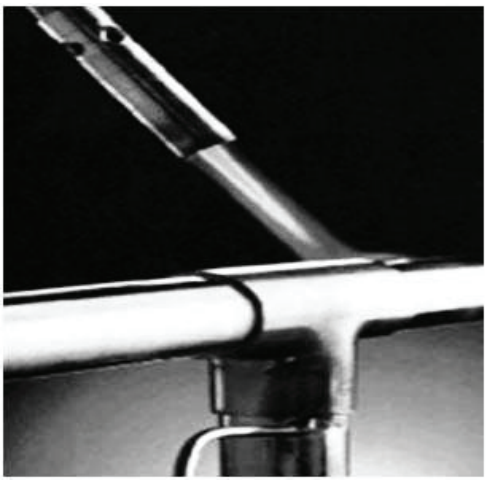
Braze Soldering

- This type of soldering is a procedure for connecting two terminals of the base metals by forming liquid metallic space filler, which runs by the attraction of a vessel through the joints and cools down to give a solid union through diffusion and atomic magnetism.
- It produces a very strong joint. It makes use of a brass metal as a space filler agent.

4.1.2 Required Tools for Soldering

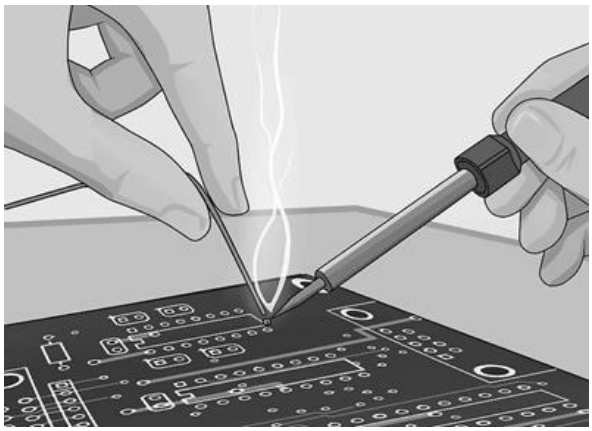
The required tools for soldering includes soldering iron, solder flux, soldering paste, etc.





Soldering Iron

- Here, soldering iron is the required primary thing, which is used as a heat source for liquefying solder. And 15W to 30W soldering guns are good for the majority of electronics or PCB [printed circuit board] job.



- For soldering heavy components and cable, you require to spend on an iron of advanced wattage approx 40W or a larger solder gun.

- The major difference between a gun and an iron is that an iron seems like a pencil and comprises of a pin-point heat supply for precise job, whereas a gun is like a gun in shape with a high wattage point excited by running electrical current simple through it.

Solder Flux

A flux is a chemical purifying agent. In soldering metals, flux provides three functions: it eliminates rust from the components to be soldered; it closes air out as a result ending extra rust, and by making easy mix improves dripping individuality of the fluid solder.

Soldering Paste

Soldering cream is employed to connect the leads of included chip packages to connection ends in the circuit blueprint on a PCB.

4.1.3 Step by Step Soldering Process

The fundamental step by step procedure of soldering is executed by the following steps:

- Start with the small components to the taller components and connecting wires
- Place the element into the PCB, making sure it goes in the correct way around
- Twist the leads a little to secure the part.
- Make sure the soldering iron has warmed up and if required, use the moist sponge to clean the tip.
- Place the soldering iron on the component of the pad and feed the solder's end onto the board
- Take away the solder and the soldering iron from the board.
- Leave the terminal to cool for a few seconds.
- Using a couple of cutters neat the excess component terminal
- If you make a mistake while heat up the joint with the iron, place the solder tip of your solder extractor and push the button.

4.1.4 Soldering Tips:

Soldering is the process that requires practicing the most. Soldering tips must assist you to become successful in your endeavour, and if anything goes wrong, you can stop practicing it, and get ready to do some serious tasks.

Use Heat Sinks: Heat sinks are an essential for the connecting wires of sensitive apparatus namely transistors and integrated circuits. If you do not have a clip on this, then a pair of pliers is a superb choice.

Clean the Iron Tip Neat: A clean iron tip indicates the conductivity of an improved heat and also a better joint. Make use of a wet piece of sponge to clean the tip among joint. Keep the tip of solder well tinned.

Check the Joints: When complex circuits are being collected it is an excellent practice to confirm joints after soldering them.

Solder Tiny Parts Initially: Solder jumper terminals, diodes, resistors and all other small parts previous to moving ahead to connect bigger parts such as capacitors and transistors. This makes assembling much easier.

Connect Sensitive Components at the End: Put in CMOS, MOSFETs, ICs and other inactive sensitive parts at the end to avoid damaging them while connecting the other components.

Use Sufficient Ventilation: Avoid breathing the smoke formed and make sure that the region you are operating in has plenty ventilation to put a stop to increase of toxic smoke.

POST-SESSION ACTIVITY

- The Trainer will divide trainees into three groups. One group of trainees will be asked to explain the methods of soldering, one group will state the steps of soldering and the other group will talk about the different tools used for soldering.

SUMMARIZATION

- Soldering is the process of fixing one or more components as one by one by dissolving and running a solder in the joint.
- Soldering process is done in various electrical and electronics projects to combine the components with the roots of the printed circuit board.
- The methods of soldering process can be classified into two, namely soft soldering and hard soldering.
- Soldering iron is the required primary thing, which is used as a heat source for liquefying solder.
- Soldering flux is a chemical purifying agent.

Test yourself

A. Fill in the blanks.

a. _____is the process of fixing one or more components as one by one by dissolving and running a solder in the joint.

b. A flux is a chemical _____agent.

c. Heat sinks are an essential for the connecting wires of sensitive apparatus namely _____and integrated circuits.

B. State whether the following statements are True or False:

a. The methods of soldering process can be classified into two, namely soft soldering and hard soldering. [ ]

b. Solder flux is employed to connect the leads of included chip packages to connection ends in the circuit blueprint on a PCB. [ ]

c. Silver provides a free running individuality, so silver soldering is not suggested for space filling. [ ]

NOTES 

CHAPTER - 5
ALTERNATING CURRENT

RECALL SESSION:

In the previous chapter, we learnt about:

- Soldering and its types
- Various methods of soldering and required tools
- The tips for soldering

LEARNING OUTCOMES:

By the end of this session, trainees would be able to:

- Understand the concept of Alternating Current
- Know about Circuits

PRE-SESSION ACTIVITY

- The Trainer will ask the Trainees the full form of AC and its concept.
- The Trainer will also ask the Trainees to share their knowledge on circuits.

Discussion:

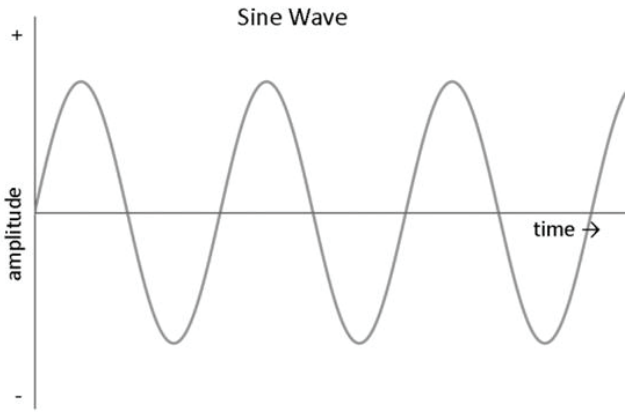
- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by rectifying the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.

5.1 Alternating Current

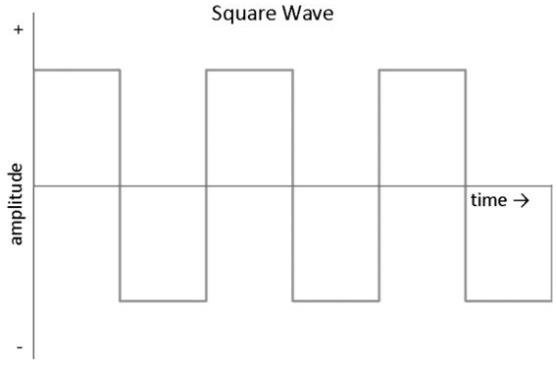
- In electricity, alternating current [AC] occurs when charge carriers in a conductor or semiconductor periodically reverse their direction of movement.
- Household utility current in most countries is AC with a frequency of 60 hertz [60 complete cycles per second]; although in some countries it is 50 Hz.
- The radio-frequency [RF] current in antennas and transmission lines is another example of AC.

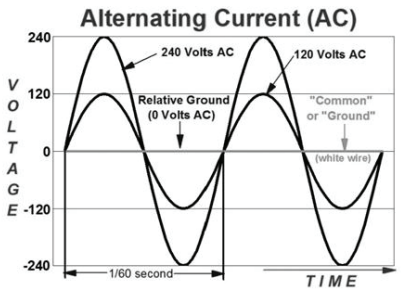
Waveforms

- AC can come in a number of forms, as long as the voltage and current are alternating. If we hook up an oscilloscope to a circuit with AC and plot its voltage over time, we might see a number of different waveforms.
- The most common type of AC is the sine wave. The AC in most homes and offices has an oscillating voltage that produces a sine wave.

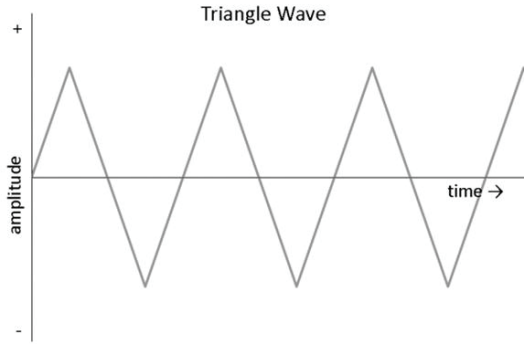


Other common forms of AC include the square wave and the triangle wave:





Square waves are often used in digital and switching electronics to test their operation.



Triangle waves are found in sound synthesis and are useful for testing linear electronics like amplifiers.

5.2 Circuit

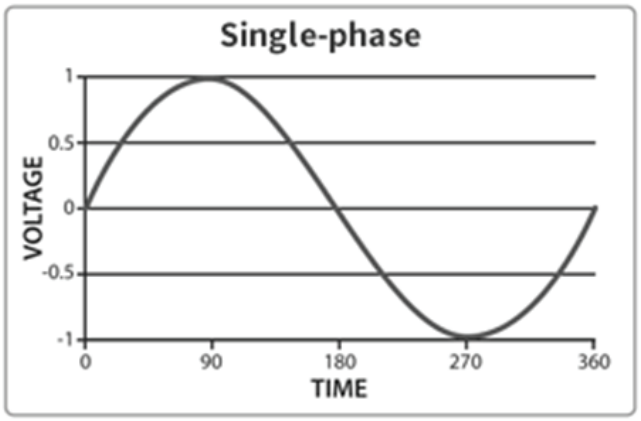
A circuit is a closed loop that allows charge to move from one place to another. Components in the circuit allow us to control this charge and use it to do work.

There are two types of circuits:

- Single-phase Circuit
- Three-phase Circuit

5.2.1 Single-phase Circuit:

- It is a two-wire Alternating Current [AC] power circuit. Most people use it every day because it's the most common household power circuit and powers their lights, TV etc.
- Supplies ample power to homes and small, non-industrial businesses.
- Adequate for running motors up to about 5 horsepower.



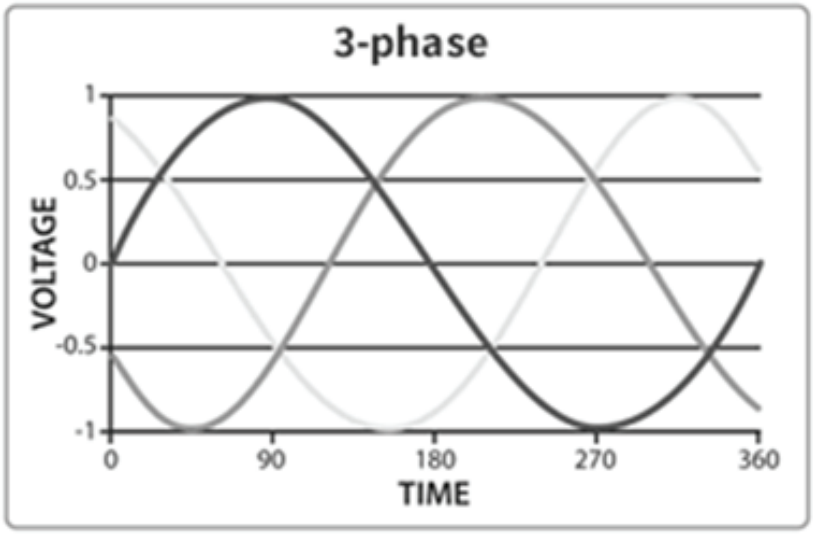
DO YOU KNOW?

The first modern commercial power plant that used three-phase altering current was at the Mill Creek hydroelectric plant near Redlands, California in 1893.

With the wave form of single-phase power, when the wave passes through zero, the power supplied at that moment is zero.

5.2.2 Three-phase circuit:

- Common in large businesses, as well as industry and manufacturing.
- Increasingly popular in power-hungry, high-density data centers.
- Expensive to convert from an existing single-phase installation, but 3-phase allows for smaller, less expensive wiring and lower voltages, making it safer and less expensive to run.
- Highly efficient for equipment designed to run on 3-phase.



POST-SESSION ACTIVITY

- The Trainer will ask the Trainees to make a chart paper project where they will be asked to draw different types of circuits and explain.
- The Trainer will divide the Trainees into a group of 2. The Trainer will ask each group to explain the concept of Alternating Current. The group that explains in the best manner will be recognized.

SUMMARIZATION

- Alternating current [AC] occurs when charge carriers in a conductor or semiconductor periodically reverse their direction of movement.
- The AC in most homes and offices has an oscillating voltage that produces a sine wave.
- Square waves are often used in digital and switching electronics to test their operation.

Test yourself

A. Fill in the blanks.

a. _____current occurs when charge carriers in a conductor or semiconductor periodically reverse their direction of movement.

b. The most common type of AC is the _____ wave.

c. _____ is a two-wire Alternating Current power circuit.

