CEW 01

KRISHNA KANTA HANDIQUI STATE OPEN UNIVERSITY

Housefed Complex, Dispur, Guwahati - 781 006

Six Month Certificate Programme in

Electrical House Wiring

BLOCK- 1

FUNDAMENTALS OF ELECTRICITY & ELECTRICAL WIRING

CONTENTS

UNIT 1 : Introduction to the Electrician Trade

UNIT 2 : Introduction to Electricity and Electric Power

UNIT 3 : Electromagnetism and Common Electrical Appliance

UNIT 4 : Eafety Requirement

UNIT 5 : Electrical Wiring and Tools

Subject Experts

1. Mr. Manoj Saud, Lecturer, Automobile Engineering Deptt., Bongaigaon Polytechnic
2. Mr. Bhaba Ranjan Sarmah, Senior Lecturer (Selection Grade), Mechanical Engineering Deptt., Assam Engineering Institute
3. Mr. Prasanta Kr. Choudhury, Assistant Professor, Mechanical Engineering Deptt., Assam Engineering College
4. Mr. Binoy Ch. Sarma, Workshop Superintendent, Nagaon Polytechnic

Course Co-ordinator(s) :

Mrs. Antara Mahanta Barua, Academic Consultant, Electronics, KKHSOU

Mr. Nabankur Pathak, Academic Consultant, Instrumentation, KKHSOU

SLM Preparation Team

UNITS	CONTRIBUTORS
1 & 4	Dipak Das, Gauhati University
	Nabankur Pathak, KKHSOU
2, 3 & 5	Dr. Kandarpa Kumar Sarma, Gauhati University

Editorial Team

Content	:	Dr. Indu Mohan Das, Ex-Professor
		Dept. of Instrumentation & USIC, Gauhati University
Language		Prof. Robin Goswami, Retd. Professor
		Dept. of English, Cotton College
Structure, Format & Graphics	:	Mr. Nabankur Pathak

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COURSE INTRODUCTION

Electrical energy is the most important form of energy. Electricity is most vital for the functioning of to-days society. Everything comes to a halt without electricity. Without electricity factories close down, phones and computers go dead, traffic slows to a crawl, food spoils in refrigerators, all machines, devices, lights, fans stops Electrical House wiring is the first essential step for utilization of electrical energy. Every body needs the services of electrician. Every house requires electrical house wiring at the beginning. Then periodic services of electrician whenever there is some extension of electrical load or some problem in the house wiring. The “Electrical House Wiring” course is a Certificate Course of 6 months duration has been designed keeping view on the importance and scope of this course on Electrical House Wiring

The first block of the programme is titles as ‘Fundamentals of Electricity & Electrical Wiring’. It contains five units. Unit 1 covers the scope of electrician trade and job opportunities for an electrician. It also includes about hazards of electricity and basics of safety procedures to be observed by an electrician engaged in house wiring. Unit 2 covers some basic knowledge about electricity and includes details about electricity and electrical power. It also includes contents like static and dynamic electricity, DC, AC, definitions and symbols relevant for electrical house wiring, advantages of electricity etc. Unit 3 covers electromagnetism and a brief discussion about some devices based on electromagnetism. Unit 4 covers safety requirement containing some relevant important topics from Indian Electricity Rules and Indian Electricity Act. Some information about BIS specification and code of practice is also included. Unit 5 contains some details about Electrical Service connection and block diagram related to electrical house wiring.

While going through the units of the course, you will find that each unit is further divided into certain sections and sub-sections, wherever necessary, for your better understanding. Again, each unit carries certain *activities* after every section. These ‘‘ACTIVITIES’’ will provide you the opportunity to practically apply your own thoughts based on the knowledge gained from reading the text in a particular section. Besides, in order to give you additional information on certain relevant topics, you will find a category called ‘‘LET US KNOW’’ after the sections in each unit. Another category that has been included at the end of each section of a particular unit is ‘‘CHECK YOUR PROGRESS’’. The purpose of this category is to help you to asses for yourself as to how thoroughly you have understood a particular section. It will be better if you answer the questions put in these boxes immediately after you go through the sections of the units and then match your answers with ‘‘ANSWERS TO CHECK YOUR PROGRESS’’ given at the end of each unit. Further more, the category called ‘‘MODEL QUESTIONS’’ is intended to give you a hint of the kind of questions you are likely to get in the examination.

FUNDAMENTALS OF ELECTRICITY & ELECTRICAL WIRING

BLOCK-1

CONTENTS

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UNIT 2: Introduction to Electricity and Electric Power (Marks: 10) Pages: 17-31

Definitions and Units; Static and Dynamic Electricity; Direct Current (DC) and Alternating Current (AC); Voltage Levels in AC; Advantages of AC

UNIT 3 : Electromagnetism and Common Electrical Appliance (Marks: 25) Pages: 32-57

Electromagnetism and its Application in Electric Appliances; Principles of AC Generators and Motors; Various Electrical Appliances; Measurement Methods of Electrical Parameters; Measuring Instruments of Electrical Parameters

UNIT 4 : Eafety Requirement (Marks: 25) Pages: 58-75

Safety and Precaution : General steps to ensure safety, Safety Sign, Electrical Safety, Extension Cord, Rules and Regulations; Hazards of Electricity : Fire Hazard, Electric Shock; First Aid : First Aid Kit, First Aid in Common emergencies; Indian Electricity Rules and Indian Electricity Act

UNIT 5 : Electrical Wiring and Tools (Marks: 25) Pages: 76-94

Wiring and its Types : Cleat Wiring, Batten Wiring, Casing Capping Wiring, Conduit Wiring; Wiring Diagrams; Tools : Screw driver, Files, Chisel, Marking punch, Calipers, Gauge, Hacksaw, Bench vice, Hammer, Taps, Wrench, Crimping tool, Drilling machine

UNIT 1 : INTRODUCTION TO THE ELECTRICIAN TRADE

UNIT STRUCTURE

1.1 Learning Objectives

1.2 Introduction

1.3 Electrician Trade

- 1.3.1 Scope of Electrician Trade
- 1.3.2 House Wiring
- 1.3.3 Employment opportunities

1.4 Dangers from misuse of electrical appliances and equipment

1.5 Responsibilities of Electrician and Wiremen

1.6 Let Us Sum Up

1.7 Further Readings

1.8 Answer to Check Your Progress

1.9 Model Questions

1.1 LEARNING OBJECTIVES

After going through this unit, you will be able to–

- describe the scope and employment opportunities of an electrician
- explain the basics of House Wiring
- discuss safety and precaution
- know about the hazards of electricity
- discuss First Aid and its importance
- explain electrical earthing.

1.2 INTRODUCTION

This is the first unit of the course Electrical House Wiring. In this unit, we will introduce you to the scope of an electrician trade and the employment opportunities available for this. Electricity is the most important

form of energy and has become indispensable in our lives. In every walk of our life electricity is an essential requirement. It is a basic need everywhere in household, industries, agriculture, healthcare, education and information technology etc. It is an important factor for growth, prosperity, development, happiness and better standard of living for the people. To provideelectricity to all the household of the country is a policy objective of the Govt. of India and Rural Electrification scheme is a necessary part of this objective and hence it is being implemented in right earnest to achieve this goal.

One of the branches of electrician trade is House Wiring. Efficient, economic and safe utilization of electricity for accomplishing various jobs depends to a great extend on quality of house wiring to a great extent. Improper house wiring can be dangerous, may lead to accidents causing damage and loss of lives and properties. Non-compliance of rules, regulations and laws pertaining to house wiring may lead to legal prosecution, fine and even punishment. With the policy of the government to provide electricity to all thehousehold, the demand for qualified and trained personnel to perform and maintain house wiring and the related jobs is on rise.

Electrician trade has very good potential as a trade. In addition to job opportunities in government, public and private sector organizations, there is enough scope for an electrician for self employment. Everyone needs the services of an electrician. Examples of persons earning handsomely and getting well established through this trade can be found everywhere.

1.3 ELECTRICIAN TRADE

The tasks performed by electricians were simpler earlier. Laying of conductors, service connection installation, fitting of energy meter and mains, distribution boards, switches, lights and fans, installation of earthing were the common tasks frequently electricians had to perform in domestic house wiring works. Now the tasks have become more challenging and demanding and at the same time more rewarding and attractive also. House

wiring plans, layout and circuit diagrams are to be prepared. Related aspects like safety, type and nature of its use etc are to be considered. Now energy meters are digital. Panel boards with control switches and digital meters to show voltage, current, power, frequency, etc. are installed. Several varities of circuit breakers are replacing the old distribution boards. Change over switches for generataros, provision for connecting inverters, voltage stabilizers, isolators and Uninterrupted Power Supplies (UPS) are to be provided. Provisions are to be made for connecting air conditioners, coolers, geysers, Heaters, water pumps, kitchenwares etc. Good quality earthing for sophisticated house hold equipment like computers etc. are to be provided. These present day requirements make the job of an electrician more challenging and rewarding challenging and rewarding.

1.3.1 Scope of Electrician Trade

Electrician, Electrical Fitter, Technician, Operator are some of the common designations of a professional associated with the electrician trade. A professional of electrician trade has to perform technical and related tasks connected with the utilization of electrical energy while at the same time ensuring safety, economy and efficiency in the use of electricity. The tasks commonly and frequently entrusted to a professional engaged in the electrician trade can be broadly divided into following categories

1. Installation : Installation of service connection, control panels and switchboards, house wiring, earthing, motors, transformers etc
2. Operation, Maintenance and repair: Operation of machineries and equipment in power houses, factories and industries. Maintenance and repair of house wiring, electrical connections. Maintenance, fault finding and fault rectification in electrical power distribution systems. Repair of electrical items, devices. Repair and maintenance of electrical machineries.
3. Testing and Measuring: Testing electrical installations, house hold wiring. Insulation testing, earth resistance measurement.

Periodic testing and checking of electrical machineries. Calculation and distribution of loads based on tests and measurements.

4. Study of drawing and specifications: Preparation, study and interpretation of plans, lay out diagrams, circuit diagrams, symbols and specifications etc.
5. Estimating and specifying : Preparation of estimates and specifications of jobs and materials and their specifications in terms of rating, quality brands etc.
6. Design, manufacture, assembly, construction: Participation as a member of a team in designing, manufacturing, assembly and construction of electrical items, products or equipment in an organization like factory or industry.
7. Record keeping: Taking readings of meters and moving instruments of various quantities in the control room, power house, industry, log book maintenance, reporting faults, problems etc.
8. Others: Lighting and decorations in events like festivals, puja, marriage ceremony etc; rewinding of motor, transformer, troubleshooting of starter; demonstration of how to operate electrical machineries, devices, practical training to newcomers to the profession etc.

1.3.2 House Wiring

Out of the above mentioned tasks of an electrician, House Wiring is most common task. So let us discuss it in some detail. House wiring refers to the ofproviding electrical connection to a house, building or premises. Proper House wiring is necessary to cause and facilitate controlled and safe flow of the electrical power from the electrical power distribution system to electrical loads in a house, building or premises. Electrical connection to a house or building is given from the nearby electrical power carrying conductors of electrical power distribution system of supplier like

the electricity board. This connection is called service connection. Rating and type of service connection depends on the electrical load. One has to apply and complete certain formalities for obtaining a service connection. House wiring starts from the entry of the service connection. At the beginning is the energy meter and main switch or circuit breaker with safety switches and devices. Then there may be panel and switchboards. Laying of conductors, cables, switch boards and the fitting of accessories for light, fan and other devices form the common house wiring tasks. Now a day installation of voltmeters, ammeters both analog and digital and indicators at various points are frequently done to display the instantaneous values. Necessary rating, specifications and quality of materials, fittings and items are to be decided considering the requirements, related factors and the possibility of future expansion. Some important steps in house wiring are

1. Making a plan
2. Drawing a layout diagram
3. Selecting location for Energy meter and Mains switch
4. Load calculation
5. Selection of wires, cables and fitting accessories.
6. Deciding on points/location for light, fan
7. Location for switch boards
8. Earthing
9. Testing

Depending on the load house wiring is classified as Domestic house wiring and Industrial house wiring. Domestic house wiring is for residential houses and buildings with normal household electric loads like light, fan etc and without heavy machineries like high capacity motors. Industrial house wiring is for factories and industrial units with heavy machineries. Industrial house wiring supplies electric powers to heavy loads like high capacity electric motors, heaters, furnace, etc.and requires special safety and control devices which are also costly.

There are several systems of house wiring. Some common types of wiring depending on the way wiring is done. Some of them are

1. Batten wiring
2. Cleat wiring
3. Casing capping wiring
4. Conduit wiring

In batten wiring the insulated conductor, wire and cables are passed through battens which are made of wood or plastics or metal. In cleat wiring the insulated conductors are passed through porcelain cleats. In casing capping wiring insulated cables are passed through wooden enclosures. In conduit wiring cables are passed through channels or pipes made of steel, iron or plastic usually buried in walls and concrete in case of buildings. Some important terms you will come across are: PVC, TRS, HRC, SWG, DPDT, SPDT switch etc. PVC stands for Poly Vinyl Chloride which is a popular insulating material. TRS stands for Tip, Ring and Sleeve. A TRS connector is a connector with two or three or even four contacts. HRC stands for High Rupting or Rupture Capacity. HRC fuse is a type of fuse. SWG stands for Standard Wire Gauge and is used to specify the size of wire. DPDT stands for Double Pole Double Throw and SPDT stands for Single Pole Double Throw, DPDT Switch and SPDT Switch are type of switches.

Safety is an important aspect of house wiring. House wiring is to be done in a safe way so that the safety for the users of is ensured. There are laws, regulations, rules, norms and guidelines for carrying out the tasks involved in house wiring. These are specified by agencies and organizations, local, state level, national level or even of international level. Examples are Indian Electricity Act, Indian Electricity Rules, Regulations of supply authority like Assam State Electricity Board (ASEB), Bureau of Indian Standards (BIS) regulations pertaining to electrical installations, National Electric Code (NEC) of America, British Standards (BS) of Institute

of Electrical Engineers (IEE) of Great Britain now known as Institute of Engineering and Technology (IET). These are documents are available in book form. It is essential and mandatory that the house wiring tasks are performed as per the relevant rules and norms. Prescribed test are to be done and a test report is to be obtained from the competent authority before the connection is given. Prevention is always better than cure and regular maintenance of house wiring is necessary to prevent any untoward accidents or emergency. It is advisable to thoroughly check the house wiring periodically say after every six months. Extension works to connect additional loads are to be done after consultation with qualified personnel. Any problem or doubt related to existing house wiring should be immediately solved, which when neglected can lead to emergencies and accidents that may affect life and property adversely.