B. State whether the following statements are True or False:

a. Single-phase Circuit is adequate for running motors up to about 15 horsepower. [ ]

b. Household utility current in most countries is AC with a frequency of 60 hertz. [ ]

c. With the wave form of single-phase power, when the wave passes through zero, the power supplied at that moment is zero. [ ]

d. A circuit is a closed loop that allows charge to move from one place to another. [ ]

NOTES 

CHAPTER - 6
EARTHING

RECALL SESSION:

In the previous chapter, we learnt about:

- The concept of Alternating Current
- Circuits and it's types

LEARNING OUTCOMES:

By the end of this session, trainees would be able to:

- Understand the purpose of electrical earthing
- Understand the types of earthing
- Know the importance of earthing
- Understand how to measure earth electrode resistance

PRE-SESSION ACTIVITY

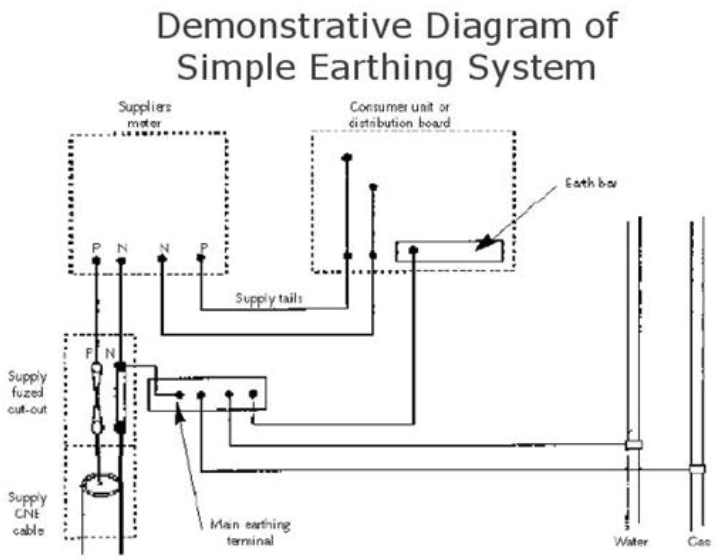
- The Trainer will ask the Trainees whether they are familiar with the concept of earthing.
- The Trainer will then conduct a group discussion on the importance of earthing.

Discussion:

- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by rectifying the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.

6.1 What is Electrical Earthing?

- The method of connecting noncurrent carrying parts of the electrical equipment or the neutral point of the supply system to the earth through the wire having negligible resistance is called electrical earthing.
- Earthing protects the electrical equipment from lightning strokes and earth fault conditions.
- It provides the easiest path to the fault or leakage current to flow through it.

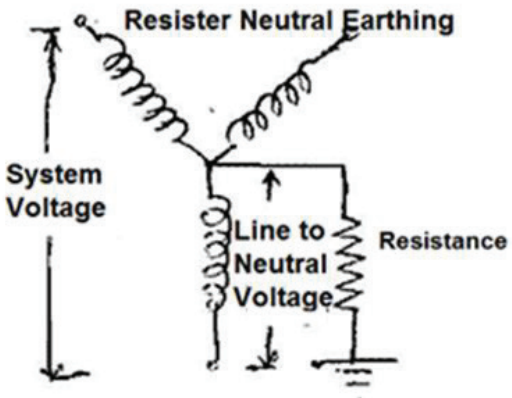


6.2 Types of Earthing

The electrical equipment mainly consists of two non-current carrying parts. These parts are neutral of the system or frame of the electrical equipment.

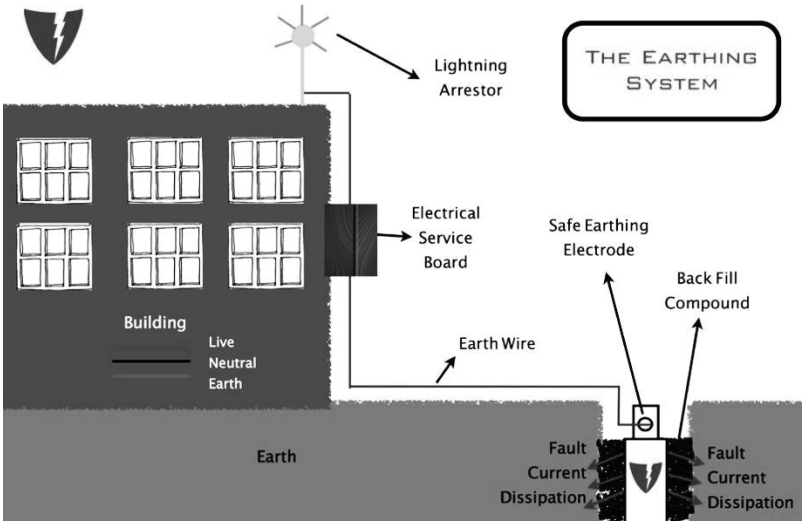
On the basis of the earthing of these two noncurrent carrying parts of the electrical system, earthing can be classified into two types.

- Neutral Earthing
- Equipment Earthing



6.2.1 Neutral Earthing:

- Neutral earthing is defined as the earthing of the system neutral to ensure system security and protection. Neutral earthing is called the system earthing.
- In neutral earthing, the neutral point of the star-connected 3-phase windings of power transformers, generators, motors, and the earthing transformer is connected to the low resistance.



DO YOU KNOW?

The Earth carries a negative electric charge of roughly 500,000 coulombs.

6.2.2 Equipment Earthing:

- Equipment earthing deals with the earthing of noncurrent carrying parts [frame or metallic body] of the electrical equipment to ensure the safety of personnel and protecting against lightning.
- It also helps in earth fault protection.

Plate type Earthing:

- Generally for plate type earthing normal Practice is used
- Cast iron plate of size 600 mm x600 mm x12 mm. OR
- Galvanized iron plate of size 600 mm x600 mm x6 mm. OR
- Copper plate of size 600 mm * 600 mm * 3.15 mm
- Plate burred at the depth of 8 feet in the vertical position and GI strip of size 50 mmx6 mm bolted with the plate is brought up to the ground level.
- These types of earth pit are generally filled with an alternate layer of charcoal & salt up to 4 feet from the bottom of the pit.

Pipe type Earthing:

- For Pipe type earthing normal practice is used
- GI pipe [C-class] of 75 mm diameter, 10 feet long welded with 75 mm diameter GI flange having 6 numbers of holes for the connection of earth wires and inserted in ground by auger method.
- These types of earth pit are generally filled with an alternate layer of charcoal & salt or earth reactivation compound.

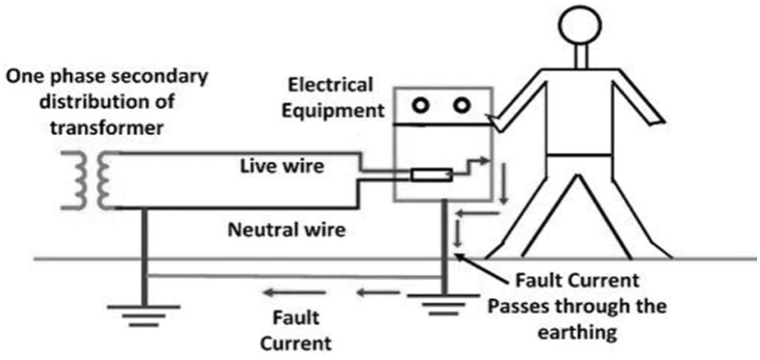
Exercise

1. The earth carries a negative electric charge of about _____.
2. How many types of earthing can be done?
3. Show a diagrammatic presentation of Neutral Earthing.

NOTES

6.3 Importance of Earthing

Earthing is essential because of the following reasons:



Electrical System With Earthing

- Earthing provides the safety of the personnel from the electric shock. It ensures that the non-currents carrying parts, such as equipment frames are always safe at ground potential even though the insulation fails.
- Earthing is essential for the safety of the equipment and personnel against lightning and voltage surges, providing the discharge path for surge arrestors, gaps, and other similar devices.
- It provides the ground connections for the ground neutral system.
- It provides a means of positively discharging and de-energizing feeders or equipment before proceeding with maintenance on them.

Earthing can be done by electrically connecting the respective parts in the installation to some system of electrical conductors or electrodes placed near the soil or below the ground level.

The earthing mat or electrode under the ground level have flat iron riser through which all the non-current-carrying metallic parts of the equipment are connected.

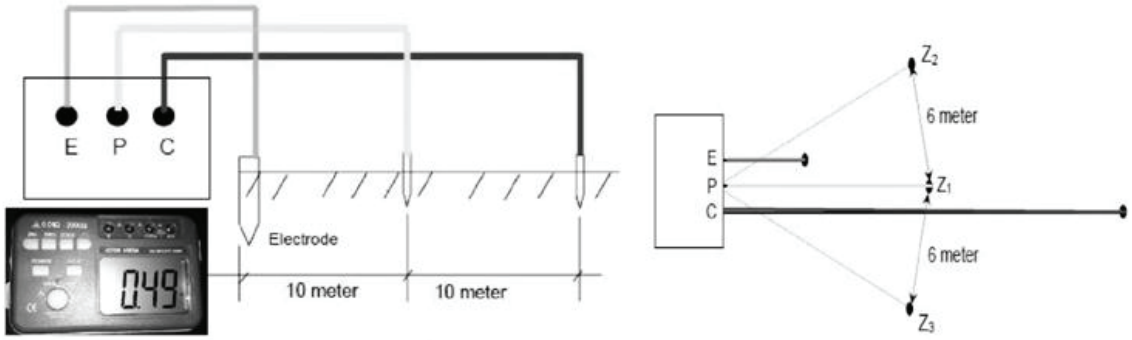
When the fault occurs, the fault current from the equipment flows through the earthing system to the earth and thereby protect the equipment from the fault current. At the time of the fault, the earth mat conductors rise to the voltage which is equal to the resistance of the earth mat multiplied by a ground fault.

The contacting assembly is called earthing. The metallic conductors connecting the parts of the installation with the earthing are called electrical connection. The earthing and the earthing connection together called the earthing system.

6.4 Earth Electrode Resistance Measurement

The object of an earth electrode system is to provide a low resistance to foreign currents that may cause injury or damage or disrupt equipment. The currents will dissipate safely when properly conducted to earth via the electrode. There are three components to the resistance:

- Resistance of the electrode materials and connections to them.
- Contact resistance between the electrode and the soil surrounding it.
- Resistance of the surrounding earth.



Earth Electrode Resistance Measurement

The resistance of the electrode materials is purposely made small so their contribution to the total resistance is negligible. Generally, copper materials are used throughout.

Ground rods usually are copper-coated steel for strength, although galvanized steel ground rods are found in applications where corrosion is a problem.

Generally, the resistance of the surrounding earth will be the largest of the three components. An earth electrode system buried in the earth radiates current in all directions and eventually dissipates some distance away depending on the soil's resistance to current flow, as indicated by its resistivity.

An earth electrode system consists of all interconnected buried metallic components including ground rods, ground grids, buried metal plates, radial ground systems and buried horizontal wires, water well casings and buried metallic water lines, concrete encased electrodes [Ufer grounds], and building structural steel.

POST-SESSION ACTIVITY

- The Trainer will conduct a quiz session by dividing the group of Trainees into two. The Trainer will then ask questions on different types of earthing and its purpose.
- The group which answers or explains correctly will be declared as the winner.

SUMMARIZATION

- Earthing protects the electrical equipment from lightning strokes and earth fault conditions.
- On the basis of the earthing of these two noncurrent carrying parts of the electrical system, earthing can be classified into Neutral and Equipment Earthing.
- Earthing provides the safety of the personnel from the electric shock.
- The object of an earth electrode system is to provide a low resistance to foreign currents that may cause injury or damage or disrupt equipment.
- The resistance of the electrode materials is purposely made small so their contribution to the total resistance is negligible.

Test yourself

A. Fill in the blanks.

a. _____ protects the electrical equipment from lightning strokes and earth fault conditions.

b. The object of an _____ _____ system is to provide a low resistance to foreign currents that may cause injury or damage or disrupt equipment.

c. _____ _____ helps in earth fault protection.

B. State whether the following statements are True or False:

a. Earthing provides the safety of the personnel from the electric shock. [ ]

b. Neutral earthing is called the system earthing. [ ]

c. Earthing protects the electrical equipment from lightning strokes and earth fault conditions. [ ]

NOTES 

Worksheet -2

[20 Marks]

1. Answer any 4 from the following questions. **[1.5x4 = 6]**

a. What do you mean by Earthing?

b. Write in 2 sentences about Pipe-type Earthing.

c. What is a single-phase circuit?

d. Describe solder flux.

e. State the different methods of soldering.

2. State whether the statements are true or false **[4x1 = 4]**

a. The solder metal has a lower melting temperature than the working piece. [ ]

b. A circuit is a closed loop that allows charge to move from one place to another [ ]

c. Soldering is the process that requires practicing the most. [ ]

d. Alternating current [AC] occurs when charge carriers in a conductor or semiconductor periodically move towards the same direction of movement. [ ]

3. Complete the following sentences **[1x5 = 5]**

Column - A	Column - B
A. Soft Soldering	**a.** In this process, a tin-lead alloy is used as space filler metal. The liquefying
B. Braze Soldering	**b.** In this type of soldering, a solid solder unites two elements of metals by spreading out into the holes of the component that are unlocked due to high temperature.
C. Hard Soldering	**c.** It is an unsoiled method supportive to fabricate small components, carrying out abnormal maintenance and built-up tools.
D. Three-phase circuit	**d.** Adequate for running motors up to about 5 horsepower.
E. Silver Soldering	**e.** This type of soldering is a procedure for connecting two terminals of the base metals by forming liquid metallic space filler.

4. Complete the following sentences **[1x5 = 5]**

a. _____ provides the easiest path to the fault or leakage current to flow through it.

b. _____ protects the electrical equipment from lightning strokes and earth fault conditions.

c. The most common type of AC is the _____ wave.

d. _____is the process of fixing one or more components as one by one by dissolving and running a solder in the joint.

e. A flux is a chemical _____agent.

CHAPTER - 7
SYMBOLS USED FOR ELECTRICAL ACCESSORIES

RECALL SESSION:

In the previous chapter, we learnt about:

- The purpose of electrical earthing
- The types of earthing
- The importance of earthing
- How to measure earth electrode resistance

LEARNING OUTCOMES:

By the end of this session, trainees would be able to:

- Understand the signs and symbols and their meanings used for various electrical accessories.
- Understand the colour codes of carbon resistors.

DO YOU KNOW?

Adding more batteries to a simple circuit will increase the electrical energy, which will make a bulb brighter.

PRE-SESSION ACTIVITY

- The Trainer will ask Trainees if they are aware of the various signs and symbols used for various electrical accessories. The Trainees will raise their hands to answer and sort out queries if any.
- The Trainer will conduct a video session on the signs and symbols for electrical accessories.

Discussion:

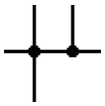
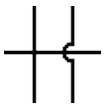
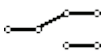
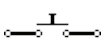
- The trainer will divide the total batch into groups of four.
- Each group will jot down the points they have learnt from the video.
- The trainer will then discuss the points for all the groups.

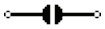
7.1 Symbols in Electronics

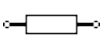
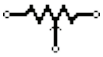
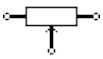
- An electronic symbol is a pictogram used to represent various electrical and electronic devices [such as wires, batteries, resistors, and transistors] in a schematic diagram of an electrical or electronic circuit.
- These symbols can [because of remaining traditions] vary from country to country, but are today to a large extent internationally standardized. Some symbols represent components [such as vacuum tubes] which ceased to be used routinely as newer technologies were introduced.

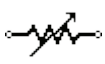
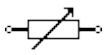
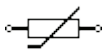
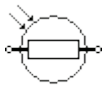
Electrical symbols and electronic circuit symbols are used for drawing schematic diagram.

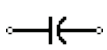
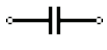
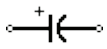
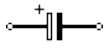
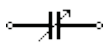
The symbols represent electrical and electronic components

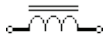
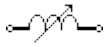
Symbol	Component name	Meaning
Wire Symbols		
	Electrical Wire	Conductor of electrical current
	Connected Wires	Connected crossing
	Not Connected Wires	Wires are not connected
Switch Symbols and Relay Symbols		
	SPST Toggle Switch	Disconnects current when open
	SPDT Toggle Switch	Selects between two connections
	Pushbutton Switch [N.O]	Momentary switch - normally open
	Pushbutton Switch [N.C]	Momentary switch - normally closed

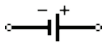
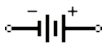
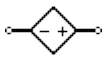
	DIP Switch	DIP switch is used for onboard configuration
	SPST Relay	Relay open / close connection by an electromagnet
	SPDT Relay	
	Jumper	Close connection by jumper insertion on pins.
	Solder Bridge	Solder to close connection

Ground Symbols		
	Earth Ground	Used for zero potential reference and electrical shock protection.
	Chassis Ground	Connected to the chassis of the circuit
	Digital / Common Ground	
Resistor Symbols		
	Resistor [IEEE]	Resistor reduces the current flow.
	Resistor [IEC]	
	Potentiometer [IEEE]	Adjustable resistor - has 3 terminals.
	Potentiometer [IEC]	

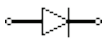
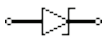
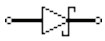
	Variable Resistor / Rheostat [IEEE]	Adjustable resistor - has 2 terminals.
	Variable Resistor / Rheostat [IEC]	
	Trimmer Resistor	Preset resistor
	Thermistor	Thermal resistor - change resistance when temperature changes
	Photoresistor / Light dependent resistor [LDR]	Photo-resistor - change resistance with light intensity change

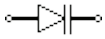
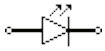
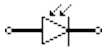
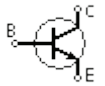
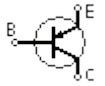
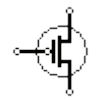
Capacitor Symbols		
	Capacitor	Capacitor is used to store electric charge. It acts as a short circuit with AC and open circuit with DC.
	Capacitor	
	Polarized Capacitor	Electrolytic capacitor
	Polarized Capacitor	Electrolytic capacitor
	Variable Capacitor	Adjustable capacitance

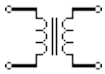
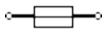
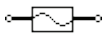
Inductor / Coil Symbols		
	Inductor	Coil / solenoid that generates magnetic field
	Iron Core Inductor	Includes iron
	Variable Inductor	
Power Supply Symbols		
	Voltage Source	Generates constant voltage
	Current Source	Generates constant current.
	AC Voltage Source	AC voltage source

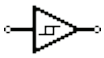
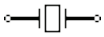
	Generator	Electrical voltage is generated by mechanical rotation of the generator
	Battery Cell	Generates constant voltage
	Battery	Generates constant voltage
	Controlled Voltage Source	Generates voltage as a function of voltage or current of other circuit element.
	Controlled Current Source	Generates current as a function of voltage or current of other circuit element.

Meter Symbols		
	Voltmeter	Measures voltage. Has very high resistance. Connected in parallel.
	Ammeter	Measures electric current. Has near zero resistance. Connected serially.
	Ohmmeter	Measures resistance
	Wattmeter	Measures electric power
Lamp / Light Bulb Symbols		
	Lamp / light bulb	Generates light when current flows through
	Lamp / light bulb	
	Lamp / light bulb	

Diode / LED Symbols		
	Diode	Diode allows current flow in one direction only - left [anode] to right [cathode].
	Zener Diode	Allows current flow in one direction, but also can flow in the reverse direction when above breakdown voltage
	Schottky Diode	Schottky diode is a diode with low voltage drop

	Varactor / Varicap Diode	Variable capacitance diode
	Tunnel Diode	
	Light Emitting Diode [LED]	LED emits light when current flows through
	Photodiode	Photodiode allows current flow when exposed to light
Transistor Symbols		
	NPN Bipolar Transistor	Allows current flow when high potential at base [middle]
	PNP Bipolar Transistor	Allows current flow when low potential at base [middle]
	Darlington Transistor	Made from 2 bipolar transistors. Has total gain of the product of each gain.
	JFET-N Transistor	N-channel field effect transistor
	JFET-P Transistor	P-channel field effect transistor
	NMOS Transistor	N-channel MOSFET transistor
	PMOS Transistor	P-channel MOSFET transistor

Misc. Symbols		
	Motor	Electric motor
	Transformer	Change AC voltage from high to low or low to high.
	Electric bell	Rings when activated
	Buzzer	Produce buzzing sound
	Fuse	The fuse disconnects when current above threshold. Used to protect circuit from high currents.
	Fuse	
	Bus	Contains several wires. Usually for data / address.
	Bus	
	Bus	
	Optocoupler / Opto-isolator	Optocoupler isolates connection to other board
	Loudspeaker	Converts electrical signal to sound waves
	Microphone	Converts sound waves to electrical signal

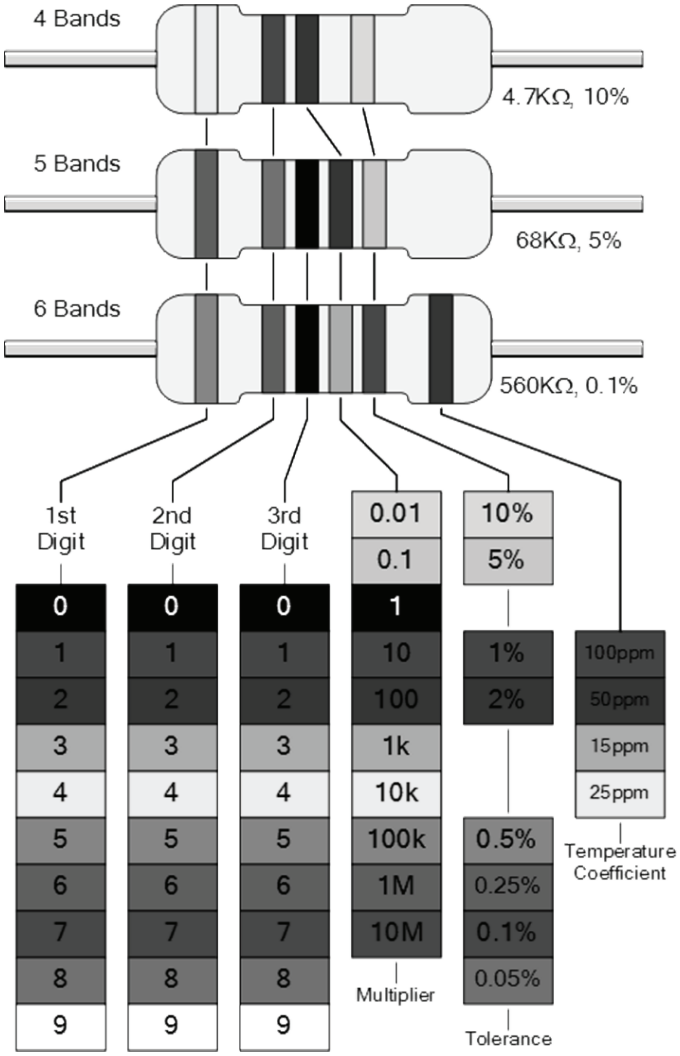
	Operational Amplifier	Amplify input signal
	Schmitt Trigger	Operates with hysteresis to reduce noise.
	Analog-to-digital converter [ADC]	Converts analog signal to digital numbers
	Digital-to-Analog converter [DAC]	Converts digital numbers to analog signal
	Crystal Oscillator	Used to generate precise frequency clock signal
Antenna Symbols		
	Antenna / aerial	Transmits & receives radio waves
	Antenna / aerial	
	Dipole Antenna	Two wires simple antenna
Logic Gates Symbols		
	NOT Gate [Inverter]	Outputs 1 when input is 0
	AND Gate	Outputs 1 when both inputs are 1.

	NAND Gate	Outputs 0 when both inputs are 1. [NOT + AND]
	OR Gate	Outputs 1 when any input is 1.
	NOR Gate	Outputs 0 when any input is 1. [NOT + OR]
	XOR Gate	Outputs 1 when inputs are different. [Exclusive OR]
	D Flip-Flop	Stores one bit of data
	Multiplexer / Mux 2 to 1	Connects the output to selected input line.
	Multiplexer / Mux 4 to 1	
	Demultiplexer / Demux 1 to 4	Connects selected output to the input line.

7.2 Colour Codes of Carbon Resistors

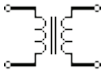
Components and wires are coded with colours to identify their value and function. Commercially, resistors of different types and values are available in the market. However, in electronic circuits, carbon resistors are more frequently used.

The Standard Resistor Colour Code Chart:



Exercise

Recognize the following symbols and their functions:

NOTES 

7.3 The Resistor Colour Code Table:

Colour	Digit	Multiplier	Tolerance
Black	0	1	
Brown	1	10	± 1%
Red	2	100	± 2%
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	± 0.5%
Blue	6	1,000,000	± 0.25%
Violet	7	10,000,000	± 0.1%
Grey	8		± 0.05%
White	9		
Gold		0.1	± 5%
Silver		0.01	± 10%
None			± 20%

POST-SESSION ACTIVITY

- The Trainer will conduct a quiz session by dividing the number of Trainees into two groups. Both the groups will be provided a sheet of paper with various symbols used for electrical components. The group which identifies the symbols along with their functions correctly in time will be awarded winner.
- The Trainer will also bring a chart paper comprising colour codes for various components and wires. The Trainees will have the chart papers distributed evenly and they will be asked to identify which colour code belongs to what electrical component.

SUMMARIZATION

- An electronic symbol is a pictogram used to represent various electrical and electronic devices in a schematic diagram of an electrical or electronic circuit.
- DIP switch is used for on-board configuration.
- Capacitor acts as short circuit with AC and open circuit with DC.
- Components and wires are coded with colours to identify their value and function.
- In electronic circuits, carbon resistors are more frequently used.

Test yourself

A. Complete the sentences.

a. An electronic symbol is a pictogram used to represent _____

b. Components and wires are coded with colours to identify their _____ and _____.

c. Carbon resistors are more frequently used in electronic _____.

B. State whether the following statements are True or False:

a. Electrical symbols and electronic circuit symbols are used for drawing schematic diagram. [ ]

b. Microphone converts electrical signal to sound waves. [ ]

c. NPN Bipolar Transistor allows current flow when high potential at base [middle]. [ ]

NOTES

CHAPTER - 8
DOMESTIC WIRING AND MEGGER TEST

RECALL SESSION:

In the previous chapter, we learnt about:

- The signs and symbols and their meanings used for various electrical accessories.
- The colour codes of carbon resistors.

LEARNING OUTCOMES:

By the end of this session, trainees would be able to:

- Understand the concept of Domestic Wiring
- Know about electrical wiring accessories
- Know how to conduct Megger test and using test lamps in faulty locations
- Know about different types of wiring system

PRE-SESSION ACTIVITY

- The Trainer will show a video to the Trainees on domestic wiring. After the video ends, the Trainees will come up with queries and opinions about the video.
- The Trainer will ask the Trainees to share their knowledge and experiences on various wiring systems.

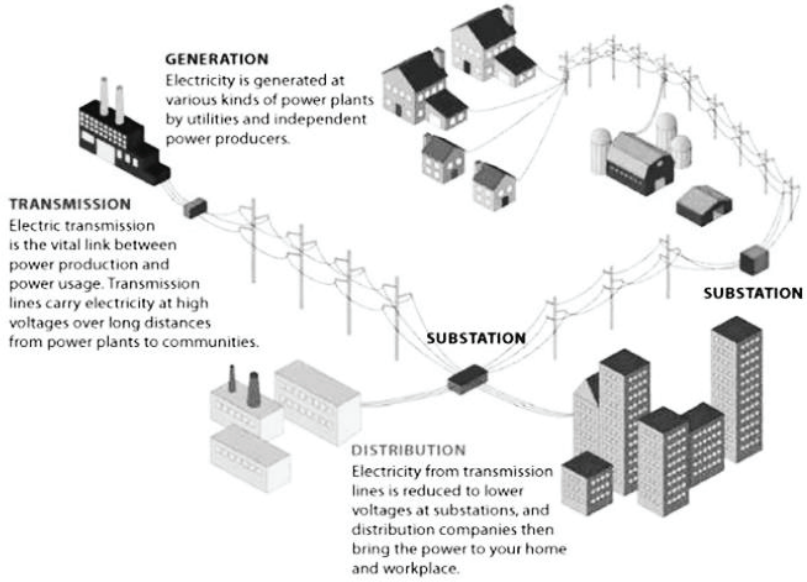
Discussion:

- The trainer will ask the students what they have learnt from the expert session
- The trainer will allow 15 minutes for the batch to jot down the important points
- All points will be cross checked and discussed in the class

8.1 Domestic Wiring

- House wiring is defined as any wiring or electrical system used in a home or its surrounding areas.
- The wiring process is fairly time consuming and requires planning for the varying power needs of electronics and appliances.
- At home, the wiring system includes outlets, the main panel and meter base, and it is essential that all pieces are installed and function together properly to keep the home safe. With this in mind, hiring a professional is usually best to ensure that the process is completed safely.