1.3.3 Employment Opportunities

There are some good employment opportunities for professionally sound electricians. Public sector organisation such as-Electricity boards, National Thermal Power Corporation (NTPC), North east Electric Power Corporation (NEEPCO), National Power Grid, National Hydro Electric Power Corporation (NHPC), Oil and Natural Gas Corporation (ONGC), Oil India Limited (OIL), Indian Railways, Department of Telecom etc recruit a good number of professionals of electrician trade every year. Factories and Industries in both Public sector and Private sector also hire electricians. Hotels, Hospitals, Apartment Flatsetc engage electricians on regular basis. Firms and companies dealing with electrical products, material and equipment appoint electricians.

There are also very good opportunities for self employment for the competent professional of electrician trade. One can start his own enterprise with minimum capital investment after acquiring

necessary skills and expertise. An electrician gets ample work in the very area he lives in;this can be extended to other areas. A very good relationship with a number of households including neighbours can be a basis to start with keeping regular contacts and then attending and solving day to day minor problems involving electricity. A knowledgeable and skilled electrician can undertake on contract basis house wiring jobs, maintenance jobs in hotels, offices, winding of motors, transformers, fans etc and assembling of electrical products and equipment. Some other options are opening unit for assembling panels, workshop for repair and servicing of electrical hardware and equipment, machineries etc and dealership or agency of electrical products, hardware and machineries.



CHECK YOUR PROGRESS

Q.1. What is House Wiring?

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Q.2. Write down the full form of NTPC and NEEPCO.

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1.4 DANGER FROM MISUSE OF ELECTRICAL APPLIANCES AND EQUIPMENT

Electricity has become an essential part of our day to day life. If we look around ourselves, we will see that most of the appliances and equipment that we use at home run on electricity. Our life becomes easier with the presence of these electrical appliances and equipment in our home, but it should be kept in mind that they can also be dangerous to us if we don't handle them carefully. The danger from electricity can come in

any form. It may endanger the lives of persons/personal, damage to equipment and or to the environment.

The danger to the personnel handling electrical equipment may come in the form of electric shock on account of the careless handling of electrical equipment. The electric shock may cause severe burn; may make the person fall down badly or may even cause death.

Improper use of electrical appliances/equipment may lead to certain danger to the equipment itself. It may damage a particular equipment or other costly equipment or appliances or even cause loss to property.

Similarly, the environment may be endangeredwhen there is an electrical fire that may cause devastation of an entire area.

These dangers can be avoided if a few precautions are followed and the electrical equipment and appliances are used keeping requirement of safety in mind. Following are the few safety precautions that may help us.

Precautions for the safety of personnel–

- Never touch any electrical equipment with wet hand or wet feet.
- Never stand on a wet floor. Wear a shoe or sandal having good insulating soles.
- Before handling any live wire switch off the mains supply.
- Always use tools with good insulated handles.
- Know what you are doing; otherwise don't do it.

Precautions for the safety of Equipment–

- Always make sure that the electrical equipment is connected properly to the mains before switching it ON.
- Before switching ON any electrical appliances check for damaged wire, broken plug or melted insulation.
- Make sure that specified power is supplied to the equipment.
- Every equipment has appropriate/proper procedure of operation specified by the manufacturer. One should always follow that procedure
- Some equipment need protection from dust, moisture etc., they should be enclosed in a safety enclosure.

- Some equipment needs cooling. Proper ventilation or space for air flow should be provided to them
- Unplug the appliances when not in use.
- Never overload the electrical outlet with multiple connections.
- While joining a wire or connecting a wire to a plug, make sure that insulation is proper.

Precautions for the safety of Environment–

- While using any electrical appliances or equipment, always follow the manufacture's safety precautions. Overheating, unusual smells, shorts, sparks and sputters are all warning signs that the appliances need to be shut off, then replaced or repaired
- If fire is caused by any electrical equipment or appliances, one should immediately pull the plug out, or switch off the power at the fuse box - if it is safe to do so.
- Never throw water on any kind of electrical fire. Use fire extinguisher.
- Damaged wire or plugs should be immediately replaced.
- Never place any cords or wires under rugs.

1.5 RESPONSIBILITIES OF ELECTRICIAN AND WIREMEN

An electrician is a person whose occupation is the installation, maintenance, repair, or operation of electric equipment and circuitry. The wireman is a person who installs and maintains electric wiring. The job of an electrician is a regulated trade for safety reasons due to the many hazards of working with electricity, requiring testing, registration, or licensing. Licensing of electricians is controlled through government and/ or professional societies. One must know some more duties and responsibilities before getting into this profession. One

- must have the sufficient knowledge about the job an electrician is expected to do.
- must take care of all safety precautions.
- must know how to handle all the tools and equipment.

- have the ability to handle emergency situations.
- must have a proper idea about making plan and cost estimation.
- must know the Indian Electricity Rules, Acts and Wiring Standards.



CHECK YOUR PROGRESS

Q.3. What are the forms of electrical danger?

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Q.4. Who is an electrician?

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1.6 LET US SUM UP

- Electrician, Electrical Fitter, Technician, Operator are some common designations of the personal handling electricians trade. A professional electrician has to perform technical and related tasks connected with electricity ensuring safety, economy and efficiency in the use of electricity.
- House wiring refers to the tasks to be done to prepare a house, building or premises for providing electrical connection.
- There are very good self employment opportunities for the professionals of the electrician trade. One can start his own enterprise with a minimum capital investment after acquiring necessary skills and expertise.
- While handling any electrical appliances any one can be exposed to the danger from electricity if proper precaution is not taken.
- The danger from electricity can come in any form. It may be a danger to the personnel, to the electrical equipment or to the environment.

- The job of an electrician is a regulated trade for safety reasons because he may be exposed to many hazards conected with electricity.The job comprises testing, registration, or licensing.



1.7 FURTHER READINGS

1) R. C. Mullin, Phil Simmons, *Electrical Wiring Residential*, Cengage learning.
2) R. C. Mullin, Robert L. Smith,*Electrical Wiring: Commercial [With Wiring Plans]*, Delmar Thomson Learning.



1.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : House wiring refers to the tasks to be done to prepare a house, building or premises for providing electrical connection.

Ans. to Q. No. 2 : National Thermal Power Corporation (NTPC), North east Electric Power Corporation (NEEPCO)

Ans. to Q. No. 3 : The danger can come in the form of a danger to personnel, to equipment or to the environment.

Ans. to Q. No. 4 : An electrician is a person whose job is connected with the installation, maintenance, repair, or operation of electric equipment and circuitry.



1.9 MODEL QUESTIONS

Q.1. What are the tasks performed by an electrician?
Q.2. What are the common designations of an electrical professional?
Q.3. What are the important steps in house wiring?
Q.4. State the common types of wiring.
Q.5. What is the importance of safety in house wiring? Name some of the norms and guidelines connected with safety.
Q.6. What happens when electrical appliances are misused?
Q.7. What are the main responsibilities of a electrician and wiremen.

UNIT 2 : INTRODUCTION TO ELECTRICITY AND ELECTRIC POWER

UNIT STRUCTURE

2.1 Learning Objectives

2.2 Introduction

2.3 Definitions and Units

2.4 Static and Dynamic Electricity

2.5 Direct Current (DC) and Alternating Current (AC)

2.6 Voltage Levels in AC

2.7 Advantages of AC

2.8 Let Us Sum Up

2.9 Answer to Check Your Progress

2.10 Further Readings

2.11 Model Questions

2.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe the concept of electricity and its types
- explain the difference between DC and AC
- examine the importance of AC
- know the definition, symbol and unit of voltage, current, power etc.

2.2 INTRODUCTION

In this unit, you will learn the basic concepts of electricity, its types and related definitions. Electricity is vital for the smooth running of the appliances that we use in our day to day life. The understanding of the working of these appliances is related to some basic terms like voltage, current, power, resistance, frequency, phase etc. These terms are often used with respective units and symbols and should be known while dealing with electricity.

2.3 DEFINITIONS AND UNITS

The unit used for measurements of electrical and related disciplines is based on metric system and is known as *Syst'eme Internationale d'Unit´es* (International system of units) written in short form as SI unit. It was introduced in 1960 and has now become the most preferred system of units of measurements. Some of the basic SI units may be expressed as in Table 1.1.

Table 1.1 : Basic SI units related to a few Physical Measurements

Quantity	Unit
length	metre, m
mass	kilogram, kg
time	second, s
electric current	ampere, A
thermodynamic temperature	kelvin, K
luminous intensity	candela, cd
amount of substance	mole, mol
Power	Watt

SI units maybe scaled up or down by powers of 10 which is denoted by prefixes attached to the unit. A few common examples can be as in Table 1.2.

Table 1.2 : Scaling of SI units by powers of 10

Prefix	Name	Meaning	Power of 10
M	mega	multiply by 1,000,000	(i.e.x 10^6)
k	kilo	multiply by 1,000	(i.e. x 10^3)
m	milli	divide by 1,000	(i.e. x 10^{-3})
μ	micro	divide by 1,000,000	(i.e. x 10^{-6})
n	nano	divide by 1,000,000,000	(i.e. x 10^{-9})
p	pico	divide by 1,000,000,000,000	(i.e. x 10^{-12})

Charge : Electricity appears in two forms - one positive and the other negative. Electric charge can be an excess distribution and accumulation of one type of electricity in a system. If the excess or additional

amount is of the negative type then it is negative charge and if the excess is of the positive type it is called positive charge.

The **unit of charge** is the coulomb (C) (1 coulomb = 6.24 x 10^{18} electrons). The coulomb is defined as the quantity of electricity which flows past a given point in an electric circuit when a unit of current is maintained for one second. Thus, Charge in Coulombs, Q= I x t. C, where **I** is the amount of current flowing and **t** is the time in seconds for which the current is flowing.

Example 1.1 : A current of 15 Amperes is flowing for 5 seconds between two points. Find the amount of charge in Coulombs that flows between the points.

Answer : Q = I x t. Here I = 15 Ampere and t = 5 seconds.

Q = 15 x 5 = 75 C.

Potential Difference : Mechanically, **force** is the factor which can be used to displace a body from one position to another. Its unit is Newton (N). The unit Newton maybe defined as the force required to give a mass of one kilogram an acceleration of one metre per second squared.

Force in Newton is expressed as

$$F = ma$$

where m is the mass of the body and a is the acceleration produced.

When force is applied on a body and it is displaced by some distance, **work** is done. The unit of this work done is Joule (J). It is defined as the amount of force in N required to displace a body by one meter from its original position. Thus, work done on a body in Joule is expressed as

$$W = Fs$$

where F is the force in Newton and s is the distance in meters.

Energy is the capacity for doing work.

When a difference of electric state or potential exists between two points, charge will flow from the higher potential to the lower. This difference in state or potential has forced a displacement of the particle from one position to another. This is defined as **potential difference** or electric

potential. Its unit is volt (V). One volt is defined as the difference in potential between two points in a conductor which dissipates a power of one watt while transferring charge from one position to another in unit time producing unit current. It is expressed as

$$\text{volts} = \frac{\text{watts}}{\text{amperes}} = \frac{\text{joules/second}}{\text{amperes}} = \frac{\text{joules}}{\text{ampere seconds}} = \frac{\text{joules}}{\text{coulombs}}$$

A change in electric potential between two points in an electric circuit is called a potential difference.

Current : Electrons are elementary particles and possess certain potential energy. In a suitable medium, however, electrons tend to move from one point to another if there exists a difference in potential energy. The movement of charges from one place to another per unit time is referred to as current. This movement takes place in a properly directed manner such that the flow is from a higher potential state to a lower potential state. A material that permits electron flow is called a **conductor** while the medium that obstructs such a flow is an **insulator**. Examples of conductors are copper, aluminum, silver etc. Rubber, wood, clay etc are a few insulators. Semiconductors have conductivity between conductors and insulators.

The unit of current is Ampere (A). One Ampere is the current recorded when one Coulomb charge flows in one second time.

Power : If, in an electric circuit, due to an applied voltage V a current I flows, the product of V and I constitutes the power consumed by the circuit. Thus, electric power is expressed as

$$\mathbf{P = V \times I}$$

V is in volts while I is in Amperes.

Its unit is Watt. If this power is continued to be absorbed by the circuit for some useful work to be done in time t, then electrical energy is obtained by it is expressed as

$$\mathbf{E = P \times t = V \times I \times t}$$

Its unit is Joules. Although the unit of energy is the joule, when large amounts of energy is involved, the unit used is the **kilowatt hour (kWh)** where

1 kWh = 1000 watt hour

= 1000 x 3600 watt seconds or joules

= 3, 600, 000 J

Example 1.2 : A source of 10 V supplies a current of 5 A for 15 minutes. What is the amount of energy provided by the source?

Solution : E = V x I x t.

= 10 x 5 x 15 x 60 J

= 45 000 = 45 KJ.



CHECK YOUR PROGRESS

Q.1. Find True or False :

a) The unit used for measurements of electrical and related disciplines is based on metric system and is known as SI.

b) The unit of charge is the coulomb (C).

c) One Ampere is the current recorded when one Coulomb charge flows in one second time.



Measurement provides the magnitude of an electrical quantity obtained by a specific equipment in a working condition.

2.4 STATIC AND DYNAMIC ELECTRICITY

While energy flows from the generator to the load in an electrical system, the transporting part of the system is carried out by a unit entity called **charge**. Electricity appears in two forms – one positive and the other negative. The fundamental concept of charge, however, comes from the description of the atom. An atom is constituted by protons and electrons. Both of these are elementary particles. Electron is electro-negative while proton is electro-positive. In the normal state the electrical characteristics of the atom is in the balanced state as the electric charge distribution of electrons and protons cancel out each other. If an electron is taken away or if there is an excess electron in the atom, the balance is disturbed. If there is excess electrons it is called negatively charges and if there is a deficiency of an electron it is called positively charged.

When a difference of electric state or potential exists between two points, charge will from the higher potential to the lower potential. This difference in state or potential has forced a displacement of the particle from one position to another. This is defined as **potential difference** or **electromotive force** (emf).

When electricity is stored between the two plates of a capacitor (figure 2.1) it cannot flow till a conductor is connected to a capacitor. In that situation a static electricity develops. The charges are held between the plates of the capacitor which continues to hold it till a conductor connected to it provides a path of flow.

Electrons that move from one atom to another are called **free electrons** and such random motion can continue indefinitely. However, if an electric pressure, potential difference or voltage is applied across any material there is a tendency for electrons to move in a particular direction. This movement of free electrons, known as **drift**, constitutes an electric current flow. Thus current is the rate of movement of charge. The movement of electric charges constitutes dynamic electricity.