Wiring may be routed in any of several different ways. For example, the cable for a switch may run through a switch box and then on to the light, or it may run through the light to the switch box via a "switch loop."

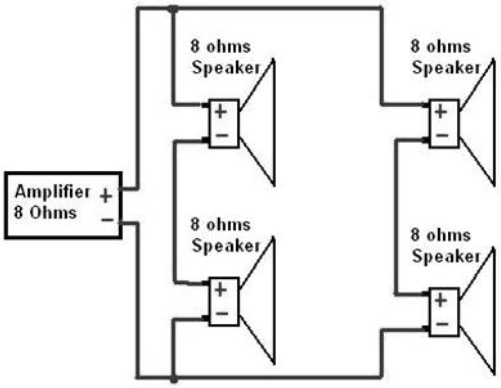


Other wires may run through either the switch box or the housing box or both, unswitched, on their way to powering different devices down the line.

Types of Wiring:

8.1.1 Parallel Wiring

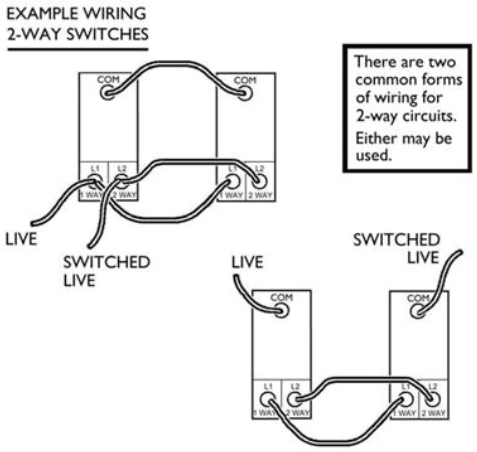
The wiring for most homes is parallel, meaning several devices are powered on a single circuit. Both the hot and neutral wires run through the various housing boxes along the route and branch off to individual fixtures and receptacles.



Series Parallel Speaker System -- 8 ohm load

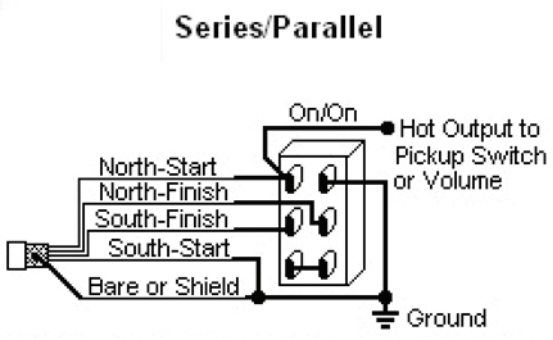
8.1.2 Switch Wiring

Switches, which are installed on hot wires, allow or disallow the flow of current to a light or other device.



8.1.3 Series Wiring

Series wiring routes the hot wire through several devices and then joins the neutral wire, which leads back to the source.



Use DPDT ON/ON Mini Switch

8.2 Components used in house wiring

In case of new home construction, wiring for all electrical services can be easily installed before the walls are finished. In existing buildings, installation of a new system, such as a security system or home theatre, may require additional effort to install concealed wiring.

Multiple unit dwellings such as condominiums and apartment houses may have complexities additional installation complexity in distributing services within a house.

Services commonly found include:

- Power points [wall outlets]
- Light fixtures and switches
- Telephone
- Internet
- Television, either broadcast, cable, or satellite

High-end features might include:

- Home theatre
- Distributed audio
- Security monitoring
- Security CCTV
- Automation
- Energy management

DO YOU KNOW?

Coal is the world's biggest source of energy for producing electricity.

- ✓ Power and telecommunication services generally require entry points into the home and a location for connection equipment.
- ✓ For electric power supply, a cable is run either overhead or underground into a distribution board in the home.
- ✓ A distribution board, or circuit breaker panel, is typically a metal box mounted on a wall of the home. In many new homes, the location of the electrical switchboard is on the outside of the external wall of the garage.
- ✓ How services are connected will vary depending on the service provider and location of the home.

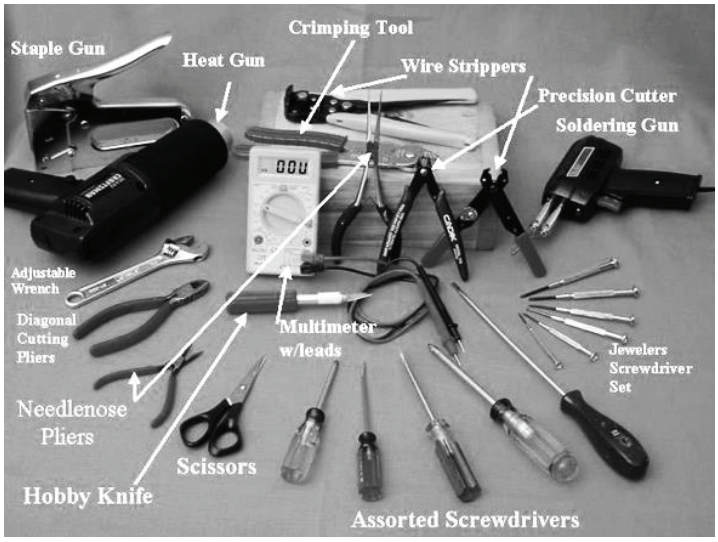
8.2.1 Wiring Basics

- Wiring a residence requires the use of three different colours of wires in addition to a bare ground wire. The bare wire serves as the ground and doesn't transfer any power. This is the wire that will trip the circuit breaker in the event of a short circuit and eliminate any electrical current moving to the device.
- Both black and red wires are called "hot" wires in the industry and carry current from the breaker to the appliance.
- White wires hold current taking the opposite path, from the appliance to the breaker and are called "returns." A 14-2 gauge wire is the minimum in most areas, but 12-2 is preferable. This is a thicker gauge wire that will handle more power, which means reduced chance of tripping a circuit. In fact, this additional power is an ideal choice for homes that have many appliances or electrical devices that will that run simultaneously.

8.2.2 Wiring Tools and Accessories

When it comes to electrical projects, large or small, having the right tools for the job makes the project a lot easier and potentially safer.

While there are numerous specialty electrical tools available, some are a must-have in the electrical toolbox.



- **Personal protective equipment [PPE]**

  Personal protective equipment [PPE] refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection.

- **Circuit Testers**

  You need to have a voltage tester of some type for electrical work, and one that you trust is working properly. The important thing is to ensure that it is working so you can verify that you have the power off on any circuit you may be working with. Check it on a known live source before trusting it to determine if your circuit is dead.

- **Screwdrivers**

  It is essential to have a good quality set of screwdrivers. It is best to purchase them in a complete set rather than individually, as this will save you money, and increase the chances that you will have the driver that best fits the need.

  A basic set of screwdrivers should include the 3 main types of screwdriver heads.

  1. The Standard blade tip
  2. The Phillips tip
  3. The recessed square shank or Robertson tip

You need at least two sizes of each, but a full set would include:

- Standard blade
- Phillips Tip
- Square Recess Tip [Robertson]

- **Cordless Screwdriver/Drill**

  If you are going to take on any project beyond the most basic of jobs, such as, for example, changing out an individual receptacle or switch, you should have a good cordless drill and driver tool, along with a complete set of screwdriver bits and drill bits. This will save you a lot of time and when used properly, a power driver can be used in place of a screwdriver for most jobs.

- **Electric Drill**

  For larger projects, with a lot of drilling required, [wood studs, etc.], an electric drill is more practical. Using rechargeable batteries, these drills are available with similar features to an AC mains-powered drill. They are available in the hammer drill configuration and most have a clutch, which aids in driving screws into various substrates while not damaging them.

- **Knife**

  You will need to have a good knife, and I prefer a standard utility knife, stripping large gauge wire, and for many other jobs as well.

- **Wire Strippers**

  Have a good quality wire stripper. I prefer a T-Stripper with a wire cutter, light-duty plier nose, and holes for bending termination loops on wires for most home electrical work. A combination crimper, cutter, stripper, bolt cutter and more, like those found in automotive electrical repair kits can be very handy as well, but the multi-purpose aspect means that the wire stripping function is compromised.

- **Lineman's Plier**

  A lineman's plier, or a bull nose plier with a wire cutter, and at least 8″or 9″ handles is also an essential part of the electrical tool list. We use these for cutting, bending, twisting wires, etc.

- **Diagonal Pliers**

  Also known as side-cutters, a standard duty diagonal plier should also be a part of your kit.

- **Hammer**

  Have a good quality, 16oz. claw hammer. You will need this for driving staples, nails, etc.

- **Nut Drivers**

  A good set of nut drivers is not essential, but come in very handy for certain jobs where a wrench or a socket set isn't practical.

- **Tape Measure**

  Have a good quality, locking tape measure and a 25'length, 1″ blade is maybe over-kill, but will come in handy for other projects around the home.

- **Pump Pliers**

  These are very handy, and essential if you are working with conduit, such as EMT, flexible conduit, or teck cable.

- **Pipe Wrench**

  It would be essential if you are working with conduit, especially rigid or EMT conduit.

- **Electrical Tape**

  Every electrical tool kit should have at least a roll of black electrical tape, and having a few colours like red and blue helps as well for identifying wires, etc.

- **Duct Tape**

  Every tool kit, electrical or otherwise, must have the universal repair tool that is a roll of duct tape!

- **Bandages**

  No matter how careful you are, accidents happen. Just do all you can to protect yourself and minimize the potential for injury. Have a first aid kit handy, in case of any emergency.

- **Keyhole saw**

  Great for cutting out openings for outlet boxes in drywall, panelboard, etc.

- **Hacksaw**

  A saw with a narrow fine-toothed blade set in a frame, used especially for cutting metal.

- **Power Saw**

  For cutting studs, blocking and reinforcing boxes, etc.

- **Wood Chisel**

  One uses it when working with wood construction.

- **Conduit Bender**

  If working with conduit, you will need a hickey bender or any bending tool designed for the conduit you are working with.

- **Fish Tape, and/or Fishing Tools**

  A fish tape is very handy, and essential if working with conduit. A fish tape or fishing tools are required if you are installing electrical in existing walls or ceilings and are trying to minimize the damage you may cause by cutting as few access holes as possible.

- **Flashlight/Headlamp**

  For when you need some extra light for dark places, or when the power is off while working on existing systems.

Exercise

Fill in the Blanks:

- _____ is defined as any wiring or electrical system used in a home or its surrounding areas.
- Series wiring routes the _____ wire through several devices and then joins the neutral wire
- A semiconductor is a type of material that has an _____ resistance
- A lineman's plier is also known as _____ plier

NOTES

8.3 What is Megger

- Insulation resistance quality of an electrical system degrades with time, environment condition i.e. temperature, humidity, moisture and dust particles.
- It also gets impacted negatively due to the presence of electrical and mechanical stress, so it's become very necessary to check the IR [Insulation resistance] of equipment at a constant regular interval to avoid any measure fatal or electrical shock.

8.3.1 Uses of Megger

- Megger enables us to measure electrical leakage in wire, results are very reliable as we shall be passing electric current through device while we are testing.
- The equipment is basically used for verifying the electrical insulation level of any device such as motor, cable, generator winding, etc.
- This is a very poplar test being carried out since very long back. Not necessary it shows us exact area of electrical puncture but shows the amount of leakage current and level of moisture within electrical equipment/winding/system.

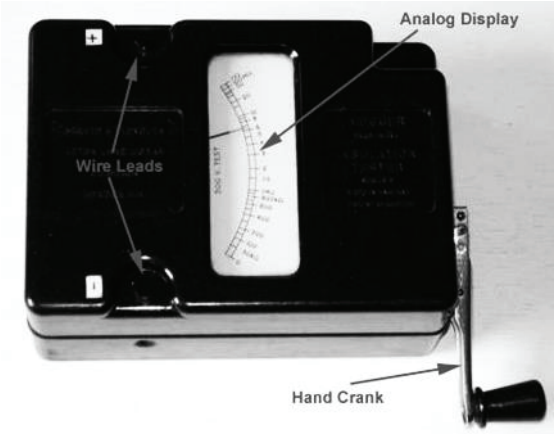
8.3.2 Categories of Megger

Megger can be separated into mainly two categories:

- Electronic Type [Battery Operated]
- Manual Type [Hand Operated]

Electronic Type Megger and its Specifications:

1) **Digital Display:** A digital display to show IR value in digital form.
2) **Wire Leads:** Two numbers of wire leads for connecting megger with electrical external system to be tested.
3) **Selection Switches:** Switches use to select electrical parameters ranges.
4) **Indicators:** To indicate various parameters status i.e. On-Off. For Example, Power, hold, Warning etc.



Manual Type Megger and its Specifications:

1) **Analog display** provided on front face of tester for IR value recording.
2) **Hand crank** used to rotate helps to achieve desired RPM required generate voltage which runs through electrical system.
3) **Wire Leads** - Used same as in electronic tester i.e. For connecting tester with electrical system.

8.3.3 Advantages of Electronic Type Megger:

- Level of accuracy is very high.
- IR value is digital type, easy to read.
- One person can operate very easily.
- Works perfectly even at very congested space.
- Very handy and safe to use.

8.3.4 Advantages of Hand Operated Megger:

- Still keeps important in such high-tech world as it's an oldest method for IR value determination.
- No external source required to operate.
- Cheaper available in market.

8.4 Construction of Megger

The circuit construction features of megger are as follows:

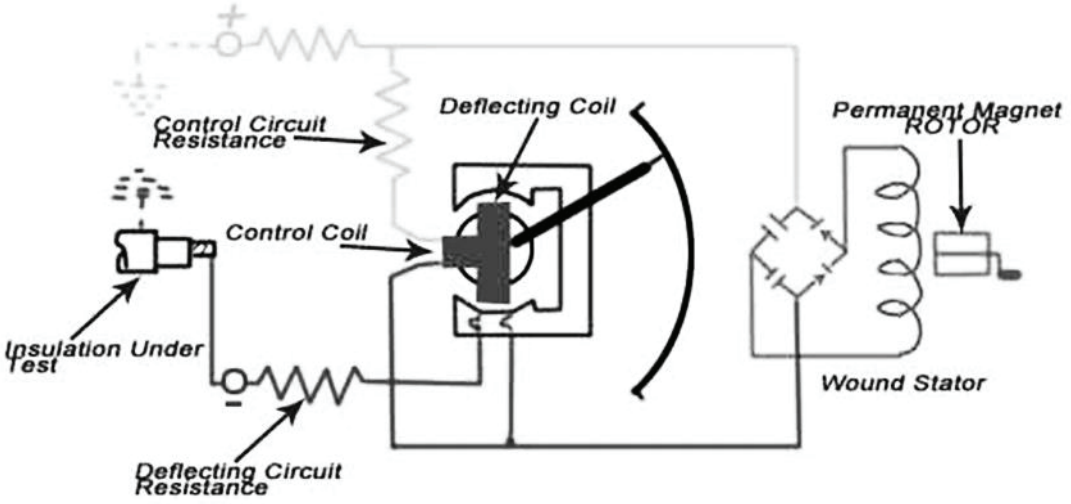
- **Deflecting and Control coil**: Connected parallel to the generator, mounted at right angle to each other and maintain polarities in such a way to produced torque in opposite direction.
- **Permanent Magnets**: Produce magnetic field to deflect pointer with North-South pole magnet.
- **Pointer**: One end of the pointer connected with coil another end deflects on scale from infinity to zero.
- **Scale**: A scale is provided in front-top of the megger from range 'zero' to 'infinity', enable us to read the value.
- **D.C generator or Battery connection**: Testing voltage is produced by hand operated DC generator for manual operated Megger. Battery / electronic voltage charger is provided for automatic type Megger for same purpose.
- **Pressure coil resistance and Current coil resistance**: Protect instrument from any damage because of low external electrical resistance under test.

8.5 Working Principle of Megger

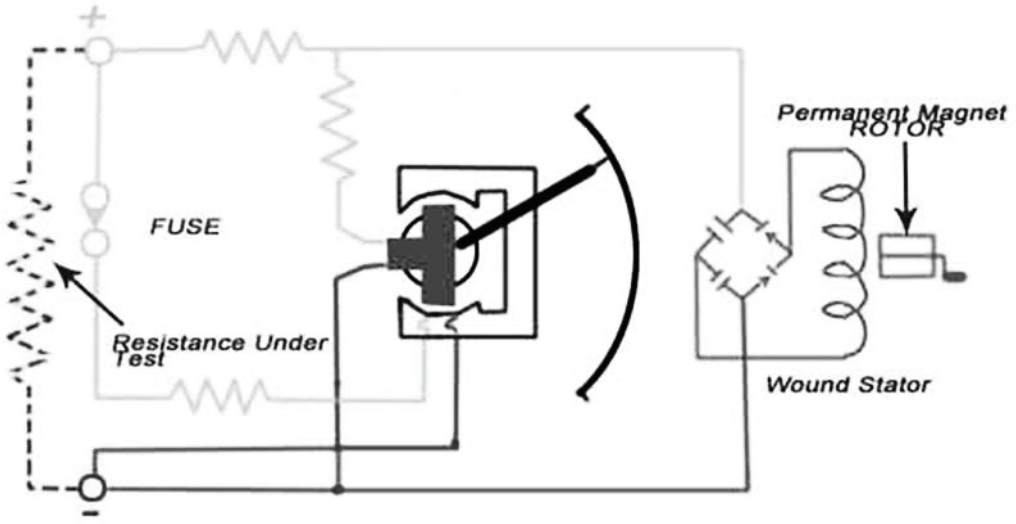
Voltage for testing produced by hand operated megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.

- 500 Volt DC is sufficient for performing test on equipment range up to 440 Volts.
- 1000 V to 5000 V is used for testing for high voltage electrical systems.
- Deflecting coil or current coil connected in series and allows flowing the electric current taken by the circuit being tested.
- The control coil also known as pressure coil is connected across the circuit.
- Current limiting resistor [CCR and PCR] connected in series with control and deflecting coil to protect damage in case of very low resistance in external circuit.
- In hand operated megger electromagnetic induction effect is used to produce the test voltage i.e. armature arranges to move in permanent magnetic field or vice versa.
- Where as in electronic type megger battery are used to produce the testing voltage.
- As the voltage increases in external circuit, the deflection of pointer increases and deflection of pointer decreases with the increase in current.
- Hence, resultant torque is directly proportional to voltage and inversely proportional to current.
- When electrical circuit being tested is open, torque due to voltage coil will be maximum and pointer shows 'infinity' means no shorting throughout the circuit and has maximum resistance within the circuit under test.
- If there is short circuit pointer shows 'zero', which means 'NO' resistance within circuit being tested.

8.6 Connection Diagram of Megger for Testing



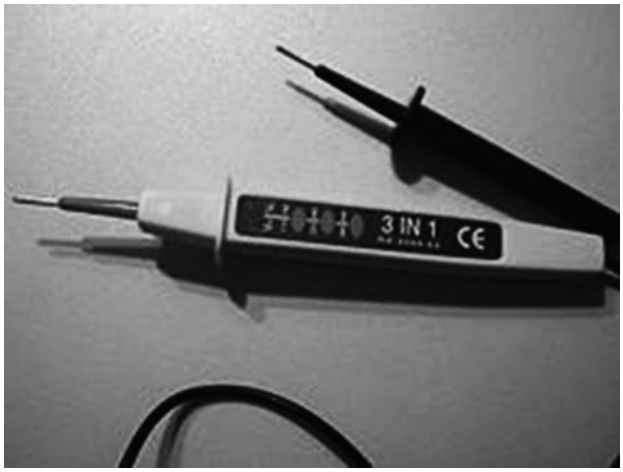
Series 3 instrument arranged for insulation test



Series 3 instrument arranged for continuity test

8.7 Use of Test Lamps

- The test light is an electric lamp connected with one or two insulated wire leads. Often, it takes the form of a screwdriver with the lamp connected between the tip of the screwdriver and a single lead that projects out the back of the screwdriver.



- By connecting the flying lead to an earth [ground] reference and touching the screwdriver tip to various points in the circuit, the presence or absence of voltage at each point can be determined, allowing simple faults to be detected and traced to their root cause.
- For higher voltages, a statiscope consisting of a neon glow tube mounted on a long insulating handle can be used to detect AC voltages of 2000 volts or more.
- For low voltage work [for example, in automobiles], the lamp used is usually a small, low-voltage incandescent light bulb. These lamps usually are designed to operate on approximately 12 V; application of an automotive test lamp on mains voltage will destroy the lamp and may cause a short-circuit fault in the tester.
- For line voltage [mains] work, the lamp is usually a small neon lamp connected in series with an appropriate ballast resistor. These lamps often can operate across a wide range of voltages from 90V up to several hundred volts.
- In some cases, several separate lamps are used with resistive voltage dividers arranged to allow additional lamps to strike as the applied voltage rises higher. The lamps are mounted in order from lowest voltage to highest, this minimal bar graph providing a crude indication of voltage.
- Incandescent bulbs may also be used in some electronic equipment repair, and a trained technician can usually tell the approximate voltage by using the brightness as a crude indicator.
- Neon-lamp type tester, which has no amplifier; this type requires a direct metallic contact to the circuit to be tested.

POST-SESSION ACTIVITY

- The Trainer will bring a handful of domestic wiring tools and distribute among the Trainees. Each trainee will hold the tools at random and state the function of that particular tool.
- The Trainer will bring a Megger. The Trainees will then be divided into groups of 2. The Trainer will then ask any 2 members of each group to describe its working principle in detail.

SUMMARIZATION

- In a home, the wiring system includes outlets, the main panel and meter base, and it is essential that all pieces are installed and function together properly to keep the home safe.
- The wiring for most homes is parallel, meaning several devices are powered on a single circuit.
- Multiple unit dwellings such as condominiums and apartment houses may have complexities additional installation complexity in distributing services within a house.
- When it comes to electrical projects, large or small, having the right tools for the job makes the project a lot easier and potentially safer.
- Every electrical tool kit should have at least a roll of black electrical tape, and having a few colours like red and blue helps as well for identifying wires, etc.
- Megger enables us to measure electrical leakage in wire, results are very reliable as we shall be passing electric current through device while we are testing.
- One of the advantages of Electronic Type Megger is that its level of accuracy is too high.
- For higher voltages, a statiscope consisting of a neon glow tube mounted on a long insulating handle can be used to detect AC voltages of 2000 volts or more.

Test yourself

A. Complete the sentences.

a. Megger enables us to measure _____.

b. Personal protective equipment [PPE] refers to _____.

c. Switches, which are installed on hot wires, allow or disallow the _____.

d. House wiring is defined as any wiring or electrical system _____.

e. Series wiring routes the hot wire through _____.

B. State whether the following statements are True or False:

a. When electrical circuit being tested is open, torque due to voltage coil will be minimum. [ ]

b. If working with conduit, you will need a hickey bender or any bending tool designed for the conduit you are working with. [ ]

c. Using rechargeable batteries, wirer strippers are available with similar features to an AC mains-powered drill. [ ]

d. For electric power supply, a cable is run either overhead or underground into a distribution board in the home. [ ]

e. Series wiring routes the hot wire through several devices and then joins the neutral wire. [ ]

NOTES 

CHAPTER - 9
STUDY OF FUSE, RELAYS, MCB AND ELCB

RECALL SESSION:

In the previous chapter, we learnt about:

- The concept of Domestic Wiring
- Electrical wiring accessories
- How to conduct Megger test and using test lamps in faulty locations
- Different types of wiring system

LEARNING OUTCOME:

By the end of this session, trainees would be able to:

- Know the functions of fuse, relays, MCB and ELCB

PRE-SESSION ACTIVITY

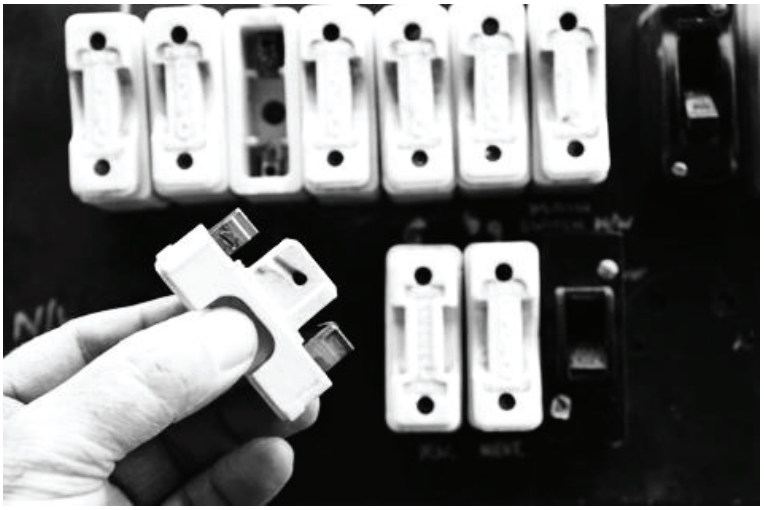
- The Trainer will bring a chart paper with diagrams on various types of fuse and distribute the same to the trainees. The Trainer will ask the Trainees to share their knowledge and ideas on these, if any.
- The Trainees will be shown a PPT that would describe various electrical components that include Fuse, Relays, MCB and ELCB.

Discussion:

- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by rectifying the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.
- The Trainer proceeds with the lesson after the Discussion.

9.1 Fuse

- Fuse is an electronic device, which is used to protect circuits from over current, overload and make sure the protection of the circuit. There are many types of fuses available in the market, but function of all these fuses is same.
- Fuse consists of a low resistance metallic wire enclosed in a non-combustible material.
- Whenever a short circuit, over current or mismatched load connection occurs, then the thin wire inside the fuse melts because of the heat generated by the heavy current flowing through it. Therefore, it disconnects the power supply from the connected system.
- In normal operation of the circuit, fuse wire is just a very low resistance component and does not affect the normal operation of the system connected to the power supply.



9.1.1 Types of Fuse in Terms of Input Supply Voltage

There are different types of fuses available in the market and they can be categories on the basis of Different aspects.

Fuses can be divided into two main categories according to the type of input supply voltage.

1. AC fuses
2. DC fuses

AC and DC Fuse:

- There is a little difference between AC and DC Fuses used in the AC and DC Systems. In a DC system, when the metallic wire Melts because of the heat generated by the over current, then Arc is produced and it is very difficult to extinct this arc because of DC constant value.
- Therefore, in order to minimize the fuse arcing, DC fuse are little bigger than an AC fuse which increase the distance between the electrodes to reduce the arc in the Fuse.
- In the AC system, voltage with 60Hz or 50Hz frequency changes it amplitude from zero to 60 times every second, so AC can be extinct easily as compared to DC. Therefore, AC fuses are little bit small in sizes as compared to DC fuses.

9.1.2 Types of Fuse in terms of One Time or Multiple Operations

- **One time use only Fuse**

  One time use fuses contain a metallic wire, which burns out, when an over current, over load or mismatched load connect event occur, user has to manually replace these fuses, switch fuses are cheap and widely used in almost all the electronics and electrical systems.

Such types of fuses can be categorised on the following basis:

- Current carrying Capacity of Fuse
- Breaking capacity
- I^2t value of Fuse
- Response Characteristic
- Rated voltage of Fuse
- Packaging Size

- **Fuse Current Carrying Capacity**

  Current carrying capacity is the amount of current which a fuse can easily conduct without interrupting the circuit.

- **Breaking capacity**

The value of maximum current that can safely be interrupted by the Fuse is called Breaking Capacity and should be higher than the prospective short circuit current.

- **I^2t value of Fuse**

The I^2t terms related to fuse normally used in short circuit condition. It is the amount of energy which carries the fuse element when the electrical fault is cleared by fuse element.

- **Response Characteristic**

  The speed at which fuse blows, depend on the amount of current flowing through its wire. The higher the current flowing through the wire, faster will be the response time.

  Response characteristic shows the response time for over current event. Fuses which respond rapidly to the over current situation is called ultra-fast fuses or Fast fuses. They are used in many semiconductor devices because semiconductor devices damaged by over current very rapidly.

DO YOU KNOW?

The voltages generated by your body are no greater than 0.1 volts

- **Rated Voltage of Fuse**:

  Each fuse has maximum allowed voltage rating, for example, if a fuse is designed for 32 volts it cannot be used with 220 volts, different amount of isolation is required in different fuses working on different voltage levels.

- **Packaging size:**

  As we have mentioned above that AC and DC fuses, have a little bit different packaging type, in the same way different application requires different packages to be used accurately in the circuit. Other factors and parameters are marking, temperature derating, voltage drop and speed.

9.1.3 Other Types of Fuses:

- **Cartridge fuses:**
  - Cartridge fuses are used to protect electrical appliances such as motors air-conditions, refrigerator, pumps etc, where high voltage rating and currents required.
  - They are available up to 600A and 600V AC and widely used in industries, commercial as well as home distribution panels.