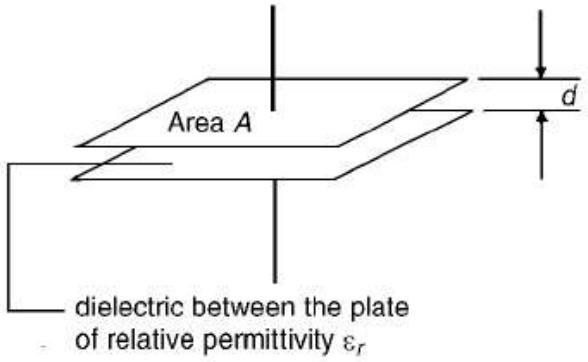


Fig. 2.1 : Parallel plate capacitor that can hold static electricity



CHECK YOUR PROGRESS

Q.2. Find True or False :

a) When a difference of electric state or potential exists between two points, charge will be from the lower to the higher.

b) The movement of electric charges constitutes dynamic electricity.

c) The charges are held between the plates of the capacitor which continues to hold it till a conductor connected to it provides a path of flow.

2.5 DIRECT CURRENT (DC) AND ALTERNATING CURRENT (AC)

Direct Current or DC is obtained from battery. It has no variation in magnitude if the voltage or the potential difference remains same despite variation in the time despite variation in time. This movement of electrons takes place in a properly directed manner such that the flow is from a higher potential state to a lower potential state. These potential states may be referred to as positive and negative polarities. It means that conventionally current flows from positive to negative sides (Figure 2.2 a).

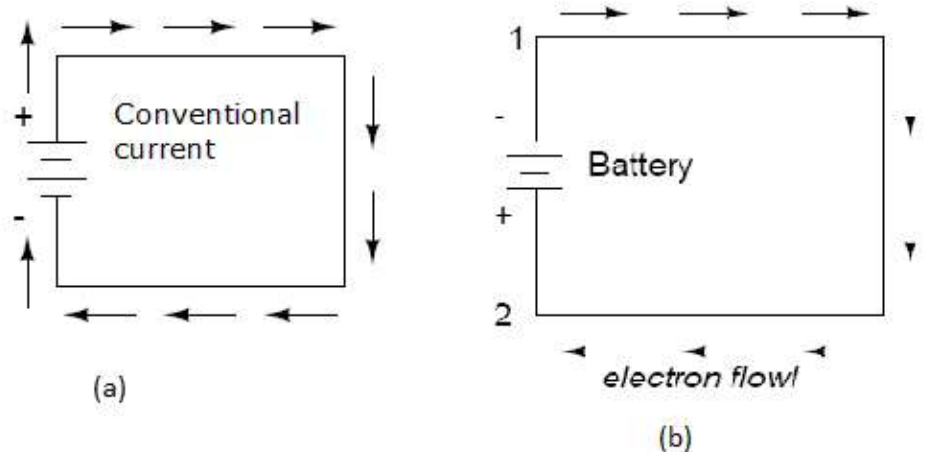


Fig. 2.2 : Setting up of conventional and electron current

But in the true sense, electron moves in the opposite direction i.e. from negative to the positive side as negatively charged electrons are attracted towards the positive polarity (Figure 2.2 b).

AC or Alternating Current are special wave forms that have their waveforms continually varying in direction (i.e. alternately positive and negative) with respect to time. The sources that generate AC produce

voltages alternating in polarity, reversing positive and negative over time. An AC waveform is similar to a sine wave.

A simple approach to generate AC is depicted below (Figure 2.3):

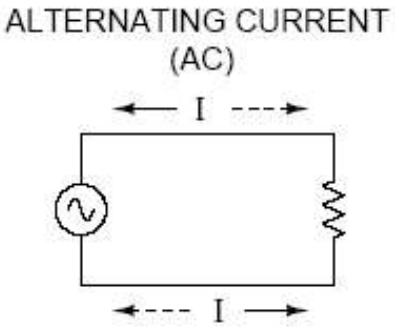


Fig. 2.3 : Arrangement with AC sourc

Let a single turn coil be free to rotate at constant angular velocity symmetrically between the poles of a magnet system as shown in Figure 2.4.

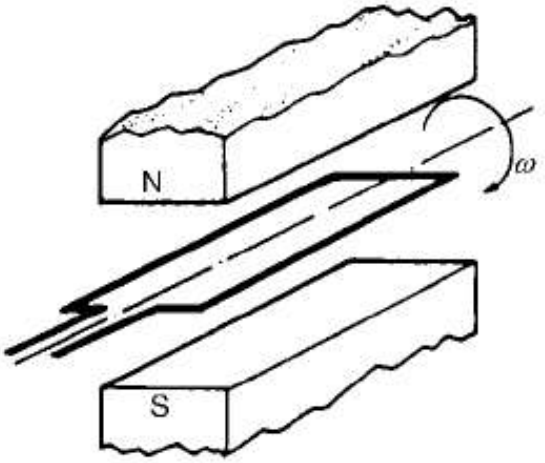


Fig. 2.4 : Arrangement to generate AC



Faraday's Law: when the magnetic flux through a closed circuit changes, an induced emf is set up in it, which lasts as long as the flux changes.

An e.m.f. is generated in the coil (from ***Faraday's Law***s) which varies in magnitude and reverses its direction at regular intervals. The waveform generated due to the movement of the magnet between the coil is a sinusoid and is depicted in Figure 2.5.

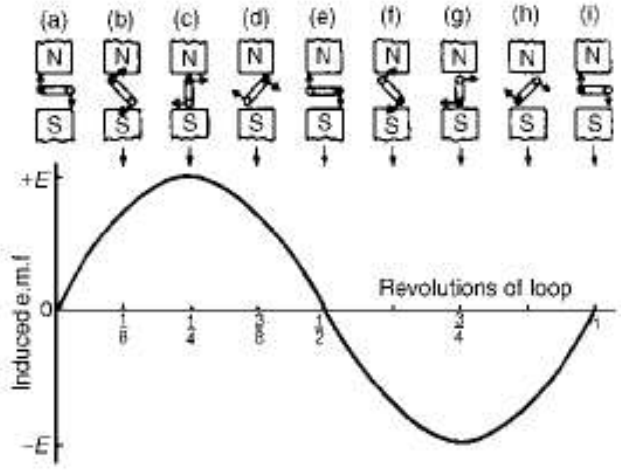


Fig. 2.5 : Sinusoidal wave generated by different pole positions of a magnet

A waveform thus created can be represented as

$$x(n) = A\cos(\omega n + \theta)$$

where angular frequency

$$\omega = 2\pi f \Rightarrow x(n) = A\cos(2\pi n f + \theta)$$

The time taken for an alternating quantity to complete one cycle is called the **period** or the **periodic time**, ***T***, of the waveform. The number of cycles completed in one second is called the **frequency**, ***f***, and is measured in **hertz**, **Hz**. In India, the standard value of AC supply is 50 Hertz.

$$T = \frac{1}{f} \text{ or } f = \frac{1}{T}$$

Electricity is produced by generators at power stations and then distributed by a vast network of transmission lines to industry and for domestic use. It is easier and cheaper to generate alternating current (a.c.) than direct current (d.c.) and a.c. is more conveniently distributed than d.c. since its voltage can be readily altered using transformers.



CHECK YOUR PROGRESS

Q.3. Find True or False :

a) DC has no variation in magnitude despite variation in time provided the voltage remains the same.

b) AC is a special waveform that has no waveforms continually varying in direction with respect to time.

c) Electricity is produced by generators at power stations and then distributed by a vast network of transmission lines to industry and for domestic use.

2.6 VOLTAGE LEVELS USED IN AC

The following terms are essential for the understanding of the working of appliances using AC.

Instantaneous values are the values of the alternating quantities at any instant of time. The largest value reached in a half cycle is called the peak value or the maximum value or the crest value or the amplitude of the waveform. Peak amplitude is the height of an AC waveform as measured from the zero mark to the highest positive or lowest negative point on a graph. The largest value reached in a half cycle is called the peak value or the maximum value or the crest value or the amplitude of the waveform.

Peak-to-peak amplitude is the total height of an AC waveform as measured from maximum positive to maximum negative peaks on a graph.

The amplitude of an AC waveform is its height as depicted on a graph over time. An amplitude measurement can take the form of peak, peak-to-peak, average, or RMS quantity.

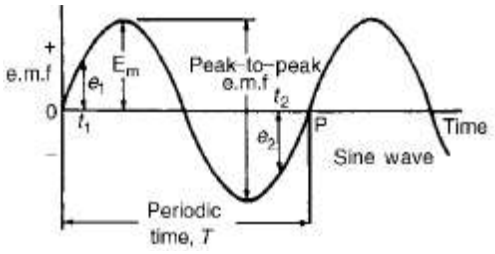


Fig. 2.6 : AC waveform and its values

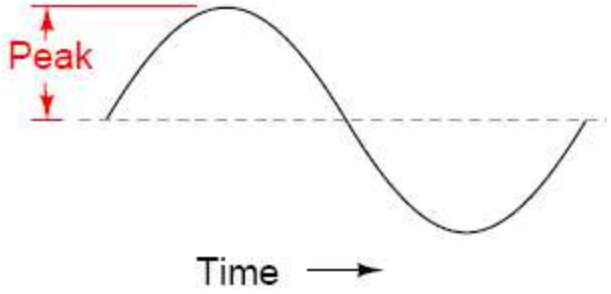


Fig. 2.7 : Peak value of a AC

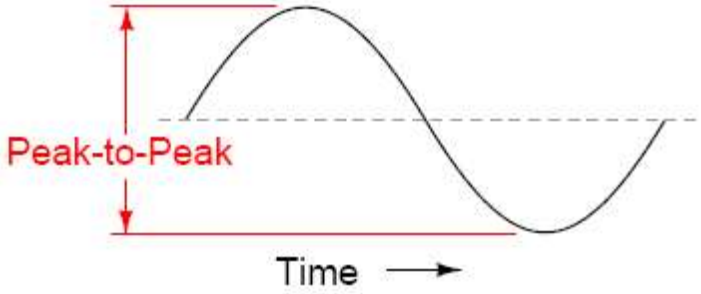


Fig. 2.8 : Peak to peak value of an AC wave

The average or mean value of a symmetrical alternating quantity, (such as a sine wave), is the average value measured over a half cycle. This is because over a complete cycle the average value of a sine wave is zero.

$$\text{Average or mean value} = \frac{\text{area under the curve}}{\text{length of base}}$$

Average amplitude is the mathematical mean of a waveform's all points over the period of one cycle. T. For a sine wave, average value = 0.637 × maximum value.

"RMS" stands for Root Mean Square, and is a way of expressing an AC quantity of voltage or current in terms functionally equivalent to DC. The effective value of an alternating current is that current which will

produce the same heating effect as an equivalent direct current. This effective value is called the root mean square (rms) value. Whenever an alternating quantity is given, it is assumed to be the rms value.

For a sine wave,

rms value = 0.707× maximum value (i.e. $\frac{1}{\sqrt{2}} \times \text{maximum value}$).



CHECK YOUR PROGRESS

Q.4. Find True or False :

a) Peak-to-peak amplitude is the total height of an AC waveform as measured from maximum positive to maximum negative peaks on a graph.

b) Average amplitude is the mathematical mean of all of a waveform's points over the period of one cycle..

c) RMS stands for Root Mean Square.

2.7 ADVANTAGES OF AC

Electricity is produced by generators at power stations and then distributed by a vast network of transmission lines to industry and for domestic use. It is easier and cheaper to generate AC than DC. AC is more conveniently distributed than DC since its voltage can be readily altered using transformers.

In applications where electricity is used to dissipate energy, the polarity or direction of current is irrelevant, so long as there is enough voltage and current to the load to produce the desired power dissipation. However, with AC it is possible to build electric generators, motors and power distribution systems that are far more efficient than DC. For high power applications AC systems are required.

Another advantage is the ease of design of ac motors compared to dc motors and the efficiency that the former provide.

The greatest advantage of the AC over DC is with regards to distribution of power. This is possible due to the use of transformer for which AC is required. The transformer's ability to step AC voltage up or down with ease gives AC an advantage which the DC cannot in the realm of power distribution.

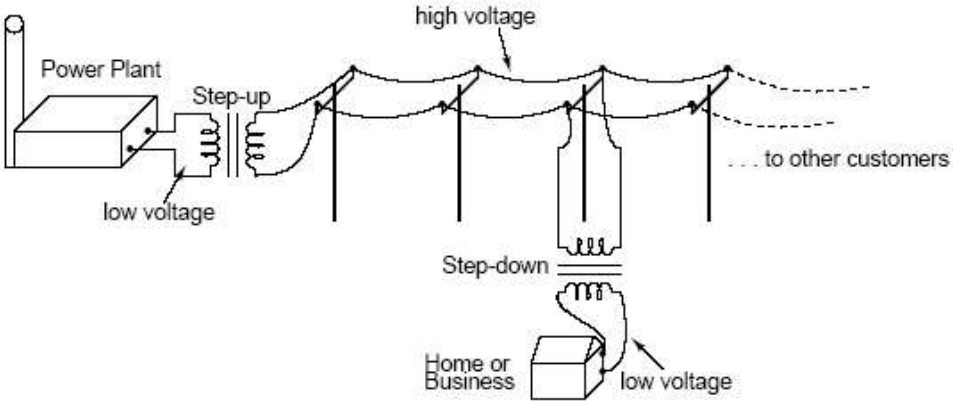


Fig. 2.9 : Power distribution

Without the ability to efficiently step voltage up and down, it would be cost-prohibitive to construct power systems for long range distribution. In such a situation power distribution would be possible only in close-range (within a few miles at most) use. Because the phenomenon of mutual inductance relies on changing magnetic fields, and DC can only produce steady magnetic fields, transformers simply will not work with direct current.



CHECK YOUR PROGRESS

Q..5. Find True or False :

a) It is easier and cheaper to generate AC than DC.

b) DC can produce steady and dynamic magnetic fields.

c) The greatest advantage of the DC over AC is with regards to distribution of power.



2.8 LET US SUM UP

- The unit used for measurements of electrical and related disciplines in based on metric system and is known as *Syst'eme Internationale d'Unit´es* (International system of units).
- Electricity appears in two forms – one positive and the other negative.
- The unit of charge is the coulomb (C) (1 coulomb = 6.24 x 10^{18} electrons).
- When a difference of electric state or potential exists between two points, charge will flow from the higher potential to the lower. This difference in state or potential has forced a displacement of the particle from one position to another. This is defined as potential difference.
- The movement of charges from one place to another per unit time is referred to as current.
- If, in an electric circuit, due to an applied voltage V a current I flows, the product of V and I constitutes the power consumed by the circuit.
- Direct Current or DC is obtained from battery. It has no variation in magnitude if the voltage or the potential difference remains same despite variation in the time despite variation in time.
- AC or Alternating Current are special wave forms that have their waveforms continually varying in direction (i.e. alternately positive and negative) with respect to time.
- It is easier and cheaper to generate AC than DC. AC is more conveniently distributed than DC since its voltage can be readily altered using transformers.



2.9 FURTHER READINGS

1) Thareja B. L., *Electrical Technology*, Khanna Publishing.
2) Hughes E., Smith I. M., *Electrical Technology*, ELBS.