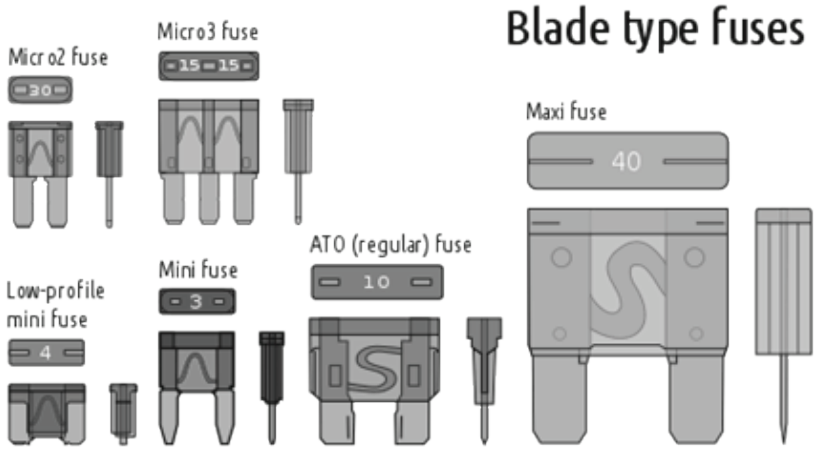
There are two types of Cartridge fuses.

1. General purpose fuse with no time delay
2. Heavy-duty cartridge fuses with time delay.

Both are available in 250V AC to 600V AC and its rating can be found on the end cap or knife blade.

- **Blade Type fuses:**

  This type of fuses [also known as spade or plug-in fuses] comes in plastic body and two metal caps to fit in the socket. Mostly, they used in automobiles for wiring and short circuit protection.



9.1.4 HRC Fuse [High Rupturing Capacity Fuse] and its Types:

- This type of fuse contains a fuse wire in it, which carries the short circuit current safely for a given time period. During this period, if fault is removed, then it does not blow off otherwise it will melt and remove the circuit from electrical supply hence, the circuit remains safe.
- The common material, which is used to make an HRC fuse is glass. However, this is not always the case. Other chemical compounds are also used in HRC fuse manufacturing and construction based on different factors.
- Its external enclosure is made fully airtight in order to avoid the effect of atmosphere on the fuse materials. The major objection on HRC fuse is low and uncertain breaking capacity of semi-enclosed fuse.

Types of HRC fuse:

- NH Fuse
- Din type
- Blade contact

9.1.5 Typical Uses and Applications of fuses:

Electronic Fuses can be used in all types of electrical and electronic applications including:

- Motors
- Air-conditions
- Home distribution boards
- General electrical appliances and devices
- Laptops
- Cell phones
- Game systems
- Printers
- Digital cameras
- DVD players
- Portable Electronics
- LCD monitors
- Scanners
- Battery packs
- Hard disk drives
- Power convertors

Exercise

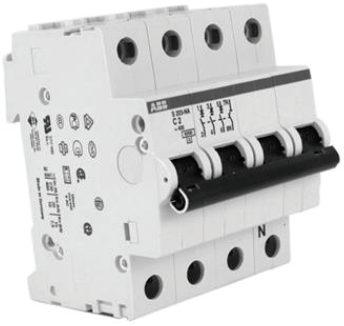
Fill in the blanks:

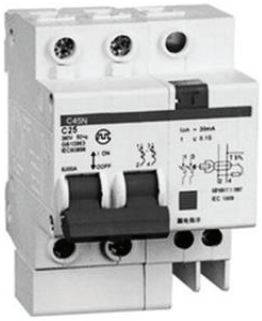
1. Fuses are most commonly used in _____ and _____.
2. HRC fuse stands for _____.
3. Two main types of fuses are _____ and _____.
4. DC fuse are little bigger than an AC fuse which _____to reduce the arc.
5. Body generates a voltage of about _____ volts.

NOTES

9.1.6 Relays

- A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current.
- The heart of a relay is an electromagnet [a coil of wire that becomes a temporary magnet when electricity flows through it]. You can think of a relay as a kind of electric lever: switch it on with a tiny current and it switches on ["leverages"] another appliance using a much bigger current.
- As the name suggests, many sensors are incredibly sensitive pieces of electronic equipment and produce only small electric currents. But often we need them to drive bigger pieces of apparatus that use bigger currents.
- Relays bridge the gap, making it possible for small currents to activate larger ones. That means relays can work either as switches [turning things on and off] or as amplifiers [converting small currents into larger ones].





9.1.6.1 Relays in practice

Suppose you want to build an electronically operated cooling system that switches a fan on or off as your room temperature changes. You could use some kind of electronic thermometer circuit to sense the temperature, but it would produce only small electric currents—far too tiny to power the electric motor in a great big fan.

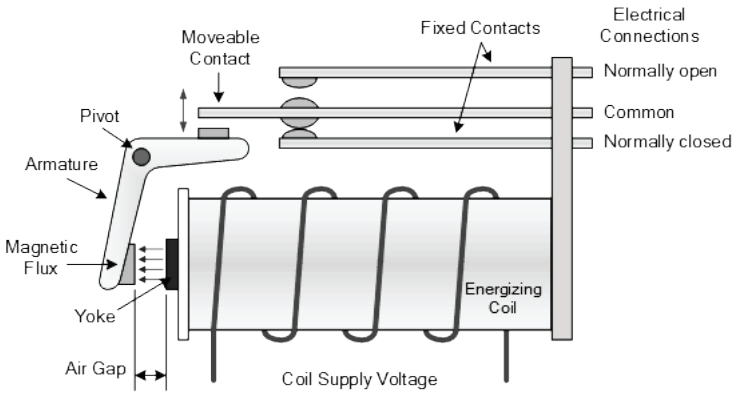
Instead, you could connect the thermometer circuit to the input circuit of a relay. When a small current flows in this circuit, the relay will activate its output circuit, allowing a much bigger current to flow and turning on the fan.

9.1.6.2Electromechanical Relay Construction

- In our simple relay above, we have two sets of electrically conductive contacts. Relays may be “Normally Open”, or “Normally Closed”. One pair of contacts is classed as Normally Open, [NO] or make contacts and another set which are classed as Normally Closed, [NC] or break contacts.

- In the normally open position, the contacts are closed only when the field current is “ON” and the switch contacts are pulled towards the inductive coil.

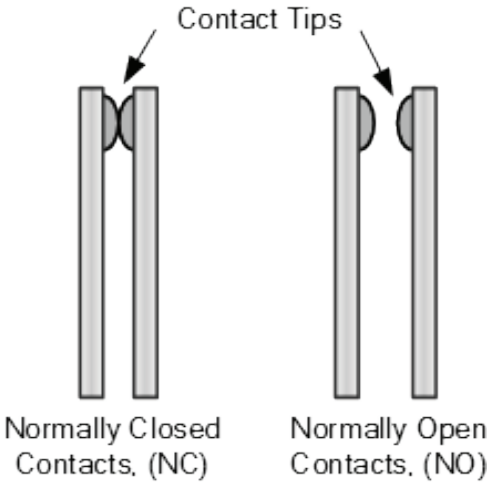
- In the normally closed position, the contacts are permanently closed when the field current is “OFF” as the switch contacts return to their normal position. These terms *Normally Open, Normally Closed* or *Make and Break Contacts* refer to the state of the electrical contacts when the relay coil is “de-energized”, i.e. no supply voltage connected to the relay coil. Contact elements may be of single or double make or break designs.



- The relays contacts are electrically conductive pieces of metal which touch together completing a circuit and allow the circuit current to flow, just like a switch. When the contacts are open the resistance between the contacts is very high in the Mega-Ohms, producing an open circuit condition and no circuit current flows.
- When the contacts are closed the contact resistance should be zero, a short circuit, but this is not always the case. All relay contacts have a certain amount of “contact resistance” when they are closed and this is called the “On-Resistance”, similar to FET’s.

9.1.7 Miniature Circuit Breaker [MCB]

- An MCB or miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a moulded insulating material.
- The main function of an MCB is to switch the circuit, i.e., to open the circuit [which has been connected to it] automatically when the current passing through it [MCB] exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary.
- MCBs are rated at 220V for DC supply and 240/415 for AC supply [single and three-phase] with different short circuit current capacity.



Typically, single phase devices have load current range of up to 100 A. Some MCBs have facility to adjust its tripping current capacity while some devices are fixed for some load current and short circuit rating.

9.1.7.1 Construction of MCB

- An MCB embodies complete enclosure in a moulded insulating material. This provides mechanically strong and insulated housing. The switching system consists of a fixed and a moving contact to which incoming and outgoing wires are connected.
- The metal or current carrying parts are made up of electrolytic copper or silver alloy depending on the rating of the circuit breaker.

9.1.7.2 How MCB Works

Under normal working conditions:

- MCB operates as a switch [manual one] to make the circuit ON or OFF. Under overload or short circuit condition, it automatically operates or trips so that current interruption takes place in the load circuit.
- The visual indication of this trip can be observed by automatic movement of the operating knob to OFF position. This automatic operation MCB can be obtained in two ways as we have seen in MCB construction; those are magnetic tripping and thermal tripping.

Under overload conditions:

- The current through the bimetal causes to raise the temperature of it. The heat generated within the bimetal itself enough to cause deflection due to thermal expansion of metals.
- This deflection further releases the trip latch and hence contacts get separated. In some MCBs, magnetic field generated by the coil causes develop pull on bimetal such that it deflection activates the tripping mechanism.

9.1.8 Earth-leakage circuit breaker [ELCB]

- An Earth-leakage circuit breaker [ELCB] is a safety device used in electrical installations with high Earth impedance to prevent shock.
- It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected.
- Once widely used, more recent installations instead use residual current circuit breakers which instead detect leakage current directly.

9.1.8.1 Purpose

The main purpose of Earth leakage protectors is to prevent injury to humans and animals due to electric shock.

9.1.8.2 How ELCB works?

- An ELCB is a specialised type of latching relay that has a building's incoming mains power connected through its switching contacts so that the ELCB disconnects the power in an Earth leakage [unsafe] condition.

- The ELCB detects fault currents from live to the Earth [ground] wire within the installation it protects. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power, and remain off until manually reset.
- A voltage-sensing ELCB does not sense fault currents from live to any other earthed body.

POST-SESSION ACTIVITY

- The Trainer brings a set of fuses and asks the Trainees to identify each of them and write their functions.
- The Trainer brings a Mini Circuit Breaker and asks the trainees to identify it and explain its working principle.

SUMMARIZATION

- Fuse is an electronic device, which is used to protect circuits from over current, overload and make sure the protection of the circuit.
- Fuses can be divided into two main categories according to the type of input supply voltage.
- In the AC system, voltage with 60Hz or 50Hz frequency changes it amplitude from zero to 60 times every second, so AC can be extinct easily as compared to DC.
- Cartridge fuses are used to protect electrical appliances such as motors air-conditions, refrigerator, pumps etc. where high voltage rating and currents required.
- A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current.
- The relays contacts are electrically conductive pieces of metal which touch together completing a circuit and allow the circuit current to flow, just like a switch.
- An MCB or miniature circuit breaker is an electromagnetic device that embodies complete enclosure in a moulded insulating material.

Test yourself

A. Complete the sentences.

a. Fuse is an electronic device, which is used to protect circuits from _____ _____.

b. An _____ is a safety device used in electrical installations with high Earth impedance to prevent shock.

c. Cartridge fuses are used to protect electrical appliances such as motor air-conditions, refrigerator, pumps etc. where high voltage rating and currents are required _____ _____.

d. When a small current flows in this circuit, the relay will _____ _____

e. Fuse is an electronic device, which is used to _____ _____

B. State whether the following statements are True or False:

a. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power, and remain off until manually reset. [ ]

b. If working with conduit, you will need a hickey bender or any bending tool designed for the conduit you are working with. [ ]

c. A voltage-sensing ELCB does not sense fault currents from live to any other earthed bod [ ]

d. When the contacts are closed the contact resistance should be zero, a short circuit, but this is not always the case. [ ]

NOTES 

Worksheet - 3

[20 Marks]

1. Answer the following questions. **[5x2 = 10]**

a. What is the significance of using symbols for electrical accessories?

b. Why carbon resistors need colour codes?

c. What are the various methods of wiring?

d. What are carbon capacitors?

e. What is Megger used for?

2. State whether the statements are true or false **[5x1 = 5]**

a. Regular testing and inspection will minimize battery life. [ ]

b. A primary cell is one that cannot easily be recharged after one use, and are discarded following discharge. [ ]

c. Fuse is an electronic device, which is used to protect circuits from over current, overload and make sure the protection of the circuit. [ ]

d. An Earth-leakage circuit breaker [ELCB] is a safety device used in electrical installations with low Earth impedance to prevent shock. [ ]

e. MCBs are rated at 220V for DC supply and 240/415 for AC supply with different short circuit current capacity. [ ]

3. Complete the following sentences **[5x1 = 5]**

	Column - A		**Column - B**
a.	Battery	I.	Generates constant voltage
b.	Resistor	II.	Reduces the current flow.
c.	SPST Toggle Switch	III.	Disconnects current when open
d.	Ammeter	IV.	Measures electric current, has near zero resistance and connected serially.
e.	Diode	V.	Diode allows current flow in one direction only - left [anode] to right [cathode].

NOTES 

CHAPTER - 10
BATTERY MAINTENANCE

RECALL SESSION: 

In the previous chapter, we learnt about:

- The functions of fuse, relays, MCB and ELCB

LEARNING OUTCOMES: 

By the end of this session, trainees would be able to:

- Understand the concept of battery
- Know about battery maintenance
- Understand primary cells and secondary cells
- Preparation of Electrolyte
- Process of discharging and recharging battery
- Types/rating of batteries and their application

PRE-SESSION ACTIVITY

- The Trainer will show a PPT to the Trainees on how to maintain a battery and take precautions while charging a battery.
- The Trainer will ask the trainees if they have knowledge about primary and secondary cells.

Discussion:

- The Trainer asks the Trainees to summarize the inputs they have derived from the above introductory activity.
- The Trainees are expected to raise their hands before speaking.
- Each Trainee must participate actively by adding relevant points to the discussion.
- Finally, the Trainer winds up by rectifying the points spoken by the Trainees and adding his / her own insight.
- The Trainees must jot down the crucial points in the discussion in their notebooks.
- The Trainer proceeds with the lesson after the Discussion.