2.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : a) True, b) True, c) True.

Ans. to Q. No. 2 : a) False, b) True, c) True.

Ans. to Q. No. 3 : a) True, b) False, c) True.

Ans. to Q. No. 4 : a) True, b) True, c) True.

Ans. to Q. No. 5 : a) True, b) False, c) False.



2.11 MODEL QUESTIONS

Q.1. What are the multiplicative terms related to mili, micro, pico, kilo, mega and giga?

Q.2. A current of 10 Amperes is flowing for 15 seconds between two points. Find the amount of charge in Coulombs that flows between the points.

Q.3. A source of 15 V supplies a current of 10 A for 15 minutes. What is the amount of energy provided by the source?

Q.4. Define the terms charge, potential difference, current, power and energy. What are the respective units?

Q.5. What are peak, peak-to-peak, average and RMS values of an AC signal?

Q.6. What are the advantages to AC over DC?

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UNIT 3 : ELECTROMAGNETISM AND COMMON ELECTRICAL APPLIANCES

UNIT STRUCTURE

3.1 Learning Objectives

3.2 Introduction

3.3 Electromagnetism and its Application in Electric Appliances

3.4 Principles of AC Generators and Motors

3.5 Various Electrical Appliances

3.6 Measurement Methods of Electrical Parameters

3.7 Measuring Instruments of Electrical Parameters

3.8 Let Us Sum Up

3.9 Further Readings

3.10 Answers to Check Your Progress

3.11 Model Questions

3.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- understand that magnetic fields are produced by electric currents,
- recognize and describe practical applications of an electromagnet,
- describe the principle of operation of a simple DC motor,
- know the measurement methods of electrical parameters and electrical measurement instruments.

3.2 INTRODUCTION

In this unit, you will learn the basic concept of electromagnetism and its application. You will also know how electromagnetism is generated and why it is so significant. The working of electrical measurements and that of some of the important instruments will be covered in this unit so that you can develop a fairly adequate understanding about them.

3.3 ELECTROMAGNETISM AND ITS APPLICATION IN ELECTRIC APPLIANCES

When electric current flows through a wire, a magnetic field is developed around the wire till the flow of current exits. This can be verified by placing some iron filings around the wire when current is flowing through it. This phenomenon of development of magnetism across a wire when current flows through it is called **electromagnetism**.

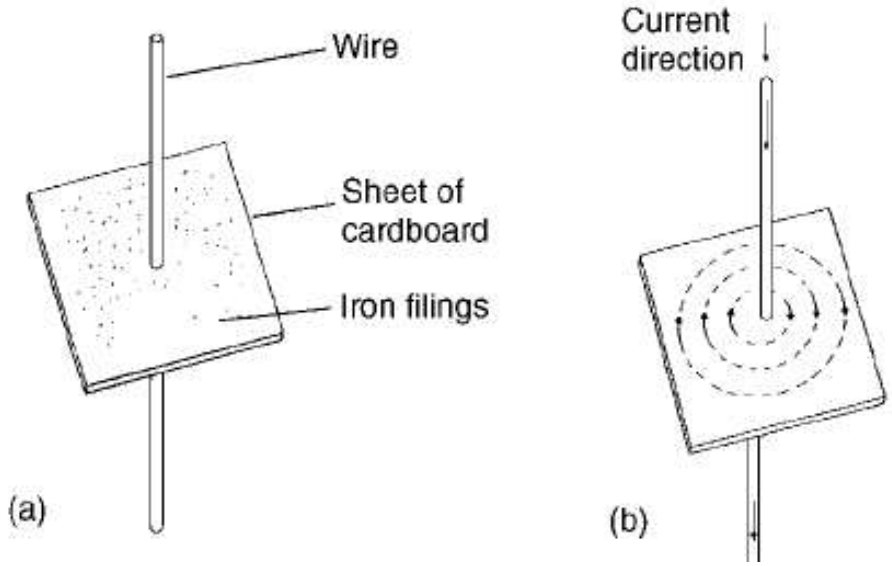


Fig 3.1 : Development of magnetism around a wire when current flows through it

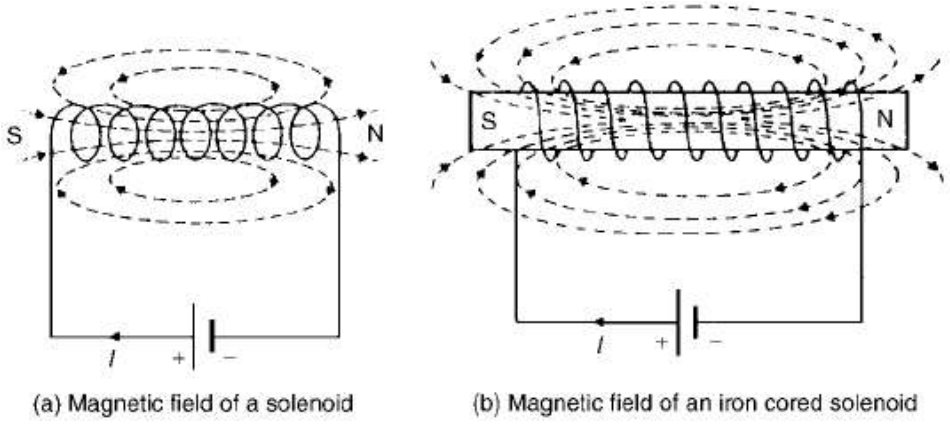
Let a piece of wire be arranged to pass through a sheet of cardboard, on which is placed some iron filings, as shown in Figure 3.1(a). If a current is now passed through the wire, then the iron filings will form a definite circular field pattern with the wire at the centre, when the cardboard is gently tapped. By placing a compass in different positions the lines of flux are seen to have a definite direction as shown in Figure 3.1(b).

If the current direction is reversed, the direction of the lines of force is also reversed. The effect on both the iron filings and the compass needle disappears when the current is switched off. The magnetic field is thus produced by the electric current. The magnetic flux produced has the same properties as the flux produced by a permanent magnet. If the current is increased the strength of the field increases and, as for the permanent

magnet, the field strength decreases as we move away from the current carrying conductor.

The direction of the magnetic lines of force is related to a screw rule. This states that: '*If a normal right-hand thread screw is screwed along the conductor in the direction of the current, the direction of rotation of the screw is in the direction of the magnetic field*.'

A magnetic field set up by a long coil, or **solenoid**, is shown in Figure 3.2(a) and is seen to be similar to that of a bar magnet. If the solenoid is wound on an iron bar, as shown in Figure 3.2(b), an even stronger magnetic field is produced, the iron becoms magnetized and behaving like a permanent magnet.



(a) Magnetic field of a solenoid (b) Magnetic field of an iron cored solenoid

Fig. 3.2 : magnetic field produced by a solenoid

Electromagnetism is often used with electromagnets which is the basis of many electrical appliances. An electromagnet, based on the solenoid, provides the basis of many items of electrical equipment, examples of which include electric bells, relays, lifting magnets and telephone receivers.

i) **Electric bell :** There are various types of electric bell, including the single-stroke bell, the trembler bell, the buzzer and a continuously ringing bell. The working of all these bells depends on the pull applied by an electromagnet on a soft iron armature. A typical single stroke bell circuit is shown in Figure 3.3. When the push button is operated, a current passes through the coil. Since the iron-cored coil is energized the soft iron armature is attracted

to the electromagnet. The armature also carries a striker which hits the gong. When the circuit is broken the coil becomes demagnetized and the spring steel strip pulls the armature back to its original position.

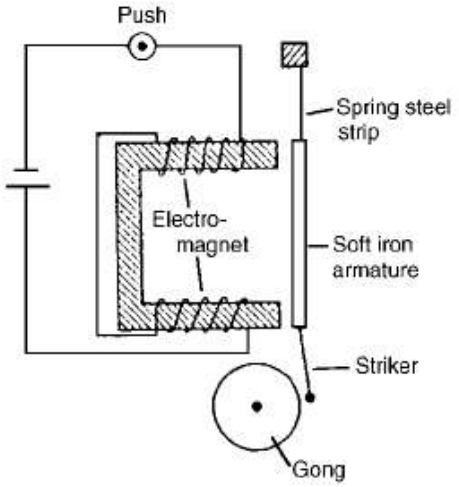


Fig. 3.3 : Electric bell

ii) Relay : A relay is similar to an electric bell except that contacts are opened or closed by operation instead of a gong being struck. A typical simple relay is shown in Figure 3.4, which consists of a coil wound on a soft iron core. When the coil is energized the hinged soft iron armature is attracted to the electromagnet and pushes against two fixed contacts so that they are connected together, thus closing some other electrical circuit.

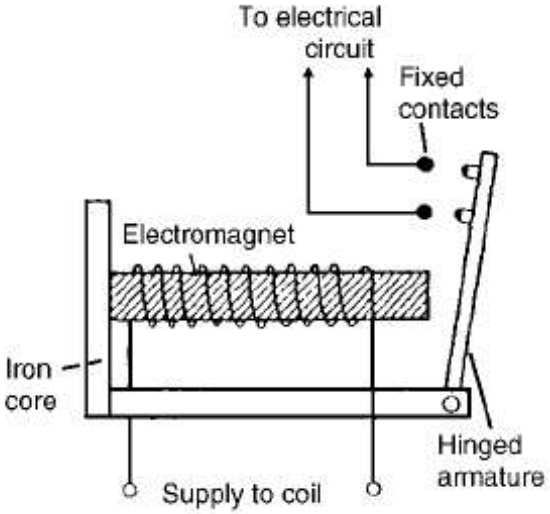


Fig 3.4 : Relay

iii) **Lifting magnet :** Lifting magnets are formed by large electromagnets. These are used in iron and steel works for lifting scrap metal. A typical robust lifting magnet, capable of exerting large attractive forces, is shown in the elevation and plan view of Figure 3.5 where a coil, C, is wound round a central core, P, of the iron casting. Over the face of the electromagnet a protective nonmagnetic sheet of material, R is placed. The load, Q, which must be of magnetic material is lifted when the coils are energized. The magnetic flux paths, M, are shown by the broken lines.

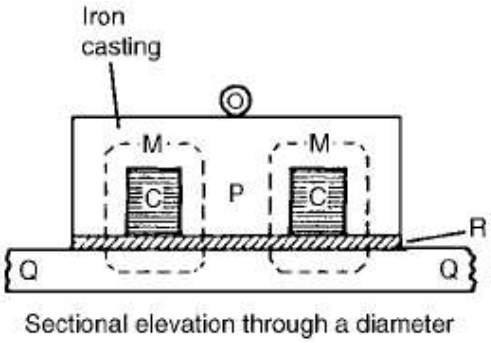


Fig. 3.5 : Lifting Magnet

iv) **Telephone receiver :** Whereas a transmitter or microphone changes sound waves into corresponding electrical signals, a telephone receiver converts the electrical waves back into sound waves. A typical telephone receiver is shown in Figure 3.6 and consists of a permanent magnet with coils wound on its poles. A thin, flexible diaphragm of magnetic material is held in position near to the magnetic poles but not touching them. Variation in current from the transmitter varies the magnetic field and the diaphragm consequently vibrates. The vibration produces sound variations corresponding to those transmitted.

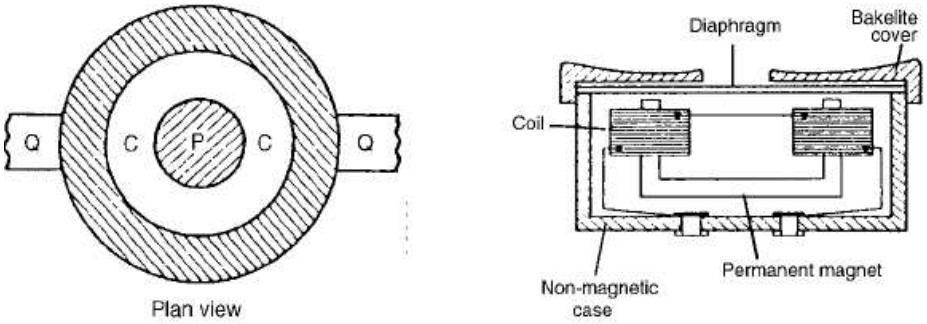


Fig. 3.6 : Telephone receiver



LET US KNOW

Magnetic lines of force or a magnetic field is defined as the curve such that the tangent to the curve at any point gives the direction of the magnetic field at that point. The lines are drawn to represent the magnetic field graphically. The number of lines crossing unit area perpendicular to the lines is proportional to the intensity of the magnetic field. These lines are closed and continuous curves. They never intersect each other. These lines are crowded whenever the field is strong.

Magnetic flux is defined as the total number of lines of force threading through a given area, provided that the area is normal to them. It is denoted by Φ. If H is the strength of the magnetic field, and A is the area normal to the lines of force, then Φ = HA.



CHECK YOUR PROGRESS

Q.1. Find which of the following statement are True or False.

a) When electric current flows through a wire, a magnetic field is developed around the wire till the flow of current exits.

b) Whereas a transmitter or microphone changes sound waves into corresponding electrical signals, a telephone receiver converts the electrical waves back into sound waves.

c) If the current direction is reversed, the direction of the lines of flux of an electromagnet is not reversed.

3.4 PRINCIPLES OF AC GENERATORS AND MOTORS

A simple approach to generate AC is depicted below (Figure 3.7): Let a single turn coil be free to rotate at constant angular velocity symmetrically between the poles of a magnet system as shown in Figure 3.7.

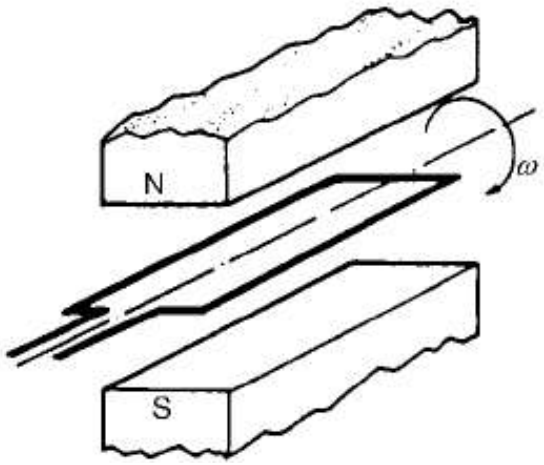


Fig. 3.7 : Arrangement to generate AC

An electro motive force (e.m.f) is generated in the coil (from Faraday's Laws) which varies in magnitude and reverses its direction at regular intervals. The waveform generated due to the movement of the magnet between the coil is a sinusoid and is depicted in Figure 3.8.

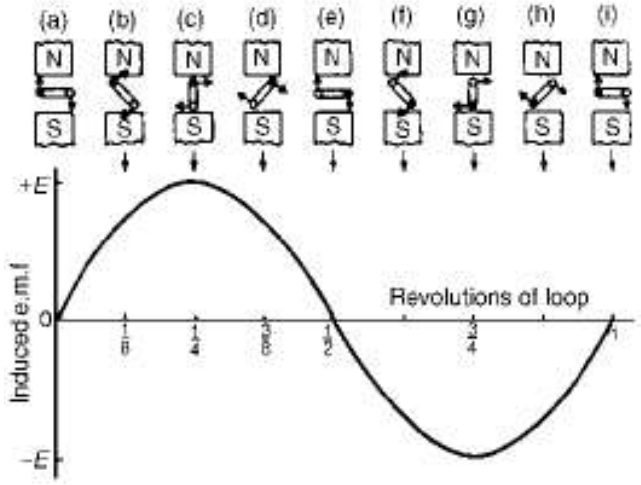


Fig. 3.8 : Sinusoidal wave generated by different pole positions of a magnet.

The variation of the magnitude of the waveform is due to the different positions of the coil inside the magnet (Figure 3.8). In positions

(a), (e) and (i) the conductors of the loop are effectively moving along the magnetic field, no flux is cut and hence no e.m.f. is induced. In position (c) maximum flux is cut and hence maximum e.m.f. is induced. In position (g), maximum flux is cut and hence maximum e.m.f. is again induced. However, using Fleming's right-hand rule, the induced e.m.f. is in the opposite direction to that in position (c) and is thus shown as E. In positions (b), (d), (f) and (h) some flux is cut and hence some e.m.f. is induced. If all such positions of the coil are considered, in one revolution of the coil, one cycle of alternating e.m.f. is produced as shown. This is the principle of operation of the AC generator (i.e. the alternator).

Electric Motor : In an electric motor, conductors rotate in a uniform magnetic field. A single-loop conductor mounted between permanent magnets is shown in Figure 3.9. A voltage is applied at points A and B in Figure 3.9 (a).

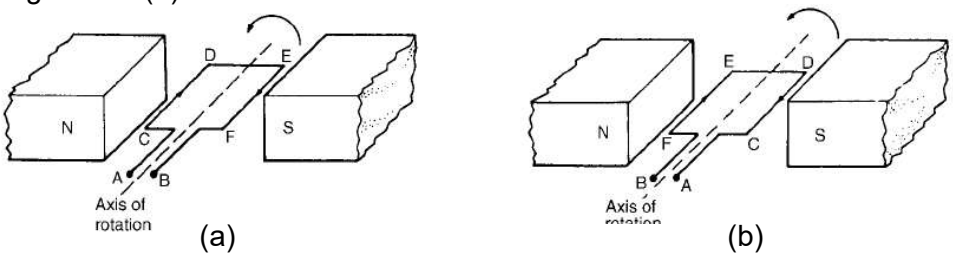


Fig. 3.9 : Electric motor

A force, *F*, acts on the loop due to the interaction of the magnetic field of the permanent magnets and the magnetic field created by the current flowing in the loop. This force is proportional to the flux density, B, the current flowing, *I*, and the effective length of the conductor, *l*, i.e. $F = BIl$. The force is made up of two parts, one acting vertically downwards due to the current flowing from C to D and the other acting vertically upwards due to the current flowing from E to F. If the loop is free to rotate, then when it has rotated through 180°, the conductors are as shown in Figure 3.9 (b). For rotation to continue in the same direction, it is necessary for the current flow to be as shown in Figure 3.9 (b), i.e. from D to C and from F to E. This apparent reversal in the direction of current flow is achieved by a process called **commutation**. With reference to Figure 3.9 (a), when a direct voltage is applied at A and B, then as the single-loop conductor

rotates, current flow will always be away from the commutator for the part of the conductor adjacent to the N-pole and towards the commutator for the part of the conductor adjacent to the S-pole. Thus the forces act to give continuous rotation in an anti-clockwise direction. The arrangement shown in Figure 3.9 (a) is called a 'two-segment' commutator and the voltage is applied to the rotating segments by stationary **brushes**, (usually carbon blocks), which slide on the commutator material, (usually copper), when rotation takes place.



CHECK YOUR PROGRESS

Q.2. Find True or False.

a) The waveform generated due to the movement of the magnet between the coil is a sinusoid.

b) The variation of the magnitude of the waveform is due to the static positions of the magnet inside the coil.

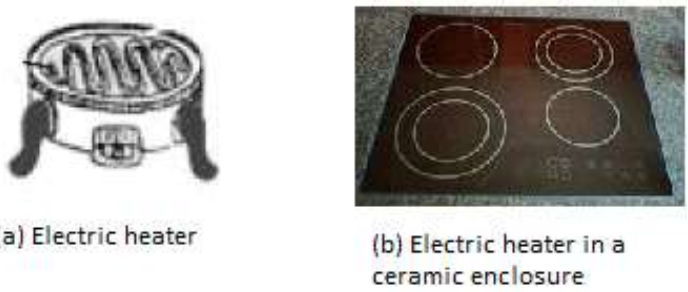
c) In an electric motor, conductors stay static in a uniform magnetic field.

3.5 VARIOUS ELECTRICAL APPLIANCES

There are a range of domestic appliances that use electricity. These appliances can be classified in terms of their working principles. Some use the thermal effect while a few thus use the magnetic effect of electricity. Some of these are described below:

Electric Stoves or Heaters : These are common domestic appliances that rely on the heating effect of electricity. The system provides an arrangement for generation of heat when connected to an electric source which can be used for cooking. In the most rudimentary form an electrical connection is established across a spiraling coil made of chrome alloy wire placed in a special arrangement through which electric current is passed. The coiling has certain thermal properties which produce heat that can be used for cooking. This approach, though simple to use electricity

to do cooking, is a bit hazardous if precautions are not taken. Also ceramic or similar insulation based heat dissipation enclosures are essential for their safe operation.



(a) Electric heater

(b) Electric heater in a ceramic enclosure

Fig. 3.10 : Electric heaters

Room Heater : It is also a common appliance that relies on the thermal effect of a electricity. A set of chromium alloy rods are placed in parallel with some spacing in between in an arrangement across which electric connection is established. These rods form the heat generators which are placed in front of a concave reflector. The reflector surface is polished and is arranged so as to reflect off the heat generated by the rods. The rods start to generate heat as soon as electric current flows through them which is radiated from the arrangement by the polished reflector surface.

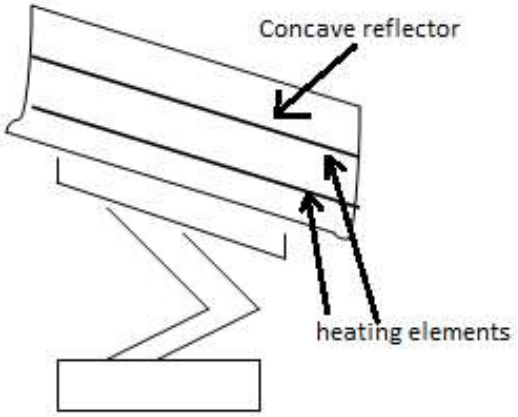


Fig. 3.11 : Room heater

Electric iron : The arrangement of an electric iron consists of a chromium alloy wire wound in a spiral form on a mica sheet. The mica layer acts as an electrical insulator while allowing heat generated to flow through it. There are two plates in the iron one called the pressure plate and the other the base plate. The pressure plate holds the heating elements

in place tightly. The heat is transferred to the cloth through the base plate. The heating coil is placed between these two plates.

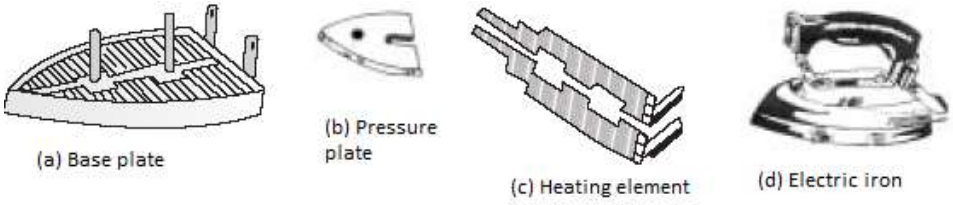


Fig. 3.12 : Different segments of an electric iron

Electric Kettle : In case of an electric kettle, the heating element formed by a nickel chromium alloy is placed at the bottom of the arrangement. When an electric current passes through the wire, heat is generated. The heat generated is allowed to distribute in a way that it heats up the water inside it. The entire arrangement is placed in an insulated arrangement so that there is less chance of receiving an electrical shock by the user.

Electric immersion rod : It is a simple means to get hot water using electricity. The arrangement consists of a nickel-chromium heating element housed in a metallic arrangement. The heating element is separated out of the metallic enclosure by putting magnesium oxide powder which acts an electrical insulator and conductors the heat generated to the liquid in contact.

Water Heaters : Water heaters are required for continuous supply of heated water for domestic and other applications. It can be an arrangement where water is held in storage of certain capacity. Below the storage tank there is a heating element which is made up of nickel – chromium alloy. When the current passes through this element, it heats up and passes on to the water held in the storage. This arrangement can be made to generate hot water of a preset temperature.

Electric lamps : There are two main categories of electric lamps. The first one is called the incandescent lamp and the second one is known as the fluorescent bulb. The incandescent lamp is formed by a glass enclosure with a wounded tungsten wire acting as the source of illumination. It works following the principle that when metallic filament is heated to a

high temperature it becomes incandescent and starts emitting light. The two ends of the filament is connected to two leads of the bulb held in a sealed glass arrangement filled with noble gases at low pressure.

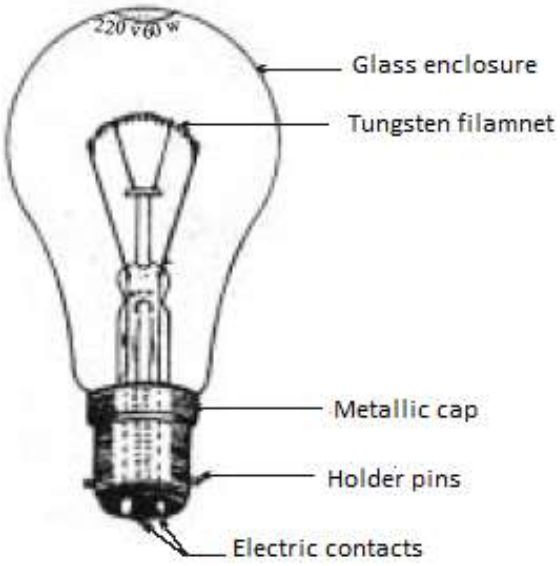


Fig. 3.13 : Incandescent lamp

The other category of lamps are the fluorescent lamps. A filament is tightly held in one end of a glass tube while another electrode is fixed at the other end. The tube is filled with some amount of mercury which starts to vaporize when heat is passed through the filament and makes it hot. An electric discharge takes place through the mercury vapours from one end of the tube to the other. It gives out visible and ultra violet light. The ultra violet light is reflected by the fluorescent coating on the inside surface of the glass tube and causes it to glow brilliantly. The colour of the light radiated depends upon the vapour content present in the tube. The advantage is that the fluorescent lamps produce a bright light with little heat which makes it highly efficient.



CHECK YOUR PROGRESS

Q.3. Find True or False.

a) DC has no variation in magnitude despite variation in time.

b) AC is a special wave form that has no waveforms continually varying in direction with respect to time.

c) Electricity is produced by generators at power stations and then distributed by a vast network of transmission lines to industry and for domestic use.

3.6 MEASUREMENT METHODS OF ELECTRICAL PARAMETERS



Measurement provides the magnitude of an electrical quantity obtained by specific equipment in a working condition.

Testing and measurements play important roles while designing, evaluating, maintaining and servicing electrical equipments. Testing is carried out to determine the present condition of equipment. Measurement provides the magnitude of an electrical quantity obtained by a specific equipment in a working condition. To detect and measure electrical quantities such as current, voltage, resistance or power etc. it is essential to transform an electrical quantity or condition into a form which is visible to the observer. This is done by using instruments popularly called meters. These provide indications of the magnitudes of quantities under test.

The indications obtained during measurement of electrical quantities may either be by the position of a pointer moving over a graduated scale or in the form of a decimal number. Depending upon this procedure of indicating electrical quantities, measurement equipment may be classified as

- Analog and
- Digital.



Analog meters have a display formed by a dial.

Analog instruments : Analog meters have a display formed by a dial. The indication of measurement is provided by a needle which points to a number on a scale placed over the dial. These meters have function and range controls which allow the user to select the kind of measurements to be made like voltage, current, power etc. These are generally low cost equipments suitable for applications where accuracy is not a criterion.

There are two types of scale—linear and non-linear. A **linear scale** is shown in Figure 3.14 (a), where the divisions or graduations are evenly spaced. The voltmeter shown has a range 0–100 V, i.e. a full-scale

deflection (f.s.d.) of 100 V. A **non-linear scale** is shown in Figure 3.14 (b). The scale is cramped at the beginning and the graduations are uneven throughout the range.

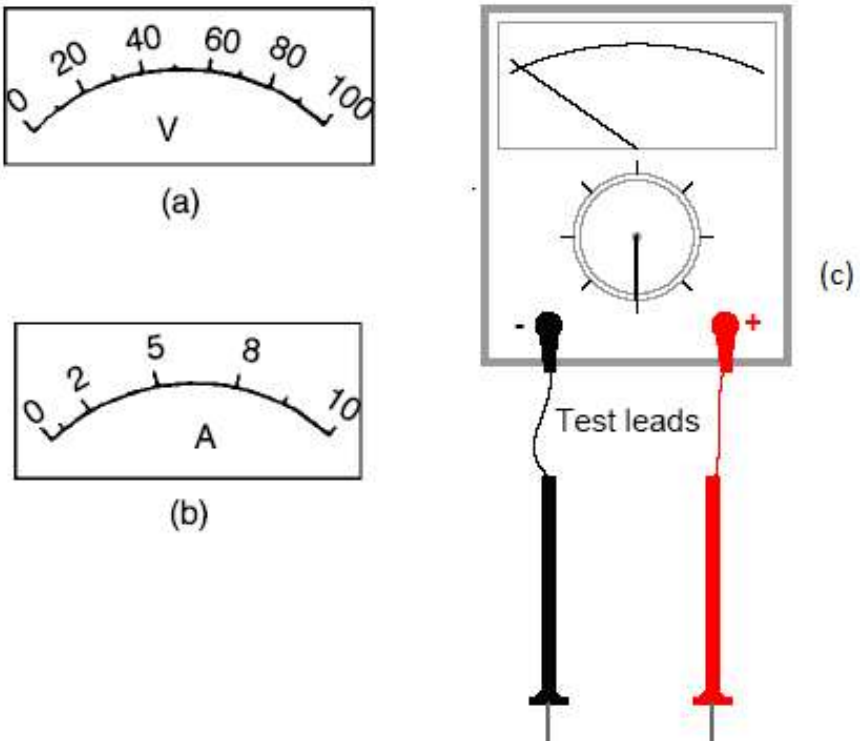


Fig. 3.14 : Dial types of an analog meter

Analog devices are constituted by the following components:

a. **A deflecting or operating device**: A mechanical force is produced by the current or voltage which causes the pointer to deflect from its zero position.

b. **A controlling device**: The controlling force acts in opposition to the deflecting force and ensures that the deflection shown on the meter is always the same for a given measured quantity. It also prevents the pointer always going to the maximum deflection. There are two main types of controlling device—spring control and gravity control.

c. **A damping device**: The damping force ensures that the pointer comes to rest in its final position quickly and without undue oscillation. There are three main types of damping used—eddy-current damping, air-friction damping and fluid-friction damping.