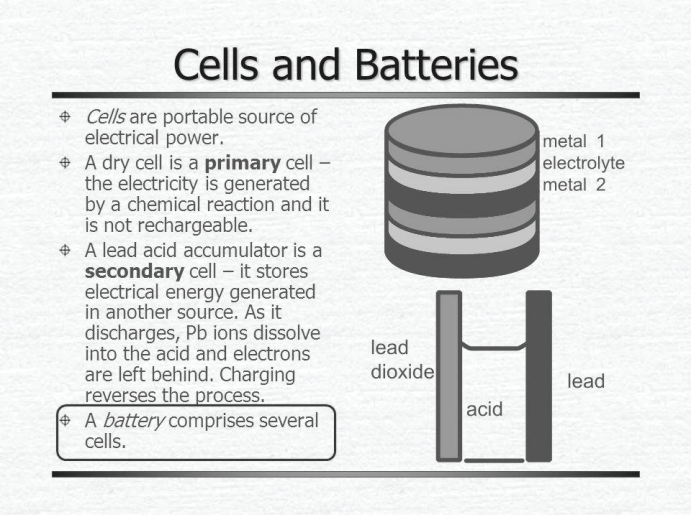
10.1 Battery

- A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars.
- When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.
- The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device.
- When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit.
- It is the movement of those ions within the battery which allows current to flow out of the battery to perform work.

10.2 Classification of Cells or Batteries

Electrochemical batteries are classified into 4 broad categories.

- A **primary cell** or battery is one that cannot easily be recharged after one use, and are discarded following discharge.
- Most primary cells utilize electrolytes that are contained within absorbent material or a separator [i.e. no free or liquid electrolyte], and are thus termed dry cells.



A **secondary cell** or battery is one that can be electrically recharged after use to their original pre-discharge condition, by passing current through the circuit in the opposite direction to the current during discharge. The following graphic evidences the recharging process.

Secondary batteries fall into two sub-categories depending on their intended applications:

- Cells that are utilized as energy storage devices, delivering energy on demand. Such cells are typically connected to primary power sources so as to be fully charged on demand.

  Examples of these types of secondary cells include emergency no-fail and standby power sources, aircraft systems and stationary energy storage systems for load-levelling.

- Cells that are essentially utilized as primary cells, but are recharged after use rather than being discarded.

  Examples of these types of secondary cells primarily include portable consumer electronics and electric vehicles.

10.3 Primary vs. Secondary – A Comparison

The following table summarizes the pros and cons of primary and secondary batteries.

Primary	Secondary
Lower initial cost.	Higher initial cost.
Higher life-cycle cost [$/kWh].	Lower life-cycle cost [$/kWh] if charging in convenient and inexpensive.
Disposable.	Regular maintenance required.
Disposable.	Periodic recharging required.
Replacement readily available.	Replacements while available are not produced in the same sheer numbers as primary batteries. May need to be pre-ordered.
Typically lighter and smaller; thus traditionally more suited for portable applications.	Traditionally less suited for portable applications, although recent advances in Lithium battery technology have led to the development of smaller/lighter secondary batteries.
Longer service per charge and good charge retention.	Relative to primary battery systems, traditional secondary batteries [particularly aqueous secondary batteries] exhibit inferior charge retention.
Not ideally suited for heavy load/high discharge rate performance.	Superior high discharge rate performance at heavy loads
Not ideally suited for load-levelling, emergency backup, hybrid battery, and high cost military applications.	Ideally suited for load-levelling, emergency backup, hybrid battery and high cost military applications
Traditionally limited to specific applications.	The overall inherent versatility of secondary battery systems allows its use and continuing research for a large spectrum of applications.

10.4 Battery Maintenance

Regular testing and inspection will help to maximize battery life. A routine inspection at least once a month is recommended to maintain optimum performance.

Keep the following points in mind in regard to maintenance of a battery:

1. Ensure the battery top is clean and dry, free of dirt and grime. A dirty battery can discharge across the grime on top of the battery casing.
2. Inspect the terminals, screws, clamps and cables for breakage, damage or loose connections. These should be clean, tight and free of corrosion.
3. Apply a thin coating of high temperature grease to posts and cable connections for added protection.
4. Inspect the battery case for obvious signs of physical damage. This usually indicates the battery has overheated or has been overcharged.
5. If the battery is maintainable, check electrolyte levels to ensure that fluid levels are over the top of battery plates. If necessary, top up using distilled or demineralized water. Never top up fluid levels with acid.
6. Test the battery using either a hydrometer or voltmeter and charge if necessary.

DO YOU KNOW?

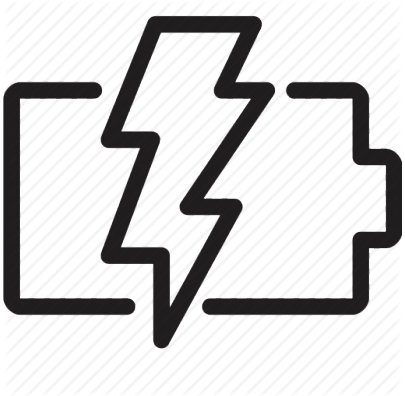
The first rechargeable battery was invented in 1859, when French physicist Gaston Plante invented the lead acid cell, which is still used in cars today.

Exercise

1. What is a battery?
2. What do you understand by primary cell and secondary cell?
3. What is Cathode and Anode?
4. When was the first rechargeable battery invented?
5. Which equipment is used to test the charge of a battery?

NOTES 

10.5 Battery Charging



- Charging your battery also plays a key role in keeping it safe and maintained. You need to charge your battery in the right manner so that it gains a long life and run without any complications.

Safety Precautions

To keep your battery safe and maintained, here are some safety precautions that you must always keep in mind prior to charging it:

1. Turn the charger off before attaching, rocking or removing the terminal clamps.

2. Keep open flames and sparks away from the battery.

3. Keep vent caps in place.

4. Charge in well-ventilated area.

5. Follow the battery charger manufacturer's instructions to avoid overheating.

10.6 Preparation of Electrolyte

An electrolyte is a substance that produces an electrically conducting solution when dissolved in any solvent.

Batteries consist of two half-cell reactions connected by a salt bridge and supported in an electrolyte solution. The two half-cells that operate in these batteries are the lead and the hydrogen half-cells. As the lead enters the solution, the electrons flow from that electrode to the other electrode where the lead dioxide molecules accept the electrons and converts to oxygen gas. The electrolyte solution is able to support the electrical flow between electrodes. In the lead acid battery, sulfuric acid and water are the electrolyte.

The steps to prepare an electrolyte are:

	I. Using electronic balance, measure exactly the amount of electrolyte you intent to use.
	II. Using a funnel, pour the entire electrolyte into the volumetric flask. III. Wash the glass and the funnel with distilled water.
	IV. Mix around 25ml of distilled water into the flask, and then shake the flask to dissolve the electrolyte.
	V. After dissolving the electrolyte add the rest of the amount of water needed until it touches the 250ml line. VI. Now you have accurately created a 250ml 0.1 or 0.3M solution.

In medicine, electrolyte replacement is needed when a patient has prolonged vomiting or diarrhea. It is also useful as a response to persistent athletic activity. Commercial electrolyte solutions are available, particularly for sick children [oral rehydration solutions] and athletes [sports drinks].

POST-SESSION ACTIVITY

- The Trainer will ask the Trainees to prepare a chart paper project where they will have to differentiate between primary and secondary cells.
- The Trainer will conduct a quiz session where he/she will divide the trainees into 2 groups. Both the groups will be asked how they will ensure complete maintenance of their batteries. The group that gives the best answer will be declared winners.
- The trainer will ask the students to watch a video on the process of making electrolyte.
- The link is: https://www.youtube.com/watch?v=UHFWOkio9dQ

SUMMARIZATION

- A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices.
- A secondary cell or battery is one that can be electrically recharged after use to their original pre-discharge condition, by passing current through the circuit in the opposite direction to the current during discharge.
- Regular testing and inspection will help to maximize battery life.
- When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.

Test yourself

A. Fill in the blanks:

1) A battery is a device consisting of one or more _____ cells with external connections provided to power electrical devices.

2) The terminal marked _____ is the source of electrons.

3) Most primary cells utilize electrolytes that are contained within _____

4) Portable consumer electronics and electric vehicles are examples of _____.

B. State whether the following statements are True or False:

1) It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. [ ]

2) Primary batteries are not ideally suited for heavy load/high discharge rate performance. [ ]

3) Ensure the battery top is clean and wet [ ]

4) Apply a thin coating of high temperature grease to posts and cable connections for added protection. [ ]

5) Test the battery using either a multi-meter or charge if necessary. [ ]

6) An electrolyte is a substance that produces electrically conducting solution. [ ]

NOTES 

CHAPTER - 11
HOME APPLIANCES & REPAIR

RECALL SESSION: 

In the previous chapter, we learnt about:

- The concept of battery
- Knowing about battery maintenance
- Understanding primary cells and secondary cells
- Preparing of an Electrolyte
- Knowing the process of discharging and recharging battery
- Understanding the types/rating of batteries and their application

LEARNING OUTCOMES: 

By the end of this session, trainees would be able to:

- Know about the types of home appliances
- Understand the construction and assembly of iron, heater, fan
- Know about the construction and assembly of OTG, mixer
- Understand the technique for repairing washing machine
- Know how to repair house wiring

PRE-SESSION ACTIVITY

- The Trainer will show a video to the trainees related to the different types of home appliances available.
- The link is: https://www.youtube.com/watch?v=66C6iG9AhPs
- The Trainer will ask the trainees if they have knowledge about home appliances and how they work.

Discussion:

- The Trainer asks the trainees to summarize the inputs they have derived from introductory video.
- The trainees are expected to jot down the points they know by seeing the video.
- Once the points are all noted down, the trainer will discuss about the common home appliances with their features.

11.1 Home Appliances and its Types

Appliances are the most important component in the present times. They are not only essential in homes but also in offices, factories, shops and many other industrial sectors.

Let us know about some of the common home appliances.

1. Table Fan
2. Cooking Range
3. Automatic Iron
4. Wet Grinder
5. Storage Heater
6. Electric Iron
7. Electric Heater
8. Ceiling Fan
9. Electric Kettle
10. Washing Machine

The current generation is dependent on all of these appliances. The level of dependency is so high that malfunctioning of these home appliances can easily give stress to people and cause inconvenience.

Let's see some pictures of the necessary home appliances.

Refrigerator

Automatic Iron

Ceiling Fan

Electric Kettle

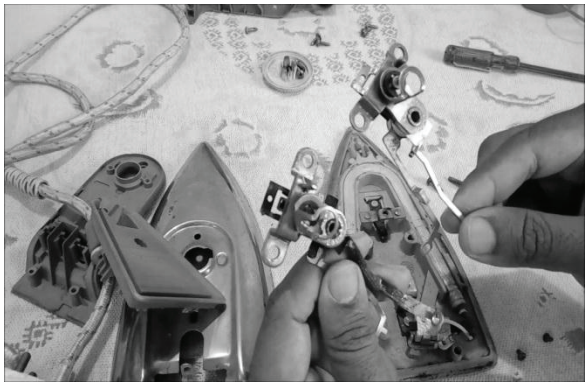
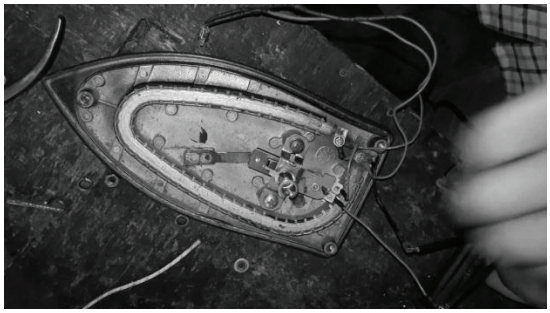
Washing Machine

11.2 How to construct and assemble Iron, Heater, and Fan

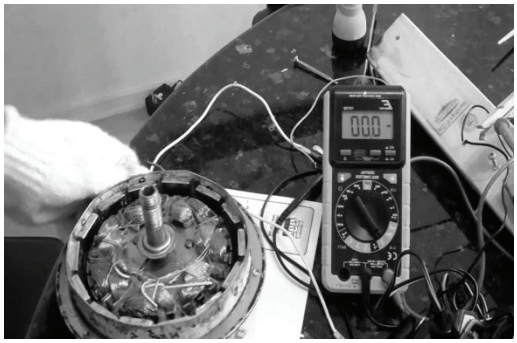
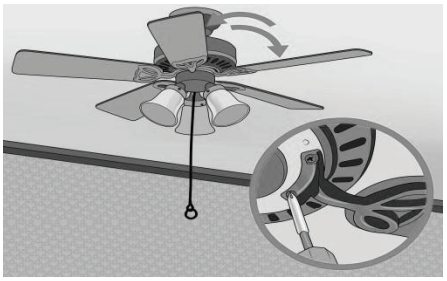
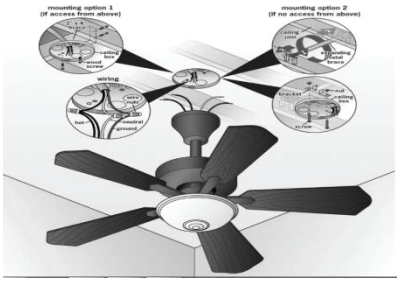
Before we start with the steps of repair and assembly, it is important to note that:

- Professional technicians have the expertise in their crafts.
- A completely qualified technician has not only good reputation but also is efficient in providing high-quality repair work.
- A skillful technician has the ability to repair appliances of various brand and models.

IRON:

	1. The first step is to switch off the connection besides the plug point.
	2. Next, unplug the iron. You should perform this step after you are sure that the appliance has cooled down.
	3. Check the electric cord, sole plate and thermostat in case it does not heat up to the highest level or the clothes clings to the appliance.
	4. One of the reasons for this fault may be due to the accumulation (built-up) of debris (mineral deposits) in steam vents.
	5. Take the help of pipe cleaner or toothpick for removing the build-up. It is important to consider that the debris should not clog or block the steam vents.
	6. With the assistance of a fine needle (sewing), clean spray nozzle carefully.
	7. For issue in sole plate, open the cover plate with an appropriate screwdriver.
	8. Check the calibration of the thermostat and then clean the sole plate.
	9. Put the cover panel back and tighten the screw.