Digital instruments : Digital meters are suitable for applications where precision is an important factor. These have no observational errors, high input resistances that remain constant in all ranges etc. The primary basis of working of digital meters is the use of binary numbers to represent measured quantities. The quantity under measurement is converted to a digital form by a block called analog to digital converter (ADC). The digital quantity, after appropriate modification and alterations, is presented over a LCD (Liquid Crystal Display) or LED (Light Emitting Diode) panel. Some digital meters have auto-ranging facility through which the scale of measurement is adjusted without any role played by the user.

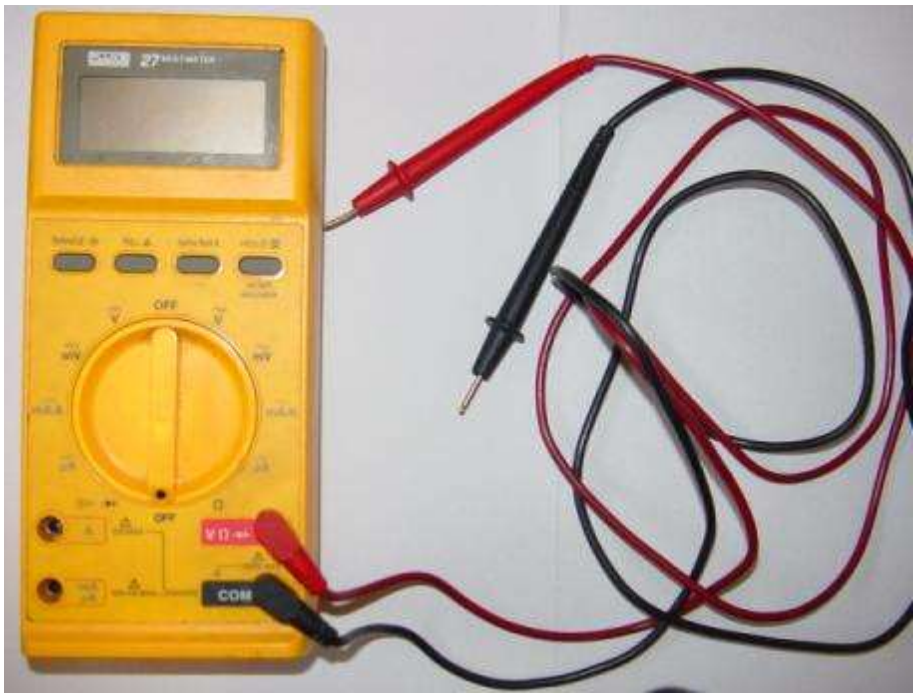


Fig. 3.15 : Digital Multimeter

Another classification of electrical measurement instruments can be made with respect to the construction arrangements of the various parts of the instruments. The following are the broad classes:

- Moving Coil
- Moving-iron and
- Moving-coil rectifier

A moving-coil instrument, which measures only d.c., may be used in conjunction with a bridge rectifier circuit (Figure 3.16). It has a linear

scale dial, uses hairspring method of control and uses eddy current method of damping. It has high sensitivity, well shielded from stray magnetic fields and lower power consumption.

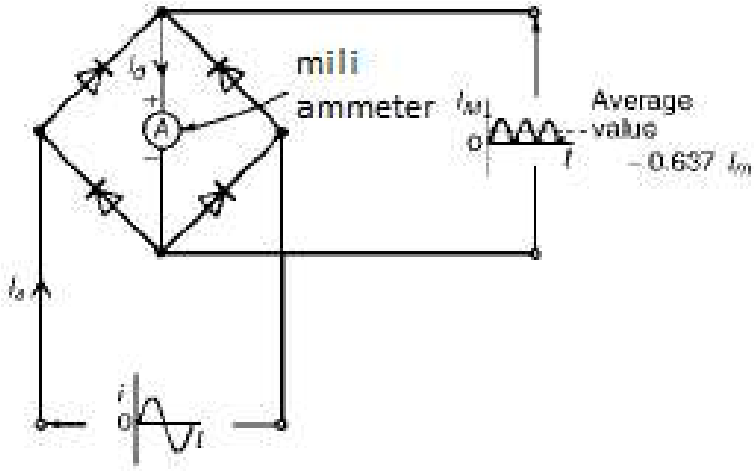


Fig. 3.16 : A moving-coil instrument

A moving iron instrument, on the other hand, is suitable for direct and alternating currents and voltages (reading in rms value) measurements. These are attraction type or repulsion type. These have robust construction, relatively cheap price, measurements in frequency range 20–100 Hz and reads RMS values correctly regardless of supply wave-form. Its main disadvantages are non-linear scale, affected by stray magnetic fields, hysteresis errors in dc circuits, liable to temperature errors and variation in readings due to fluctuation in frequency.

But moving coil rectifier instruments can handle both alternating current and voltage (reads average value but scale is adjusted to give RMS value for sinusoidal waveforms) in a frequency range of 20–100 kHz and gives a read-out in a linear scale.



CHECK YOUR PROGRESS

Q.4. Find True or False.

a) Analog meters have a display formed by a dial.

b) There are two types of scale—linear and non-linear.

c) Digital meters are suitable for applications where precision is an important factor.

d) A moving iron instrument is suitable for direct and alternating currents and voltages.

3.7 MEASURING INSTRUMENTS OF ELECTRICAL PARAMETERS

Electrical quantities like voltage, current, power, resistance etc are measured for specific applications with equipment designed for the purpose. The most basic device that can be used to measure both voltage and current is the galvanometer. The galvanometer consists of a coil wrapped around a magnet, to which a pointer is attached. When electric current passes through the coil, an opposing magnetic field is created which makes the coil move. The moving coil compresses a spring attached to it, which subsequently deflects the pointer attached to it. The galvanometer can be suitably modified to measure both voltage and current. Analog meters are variations of galvanometers while digital multimeter (DMM)s can be used to obtain digital read outs of voltage, current and other electrical quantities.



Voltage is measured using a voltmeter.

Voltage Measurement : Voltage is measured using a voltmeter. Signals are input to the voltmeter through two leads (generally red for positive and black for negative), and then the value measured is displayed. While measuring voltage across a resistance, the voltmeter must be connected in parallel to the resistance (Figure 3.17). There are two primary reasons behind it.

First, is to ensure that the voltage across the device under test (DUT) is the same as the voltage across the voltmeter. Second, the voltmeter has a in-built resistance. When connected in parallel across a resistance to measure voltage across, the voltmeter will generate an equivalent resistance closer to the resistance under test. As a result the voltmeter will capture a reading of the voltage drop which is approximately equal to the voltage drop that takes place across the resistance.

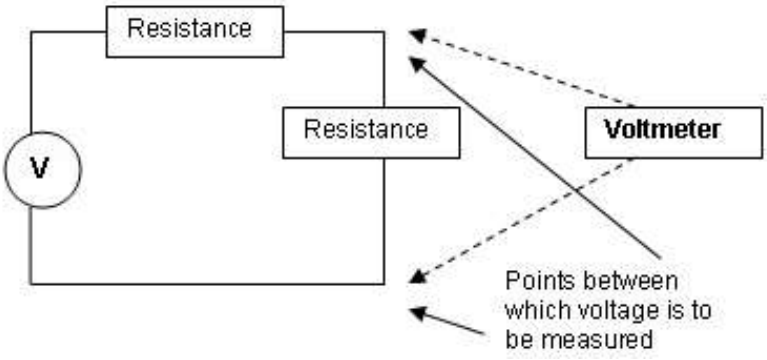


Fig. 3.17 : Measuring voltage across a resistance

A voltmeter is formed by the addition of a high resistance in series with a galvanometer coil. This modification makes the reading of the galvanometer proportional to the voltage being measured. It increases the internal resistance of the voltmeter. Typical values of 10 Mega ohms are used. An ideal voltmeter should have infinite internal resistance so that no current flows through it and create a difference in measurement. In actual voltmeters, this effect cannot be exactly eliminated but reduced by adding high resistance in series with the galvanometer.

Current is measured using an ammeter.

Current Measurement : Current is measured using an ammeter. While measuring current the ammeter must be connected in series (Figure 3.18). This is because an ammeter measures current flowing through it. Secondly, to ensure that same current flows through the device under test (DUT) and the ammeter.

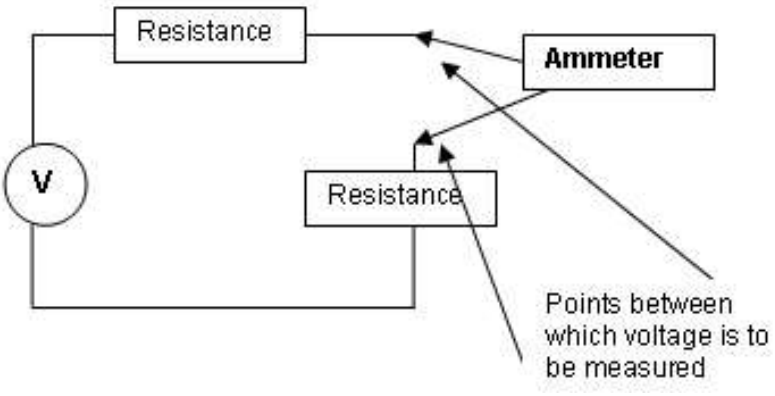


Fig. 3.18 : Measuring current

An ideal ammeter should have zero internal resistance. The reason is that it causes no voltage drop across itself while measuring current. A

galvanometer acts as a natural ammeter. It can perform the role of an ammeter without any modifications with the certain calibration.

Power measurement : Power is measured using a wattmeter. A wattmeter used for measuring electrical power supplied to a coil in a circuit is configured as shown in Figure 3.19.

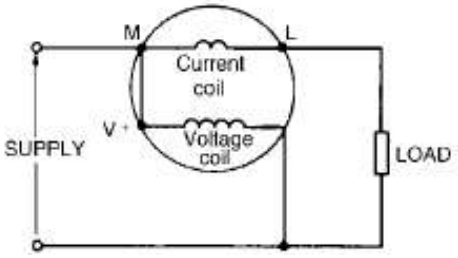


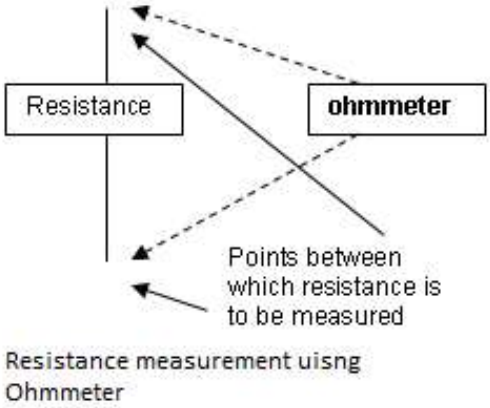
Fig. 3.19 : Measuring power

The instrument has two coils:

i. A current coil, which is connected in series with the load, like an ammeter, and

ii. A voltage coil, which is connected in parallel with the load, like a voltmeter.

Resistance measurement : For measurement of resistance, ohmmeter is required. The ohmmeter is connected in parallel across a resistance for making the measurement. The resistance should be isolated from the supply sources or circuits while making measurement using a ohmmeter. In the ohmmeter the energy required to make measurements is supplied by a self-contained source of voltage, such as a battery. Also, the ohmmeter's initial reading should be made zero before making the measurement.



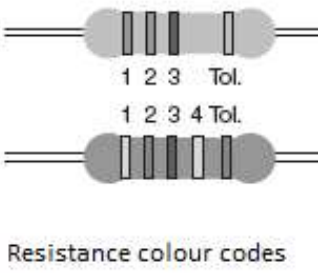


Fig. 3.20 : Measuring resistance

Resistances can also be measured from visual inspection of the colour codes printed. Two other resistance measurements include insulation resistance and earth resistance.

Insulation resistance is usually measured by a special purpose ohmmeter called an **insulation resistance tester** or megger.

Insulation Resistance : Insulation resistances are of very high order usually around mega ohm range. These are usually measured by a special purpose ohmmeter called an **insulation resistance tester** or megger. A capacitor generates very low insulation resistance between its plates such that conventional meters are unable to determine it correctly. Insulation resistance measurement becomes essential while checking transformers, windings across inductive coils and conductors etc. Plastic-impregnated glass fibre board, or SRBP (synthetic resin bonded paper), ceramic (like porcelain) or vitreous (like glass) materials etc have very high insulation resistances and are suitable for fabrication of circuit boards.

Earth Resistance : Grounding enables optimum electrical continuity between conducting objects and earth.

While installing electrical equipments, it is important to have proper connection with ground to ensure continuous flow between the electric appliance and earth. Grounding enables optimum electrical continuity between conducting objects and earth. Effectively grounded equipment is permanently connected to earth through a ground connection with sufficiently low impedance. The connection should have sufficient current- carrying capacity so that a ground fault cannot cause dangerous voltage buildups.

Frequency measurement : Frequency of an applied signal can be measured using a Cathode Ray Oscilloscope (CRO). A CRO is a device that provides a visual means of measuring a signal with display of voltage graphs versus time. The display shows voltage on the vertical axis and time on the horizontal axis. The user can control the scale of both the time and the voltage axes. Most CROs can accept a minimum of two channels and display the inputs simultaneously. The display modes can be both mono and dual meaning selection of one and two channels respectively. This is useful because it allows a comparison of the two signals.

When a sinusoidal signal is applied, then the vertical position is proportional to the voltage at any instant. If an input sinusoidal signal repeats every half millisecond– a frequency of 2kHz – a display as in Figure 3.21 is obtained.