FAN:

	1. The first step is to turn off the fan's circuit breaker.
	2. Unscrew the outside nuts of the fan and remove the connection that holds the fan with the main switch.
	3. Pull out the switch and leave the wires attached.
	4. Note down in a separate sheet the wire colours attached to each terminal
	5. If the problem is related to the switch, first detach the wires. After that, take the switch as per the fan model.
	6. In case of new switch installation, you will find the attachment of wires directly with the terminals. So, you need to bend the individual wire around the respective terminal. You should tighten the screws in a clockwise direction.
	7. Suppose the switch wire is connected with wire-nuts, with a wire insulation strip of 1/2" to 3/4" width, wrap the two in a clockwise direction.
	8. After covering the bare wire, it is mandatory to twist the connector in clockwise.
	9. Now you can see a hole in fan housing. So, from inside, insert the switch. And from outside, thread the nut.
	10. Attach the cover and turn on the breaker.

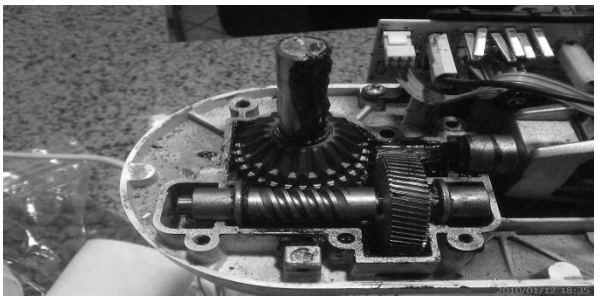
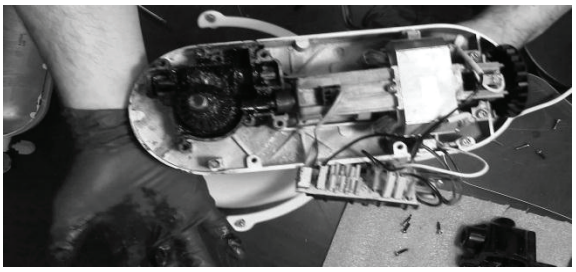
11.3 How to Assemble and Repair OTG, Mixer, Kettle, and Washing Machine

A mixer has various parts that require proper repairing and timely servicing.

- **Motor**

	1. Before detaching the motor from the mixer body, test it for continuity.
	2. Now remove the wires that connect the housing or the mixer body with the motor.
	3. It is important that while servicing the motor, you should not connect different wires in the incorrect slot. So, it is advisable to note down the wires and their positions beforehand.

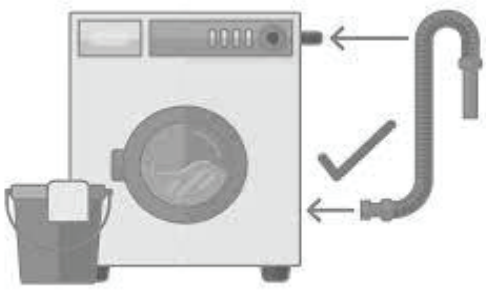
- **Gears**

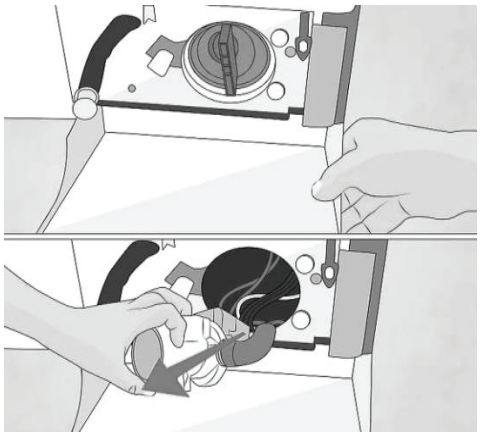
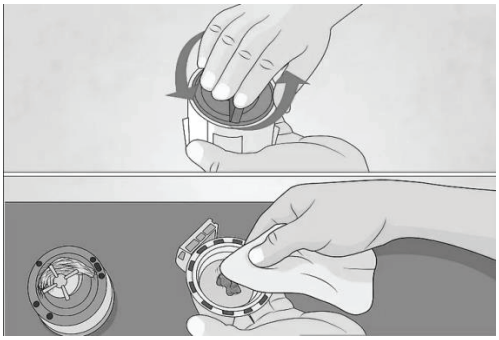
1. Before you start the servicing of the gear, unplug the appliance.	
2. For exposing the gear, remove its upper housing.	
3. Examine the worm gear and lubricate it very well.	
4. Repeat the above step for pinion gears too.	
5. Ensure that the electrical components or motor is not coated with excess lubricant.	
6. Before reassembling, remove loose pieces or shavings in the housing.	

Cooking Range

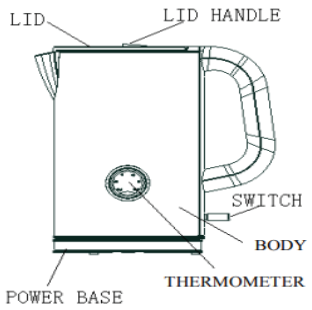
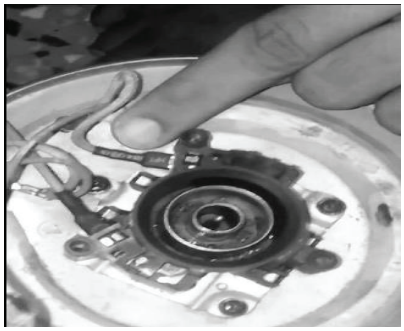
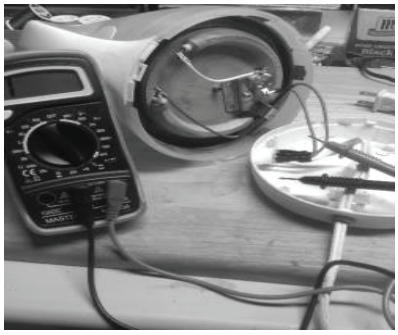
1. Remove screws holding the panels to pull straight off the cooking range's control knobs.	
2. With the help of Allen wrench or screwdriver, pull the knobs off.	
3. On control panel, you will find back service panel. Remove control knobs by unscrewing the mounting screws inside moldings or trims.	
4. Remove burner grates to access burner assemblies. Lift up The complete range top.	
5. Remove panels or any retaining screws and try to access the bulb (if it's the faulty one)	
6. After your work is done, put back the range top and put back the screws in their trims and tighten it with the screwdriver.	

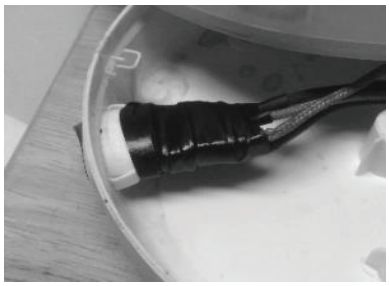
The following diagram shows how to repair a washing machine:

	1. Carefully check the drain hose situated at the back of the machine.
	2. To check the hose is clogged or unclogged, run water from moderate to high speed. (If the issue is here, clean the hose. If the problem persists, change the hose.)
	3. Position the regulator on the washing machine panel to DRAIN.

	4. If the problem continues, unplug the machine from the power source.
	5. Locate the pump (round with oval handle in center) on the machine after opening the panel. In front loaders, its location is below the door and at the back in case of top loader.
	6. Remove the screen by turning the handle in a counter-clockwise direction.
	7. Put the pump under the jet of water to remove lint or pieces of cloth.
	8. On the right side of the screen, stick a finger to ensure that nothing is clogging the pump fan.
	9. After replacing the filters put it in its designated place and tighten its grip by turning it clockwise.
	10. Put the panel back and secure it with the screws that you have opened earlier.
	11. Connect the washing to the main power source.
	12. Run the spin or rinse cycle to see if the water is draining properly or not.

Kettle

	1. Disconnect the kettle from the main power source.
	2. With the help of an appropriate screwdriver, unscrew the security screws.
	3. When the base comes off, look for any shrunk ends at the point of the switch.
	4. If you see a frayed wire, there lies the main fault.
	5. You will find 2 wires. Take the help of a multi-meter to check which one is the neutral one.
	6. If the wire is burnt, solder a new cable in its place. This treatment is applicable in the other end too.
	7. Wear safety gloves and insulated latex (rubber) shoes and then connect the main plug to the power source.
	8. If the kettle restarts, switch it off and remove it from the main power point.

	9. Put back the base cover and screw back the thread pitch (screw).
	10. After removing it from direct current, cover the soldered area with electrical tape. Don't use any alternative. It is for extra safety.

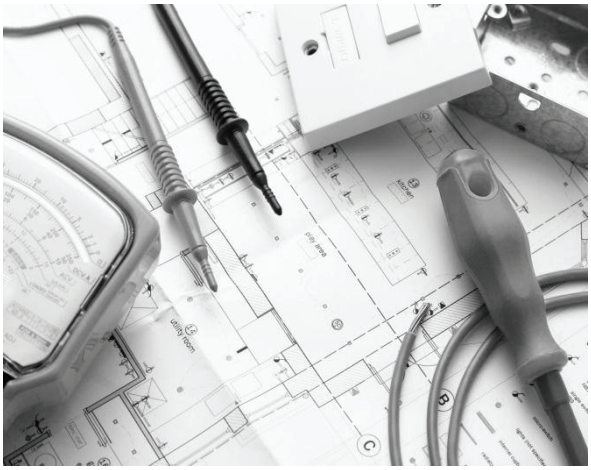
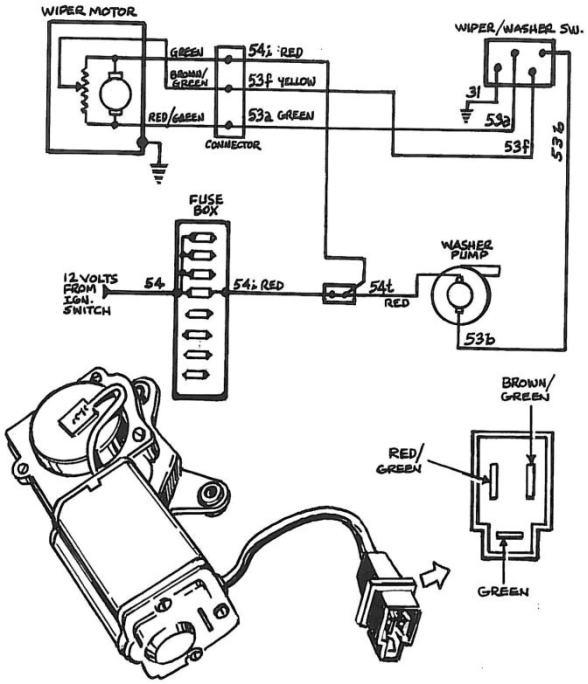
Exercise

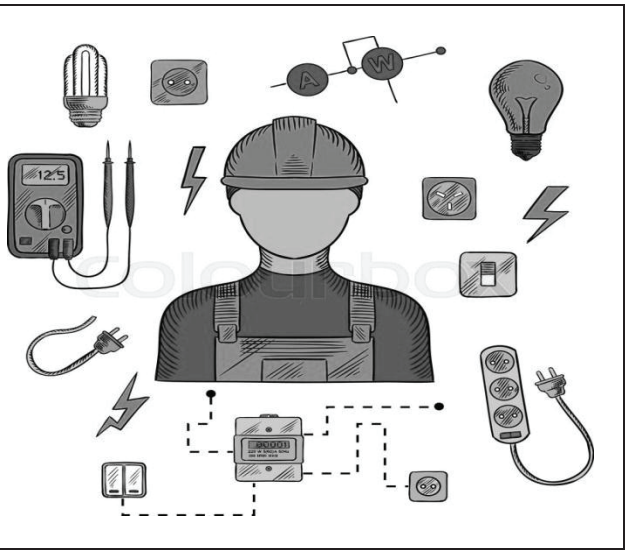
1. Explain the steps to repair and assemble an electric kettle.
2. What do you understand by Home Appliances?
3. Name at least 5 common home appliances.
4. Explain the steps of assembling a cooking range.
5. Show a diagrammatic representation of repairing a washing machine.

NOTES 

11.4 How to repair House Wiring Cables

The following diagram shows the steps of house wiring repair:

1. Switch off the power source connecting the damaged cable.	
2. Added to it, for extra safety, switch off the main power lines. Location of the source can be in the breaker box.	
3. Try to locate the damaged section. Look if the problem is with multiple wires (single sheath) or a single one.	
4. Look if the wire's copper core is intact or not. Also, see if the wire's metal is fused with another.	
5. Remove the damaged section and throw it away. To expose the non-damaged end of the cable, cut and remove 2" off the sheathing.	
6. Choose the required replacement cable length and remove 2" off the sheathing. This will help in ensuring similar length of replacement cable's gauge with that of the damaged cable. Also, it will help in identifying the wires as per their colour.	
7. From each wire's end, expose a minimum of 1" copper wire core. This splicing will be for all the 4 ends – 2 from removed section and 2 from replacement's one.	
8. With wire cutters, get rid of wire shielding without damaging the wires.	

9. Join the ends by intertwining the wires. Look for same colours when joining the wires.	
10. In the joint area, cover the copper wires with electrical tape. A minimum of 3 layers is advisable.	
11. For better result, cover all of those with another layer of electrical tape.	
12. Switch on both the power points and test its functionality.	

POST-SESSION ACTIVITY

- The Trainer will ask the trainees to prepare a chart paper project where they will have to show the process of repairing any electric home appliance of their choice.
- The trainer will also arrange few home appliance parts (preferably from fan, washing machine, electric iron), and ask the trainees to identify the parts.
- The best response will be appreciated.

SUMMARIZATION

- Appliances are the most important component in the present times.
- They are not only essential in homes but also in offices, factories, shops and many other industrial sectors.
- Some common home appliances are kettle, iron, fan, refrigerator, washing machine etc.
- Repair and assembling knowledge gained for ceiling fan, washing machine, electric kettle etc.

Test Yourself

1. Fill in the blanks:

- A home appliance is defined as _____.
- A skillful technician can repair appliances of _____.
- Most professional technicians have _____ in their crafts.

2. Show a diagrammatic repair procedure presentation of a ceiling fan.

3. State True or False:

- If you see a frayed wire in an electric kettle, there lies the main fault. [ ]
- Put the pump under the jet of water to remove lint or pieces of cloth in a washing machine [ ]
- **In case of repairing house wiring:** from each wire's end, we have to expose a minimum of 1" copper wire core. This splicing will be for all the 4 ends – 2 from removed section and 2 from replacement's one. [ ]
- It is important that while servicing the motor, you should connect different wires in the incorrect slot to check for faults. [ ]

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