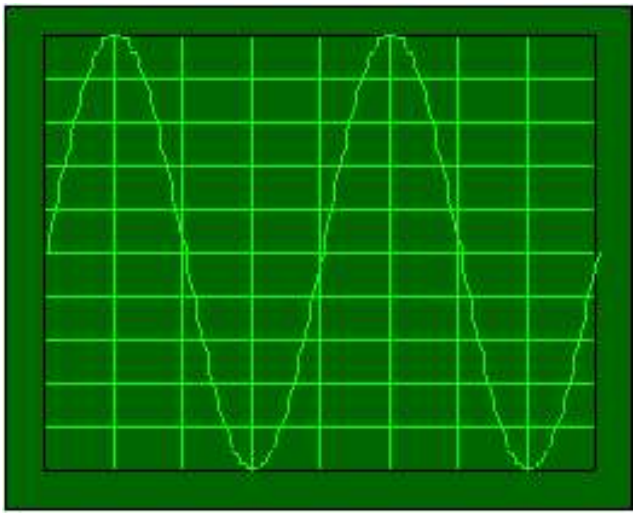


Fig. 3.21 : CRO display of a 2 KHz sinusoidal signal

Readily available frequency meters are also available to the technicians and engineers. Frequency meters are available in two forms: pocket frequency meters with a measurement range from 10 Hz to GHz range usually used by professionals and laboratory frequency meters (tabletop) with a similar range are used for academic purposes.



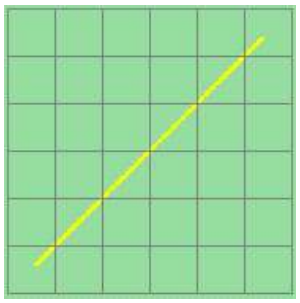
Fig. 3.22 : Table top frequency meters

Phase measurement : CROs can be used to measure frequency and phase as well. Sinusoidal voltages are applied to the horizontal and vertical deflection plates of the CRO, they have the form

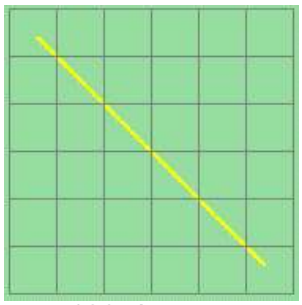
$V = A\sin(2\pi ft + \varphi)$, where A is the amplitude, f is the frequency and φ is the phase.

Phase differences are found from the patterns as below:

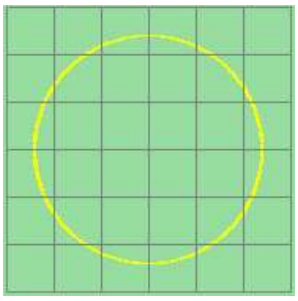
a) 0, 90 or 180 :



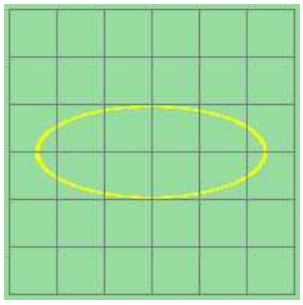
0 degree



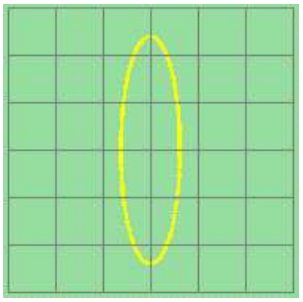
180 degree



90 degree (amplitude of x = amplitude of y)



90 degree (amplitude of x > amplitude of y)



90 degree (amplitude of x < amplitude of y)

b) General case : The following circuit can be used to generate a phase shifted signal from the original signal applied from a function generator and observe the Lissajous figure produced on the CRO. Whether X or Y leads in phase is unknown unless the sense of rotation of the circle or the ellipse is known. Clockwise rotation means y leads x while anticlockwise rotation indicates x leads y (Figure 3.23).



Fig. 3.23 : Phase meter used to measure domestic power consumption

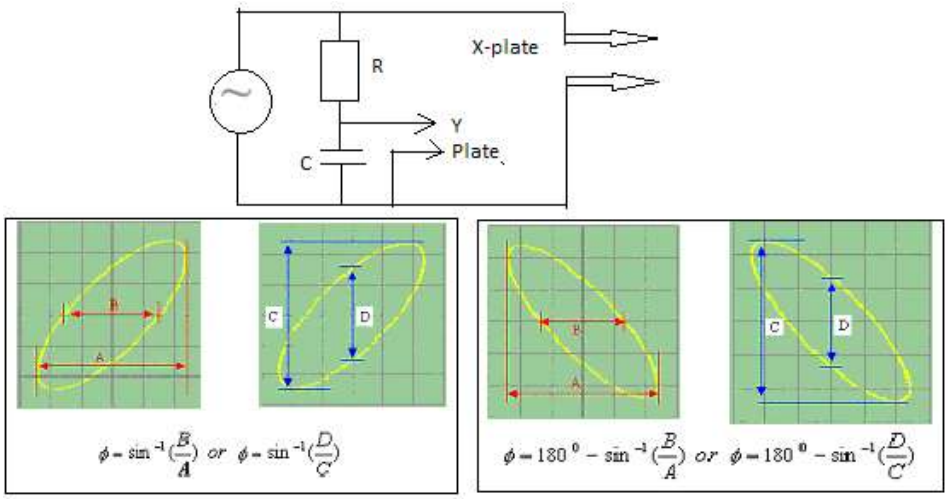


Fig. 3.24 : Lead- lag diagram for phase measurement

Phase meters are available to determine electrical energy consumed by consumers as part of a distribution system. Phase meters used as consumer appliance are diagnostic and measurement tools that continuously monitor smooth supply and delivery of electricity. These devices run continuously, measuring both voltage and the ensuing current being supplied and provide an accurate reading of overall power consumption.

Standard models have an aluminum dial is connected to the read-out screen to show the amount of power used at any given time by monitoring the number of revolutions that the disk makes per hour. The resulting numbers on a phase energy meter are displayed either in kilowatt hours (kWh) or megajoules (MJ) to determine the total usage for that structure.



CHECK YOUR PROGRESS

Q.5. Find True or False.

a) The most basic device that can be used to measure both voltage and current is the galvanometer.

b) Current is measured using an ammeter.

c) Power is not measured using a wattmeter.

d) Insulation resistances are of very low order.

e) Grounding enables optimum electrical discontinuity between conducting objects and earth.



3.8 LETS SUM UP

- When electric current flows through a wire, a magnetic field is developed around the wire till the flow of current stops
- There are various types of electric bell, including the single-stroke bell, the trembler bell, the buzzer and a continuously ringing bell. The working of all these bells depends on the pull applied by an electromagnet on a soft iron armature.
- A relay is similar to an electric bell except that contacts are opened or closed by operation instead of a gong being struck.
- Lifting magnets are formed by large electromagnets. These are used in iron and steel works for lifting scrap metal.
- Whereas a transmitter or microphone changes sound waves into corresponding electrical signals, a telephone receiver converts the electrical waves back into sound waves.
- An electro motive force (e.m.f). is generated in the coil (from Faraday's Laws) which varies in magnitude and reverses its direction at regular intervals. The waveform generated due to the movement of the magnet between the coils is a sinusoidal.
- In an electric motor, conductors rotate in a uniform magnetic field.
- Electric Stoves or Heaters are common domestic appliances that rely on the heating effect of electricity.
- The arrangement of an electric iron consists of a chromium alloy wire wounded in a spiral form on a mica sheet. The mica layer acts as an electrical insulator while allowing heat generated to flow through it.
- In case of an electric kettle, the heating element formed by a nickel chromium alloy is placed at the bottom of the arrangement.

- Water heaters are required for continuous supply of heated water for domestic and other applications.
- There are two main categories of electric lamps. The first one is called the incandescent lamp and the second one is known as the fluorescent bulb.
- Testing and measurements play important roles while designing, evaluating, maintaining and servicing electrical equipments.
- Analog meters have a display formed by a dial. The indication of measurement is provided by a needle which points to a number on a scale placed over the dial.
- Digital meters are suitable for applications where precision is an important factor. These have no observational errors, high input resistances that remain constant in all ranges etc. The display is in numbers
- Electrical quantities like voltage, current, power, resistance etc are measured for specific applications with equipments designed for the purpose. The most basic device that can be used to measure both voltage and current is the galvanometer. The galvanometer consists of a coil wrapped around a magnet, to which a pointer is attached.



3.9 FURTHER READINGS

1) Thareja B. L., *Electrical Technology*, Khanna Publishing.
2) Hughes E., Smith I. M., *Electrical Technology*, ELBS.



3.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : a) True, b) True, c) False.

Ans. to Q. No. 2 : a) True, b) False, c) False.

Ans. to Q. No. 3 : a) True, b) False, c) True.

Ans. to Q. No. 4 : a) True, b) True, c) True, d) True.

Ans. to Q. No. 5 : a) True, b) True, c) False, d) False, e) True.



3.11 MODEL QUESTIONS

Q.1. What is electro-magnetism? Show how it is developed.

Q.2. Write briefly about electric bell, relay and telephone receiver and show how electro-magnetism is related with these appliances.

Q.3. Describe briefly the working of an AC generator.

Q.4. Describe the working of the following appliances: electric bulb, electric heater, room heater, electric iron and water heater.

* * * * * * * * * *

UNIT 4 : SAFETY REQUIREMENT

UNIT STRUCTURE

4.1 Learning Objectives

4.2 Introduction

4.3 Safety and Precaution

- 4.3.1 General steps to ensure safety
- 4.3.2 Safety Sign
- 4.3.3 Electrical Safety
- 4.3.4 Extension Cord
- 4.3.5 Rules and Regulations

4.4 Hazards of Electricity

- 4.4.1 Fire Hazard
- 4.4.2 Electric Shock

4.5 First Aid

- 4.5.1 First Aid Kit
- 4.5.2 First Aid in Common emergencies

4.6 Indian Electricity Rules and Indian Electricity Act

4.7 Let Us Sum Up

4.8 Further Readings

4.9 Answers to Check Your Progress

4.10 Model Questions

4.1 LEARNING OBJECTIVE

After going through this unit, you will be able to:

- discuss safety and precaution
- explain the hazards of electricity
- explain about first aid
- discuss about Indian Electricity Rule and Indian Electricity Act.

4.2 INTRODUCTION

In the previous unit you have been introduced to electromagnetism. In this unit you will be mainly introduced to the rules and regulations for

safety requirement. First the unit will describe the basic safety and precaution that are to be maintained while handling electricity. Then you are going to be familiarised with the hazards of electricity and finallythe unit discuss the Indian electricity rules and Indian electricity act. So let us now just begin with the topic of safety and precaution.

4.3 SAFETY AND PRECAUTION

Safety is a primary concern for all of us. Whether at home or in workplace safety is a must. Electricity is very useful and is essential in our everyday life. But electricity can be dangerous if proper safety precautions are not taken and it can even lead to death. Awareness and continuous effort of all concerned are required to ensure safety. Lack of safety or breach of safety norms may lead to undesirable event like accident, fire etc which can lead to damage or harmful impact on life and property.There are always certain most suitable steps and procedures to perform and complete a job satisfactorily and safely. Haphazard way of doing a job is unsafe and can lead to undesirable events.

Safety procedure is a set of steps that are to be followed to ensure safety. It may consist of a list of **Do**s and**Don't**s. There are certain general steps that are always relevant.

4.3.1 General Steps to Ensure Safety

Some General steps relevant in ensuring safety are:

1. Always be careful. A careless person is a potential danger to himself, his fellow workmen and to the environment.
2. Never work with tools, equipment or electricity when you are sick or dizzy or donot feel well
3. Working with barefoot should be avoided. Wear shoes with good insulating sole.
4. Know the locations of Mains of electrical supply and switches, fire extinguisher and emergency exit, if any. One should also have an idea about the most valuable things to be removed first in case of emergency.

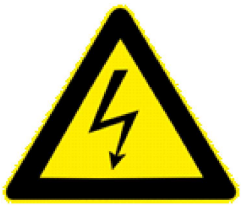
5. Before starting the work collect information necessary to complete the work. At times it is important to ensure that you are authorized to do the work.
6. Know the possible hazards associated with the work and steps to be initiated in case of emergency.
7. You should not tamper with anything unnecessarily and without any specific purpose. You must not play with tools, accessories, equipment etc.
8. Do not put sharp edged tools, accessories or spare in pocket.
9. Avoid using tools like knife, screw driver, hand saw etc that are without handle. Be careful in handing over such tools to someone to avoid injury.
10. Battery charging room should be well ventilated and should have sufficient light.
11. Ensure good working environment. Clean working table, adequate amount of light and air circulation and proper ventilation are necessary. The environment should be free from dust, noise, smoke, vibration etc.
12. Very old or worn out tools, parts etc should be disposed of. The tendency to try to use very old or worn out tools or parts or components whose intended life has expired should be avoided.

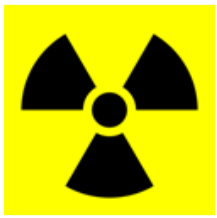
4.3.2 Safety Sign

Safety signs are standard symbols, pictures or signs. They are displayed to inform about status of some items or locations. The basic purpose is to prominently display what to DO and what NOT TO DO. Safety signs are very important items in ensuring electrical safety. There are many Safety Signs used in electrical installations and works. It is very important for an electrician to get acquainted with the safety signs. Some common safety signs are given below.


Danger Sign


Caution Sign


High Voltage Sign


Radiation Sign

One can easily get the set of commonly used safety signs in poster form from various sources.

4.3.3 Electrical Safety

Some general rules pertaining to electrical safety are

1. The electrical power supply connection also called the service connection to the premises should be properly installed by licensed persons. Wiring should be done using good quality wires of necessary rating. One should always use items and equipment of reputed manufacturer.
2. Wire joints demands special care. Improper wire joints and loose connections are potential hazards and may lead to unnecessary heating of wires and cables, sparking and ultimately to fire. Hence wire joints should be avoided as far as possible. When it is necessary the wire should be joined preferably using lugs and should be securely tightened using screw and nut and should be insulated and taped properly. One has to be more careful in joining wires of different metals e.g. joint of copper wire and aluminum wire as joints of dissimilar metals are more problematic.
3. It is mandatory and essential to install good electrical earthing in every premise. Earthing should be properly installed and should be tested by licensed persons.
4. The main switch fuse used should be of appropriate rating. All adult persons in the premises should know how to switch off the main switch in the event of emergency.
5. The electrical system should be periodically inspected thoroughly at least once in every year.

6. Sparks or flashes, abnormal sound, odor of insulation burning, frequently blown fuse or circuit breaker that trips frequently, warm or hot wires, or faceplate of outlets etc are danger signals and are indication of some defects. The defects should be rectified immediately.
7. Outlets and plugs that are old or worn out or has loose pins or are partially damaged or burnt or gets discolored because of heat etc should be replaced immediately. Loose and bad quality outlet and plugs can be dangerous.
8. Never disconnect a plug by pulling flexible cable particularly when the switch is on.
9. Always use electrically insulated tools. It is essential that you use good quality proper tools for a particular job.
10. Sudden change and frequent on off can result in power surges that can damage equipment, particularly the sensitive electronic devices like computer etc. and this practice should be avoided.
11. One must have clear idea about personal protective equipment like electrically insulated shoes, hand gloves, insulating mats, safety glasses etc and while working in an area of potential electrical hazard one must use personal protective equipment appropriate for the specific work.

4.3.4 Extension Cord

Extension cords are very useful. It takes electrical power to places where outlets are not available. However certain precautions are essential in using extension cords. Accidents and injuries may occur from the misuse of extension cord.

1. Extended cords are for temporary use. Frequent use for the same job in the same location should be avoided and in such cases a power outlet should be installed.
2. Overloading of extension cords can be dangerous. Overloading heats the cord, the insulation melts because of heat and short circuit, electric shock may result.

3. Only three wire type (live, neutral and ground) extension cords should be used. Two wire extension cords without ground wire connection should be avoided.
4. Common defects in extension cords are loose parts, deformed and missing pins, damaged insulation, improper taping of joints, pinched or crushed outer jacket etc. Before using an extension cord, one should thoroughly examine the same and should rectify the defects, if any.
5. Joints in extension cords should be avoided and must be properly taped by insulation tape in case it is unavoidable.
6. Extension cords should not be run through places where it may get damaged. On should be careful while running extension cord through walls, doors, windows, sharp corners etc.
7. Wires and cords of portable equipment must not be used to lift or to lower or to drag the equipment.
8. Avoid using electrical extension cords in wet or damp place. Electrical extension cord must not be used in locations where there is water.

4.3.5 Rules and Regulations

There are laws, regulations, rules, norms and guidelines for carrying out the tasks involving electricity. These are specified by government and non-government agencies and organizations of local, state level, national level and international level. Examples are: Indian Electricity Act, Indian Electricity Rules, Regulations and Manuals of supply authority like Assam State Electricity Board (ASEB), Bureau of Indian Standards (BIS) regulations pertaining to electrical installations, National Electric Code (NEC) of America, British Standards (BS) of Institute of Electrical Engineers (IEE) of Great Britain now known as Institute of Engineering and Technology (IET). These are documents available in book form.

Indian Electricity Act governs the relations between the consumer and supplier of electrical energy. Permissions for the

generation, distribution and supply of electrical energy, are given as per this Act. The Act defines powers and obligations of such agencies and also the obligations of consumers.

The Indian Electricity Rules are framed as per provisions of Indian Electricity Act. These rules regulate the supply, transmission, generation and use of electricity. These rules specify how the tasks related to electricity are to be performed and they cover aspects like construction, installation, maintenance, transmission, distribution, generation, safety and use of electricity. Everyone has to obey these rules.

An important reference document is British Standard BS 7671 of IEE which contains wiring regulations and defines how works relating to electrical installations are to be carried out providing safety and proper functioning for intended use.

It is essential and mandatory that the house wiring tasks are performed as per the relevant rules and norms.



CHECK YOUR PROGRESS

Q.1. Fill in the blanks-

a) One should not use tools like knife, screw driver, hand saw etc that are without _____.

b) Safety signs are very important items in ensuring _____.

c) Extension cords without _____ connection should be avoided

d) BIS stands for _____.

4.4 HAZARDS OF ELECTRICITY

Electricity can be dangerous if proper adequate precautions are not taken. A large number of accidents and fire resulting from hazards of

electricity causing death of persons and loss of property are reported every year. The hazards associated with electricity are electric shock, electric burn, electric fire etc.

4.4.1 Fire Hazard

Fire is combustion of a substance with generation of heat and light. Basically it is a chemical process in which oxygen chemically combines with the burning substance producing heat, light and by-products like ash. When a substance gets heated, the temperature gradually increases. Above certain temperature oxidation of the hot substance begins and fire starts producing heat and light. Heat, fuel and oxygen are essential for a fire to continue and a fire ceases to exist when any one or more of them are absent. Fire fighting strategy consists of removing any one of the essential elements of fire, namely fuel, heat or oxygen. Ordinary fire resulting from burning of wood, paper, cotton cloth, etc can be extinguished by throwing water on the fire. By its cooling effect water removes the heat necessary to sustain such fire and fire ceases to exist. Fire resulting from burning of petroleum products like petrol, kerosene or chemical substances which reacts with water cannot be extinguished by water and special fire extinguishing substances and techniques are required. Old or faulty wiring or equipment, overloading of circuits, loose connection, sparking etc can cause electrical fire. Overloading heats the wires, insulating material melts because of heat and fire starts. Water is a conductor of electricity and gets converted to vapour when it comes into heated wires or insulating material. Throwing of water on electrical fire can hence be dangerous and involves risk of electric shock. One must not throw water on electrical fire. In case of electrical fire the electrical supply should immediately be disconnected. Throwing of dry sand is helpful and fire extinguisher is necessary to extinguish the electrical fire.

4.4.2 Electric Shock

A person gets an electric shock when he comes in direct contact with live wire or voltage source and current passes through him. Severity of shock depends on the amount of current, path of current through the body, duration of contact and area of contact. The current, again, depends on the voltage and body resistance. Body resistance varies from person to person and depends on the condition of skin. With dry skin electrical resistance of the human body is of the order of mega ohms and with wet skin it may be as low as kilo ohms. The electrical resistance of internal human body is smaller than kilo ohm. The minimum current for electric shock is about 1 milli ampere which gives a mild electric shock that result in tingling sensation. Severe electric shock involving more current may results in muscular contraction, electric burn, respiratory paralysis and even death. The victim may become unconscious and his breathing may be slow or stop. Immediate attention and care is necessary to save the victim. The victim may remain stuck to the source of electricity. The most important thing is to immediately turn off and disconnect the power supply. While dealing with a victim of electric shock one should be very careful and the following points are particularly important.

1. Do not touch the person without being sure that he is not in contact with live conductor or apparatus or source of electricity. In case the victim of electrical shock is still in contact with live apparatus or conductor, anyone touching him will also get electrical shock.
2. Immediately switch off the Mains switch and disconnect electrical supply.
3. Separate the victim. Do not touch him/her with bare hands. Use non conducting materials like dry wood, insulated hand gloves etc.
4. Once the victim has been separated, check if he is breathing. If breathing has stopped or is slow, administer artificial

respiration to restore or assist breathing. Continuous direct mouth to mouth artificial respiration is necessary till the breathing condition improves.

5. If the victim has burns, do not break the blisters. Rinse the burn with cool running water and cover the burn with a dressing.
6. Get emergency medical help as soon as possible.

4.5 FIRST AID

Whether it is home or workplace, there must be First Aid kits so that immediate actions can be taken in response to accidents and emergencies that may occur. First Aid kits are a must at workplace. In the event of an accident, injury or emergency First aid is to be administered so that the situation does not worsen till proper medical care is reached.First aid is the provision of initial care for an illness or injury. It is usually performed by a lay person to a sick or injured casualty until definitive medical treatment can be accessed. Certain self-limiting illnesses or minor injuries may not require further medical care past the first aid intervention. It generally consists of a series of simple and, in some cases, potentially life-saving techniques that an individual can be trained to perform with minimal equipment. The main aims of first aid can be summarised in the three key points given below:

- **Preserve life–** the overriding aim of all medical care, including first aid, is to save lives.
- **Prevent further harm–** also sometimes called prevent the condition from worsening, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed from becoming dangerous.
- **Promote recovery–** first aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

First aid training also involves the prevention of initial injury and responder safety, and the treatment phases.

4.5.1 First Aid Kit

A basic minimum First Aid Kit should contain the following items

- Adhesive strips and tape for dressing
- Sterilized Cotton, gauge pad and roll, cotton swab for cleaning wounds
- Bandage materials, band aid, triangular bandage
- Antiseptic solution
- Antibiotic ointment
- Petroleum jelly
- Eye pads for emergency eye cover
- Thermometer
- Sterile / saline water for cleaning wounds and for eye wash
- Scissors, tweezers, needles and safety pins
- Soap and sanitizer for washing and cleaning.
- Syringe, medicine cup and spoon
- Torch light with extra batteries, candle and match
- Emergency Phone numbers of doctors, emergency services, ambulance etc.
- A First Aid Manual and poster display.

The First Aid Kit should be checked regularly and all items should be kept in good ready to use condition. Location of the First kit should be easily accessible and everyone should be familiar. There may be suitable poster display near the First Aid kit. Large organizations have separate room for administering First Aid, more additional facilities and responsible persons trained in First Aid Techniques.

4.5.2 First Aid in Common Emergencies

Some of the very common and possible injuries and illness that may occur at workplace are burn, bleeding and cut, eye injury, fall, electric shock, unconsciousness, breathing problem etc. and First Aid for these emergencies should be available.

A **minor burn** should immediately be cooled by applying cold running water or by immersing in cold water. Use of ice is not recommended as it may cause frostbite and can damage the skin. Never break blisters as broken blisters easily catches infection. The burn should be covered by a sterile bandage. In case of severe burn, removal of burnt clothing and use of cold water to cool the burn are not recommended. For severe burn, immediate proper medical care is essential and the area of burn may be covered by sterile loose cool bandage or cotton cloth till proper medical care is reached. Anti burn ointment which is now available may also be used.

In case of a **cut or bleeding injury** the bleeding is to be stopped first by applying pressure and then by using a bandage or clean cloth. Once bleeding stops, the wound should be cleaned by clean sterile water and an antibiotic cream or ointment should be applied at the wound. The wound should be covered by bandage and further treatment with consultation of doctors should be taken. It is always better to take anti titanus injection.

Eyes are delicate and immediate medical treatment should be taken in case of **eye injury**. There is a tendency to rub the eye in case of an injury. Never rub the eye as rubbing can cause further damage. In case of eye irritation or minor injury resulting from dust, foreign particle in the eye or from chemical burns or fume etc rinse the eye with clean water.

To administer First Aid to victims who have become unconscious because of **fall**, electric shock or other injury, the most important point is to ensure breathing. Oxygen is essential for

survival.Without air or oxygen permanent damage or even death may result. Suffocating condition may be dangerous and hence it is to be ensured that the victim gets open air for breathing. In case the victim is not breathing oris breathing slowly, the victim is to be assisted by artificial respiration. Mouth to mouth direct artificial respiration is an effective method in such situations and the procedure (taken from safety manual of Bangalore Electricity Supply Company Limited with website www.bescom.org) is given below.

Direct Artificial Respiration (Mouth to mouth method) **:**

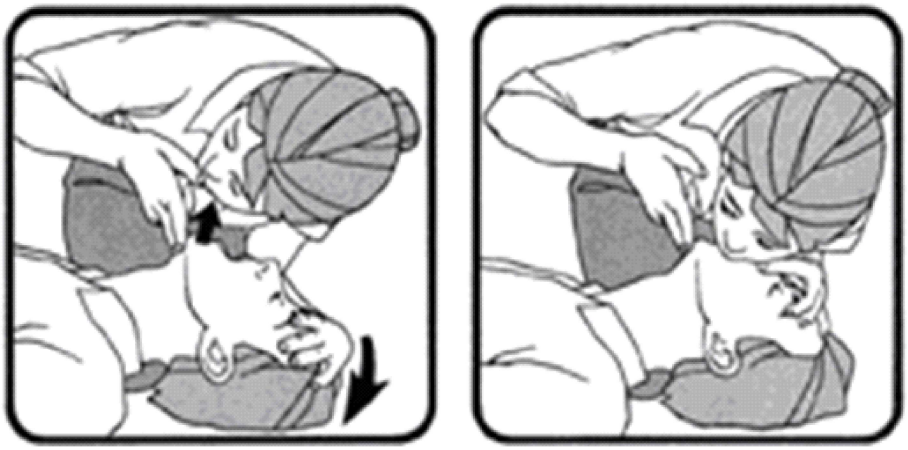


Fig. 4.1 : Direct artificial respiration

a) Place the victim on back immediately
b) Clear the throat of water, mucous, toys, coins or food.
c) Tilt the head back as far as possible
d) Lift jaw to keep the tongue out of air passage
e) Pinch nostrils to prevent air leakage when you blow.
f) Blow until you see the chest rise
g) Listen for snoring and gurgling signs of throat obstruction
h) Repeat the blowing 10-20 times a minute

In case of infant or small children tilt the head fully back, surround the mouth and nose completely with your mouth. Blow with enough force to produce a visible rise in the victim's chest and no more. Repeat every 3 seconds.

Continue direct artificial respiration until the victim breathes for himself or until expert help is obtained.



CHECK YOUR PROGRESS

Q.2. Fill in the blanks:

a) The burn should be covered by a _____ bandage.

b) Use of _____ is not recommended to cool severe burn.

d) Rubbing of injured eye is _____.

e) A victim not breathing is to be assisted by _____.

4.6 INDIAN ELECTRICITY RULES AND INDIAN ELECTRICITY ACT

THE INDIAN ELECTRICITY ACT governs the matter relating to the supply and use of electrical energy. In our country all aspects like generation, distribution, transmission and supply, licensing, utilization, safety, offences etc. relating to the supply and use of electricity are as per this Act. Indian Electricity Rules are framed under the guidelines of Indian Electricity Act. For application of the principles of the IE act in the real life, IE rules are needed.

The Act is passed by the Government and the rule is made to implement and follow the Act. Few points about the rules are noted below-

- The main purpose of these rules is to ensure the safety of human beings, animals and property. Other purposes of these rules are smooth, safe and efficient utilization of electrical energy. The responsibilities of an electrician & others including the supplying authority and the consumer include conforming of the norms and rules as specified by Indian Electricity rules as per Indian Electricity act.
- As per Indian electricity rules all electric supply lines and apparatus shall be of sufficient ratings for power, insulation and estimated fault current and of sufficient mechanical strength, for the duty which

they may be required to perform under the environmental conditions of installation, and shall be constructed, installed, protected.

- The relevant code of practice of the Bureau of Indian Standards including National Electrical Code should be followed.
- The material and apparatus used shall conform to the relevant specifications of the Bureau of Indian Standards
- As per Indian electricity rules it is the responsibility of the supplier that he ensures all electric supply lines, wires, fittings andapparatus belonging to him or under his control, which are on a consumer'spremises, are in a safe condition and in all respects fit for supplying energy andthe supplier shall take due precautions to avoid danger arising on such premisesfrom such supply lines, wires, fittings and apparatus.
- The consumer shall, as far as circumstances permit, take precautions forthe safe custody of the equipment on his premises belonging to the supplier. It is one of the responsibilities of wiremen/ electrician to create awareness.
- The supplier shall provide a suitable cut-out in each conductor of everyservice-line other than an earthed or earthed neutral conductor or the earthedexternal conductor of a concentric cable within a consumer's premises, in anaccessible position. Such cut-out shall be contained within an adequatelyenclosed fireproof receptacle.
- An indication of a permanent nature shall be provided by the owner of theearthed or earthed neutral conductor, or the conductor which is to be connectedthereto, to enable such conductor to be distinguished from any live conductor.
- The supplier shall provide and maintain on the consumer's premises for theconsumer's use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under rule.
- The consumer shall take all reasonable precautions to prevent mechanicaldamage to the earthed terminal and its lead belonging to the supplier.

- Where bare conductors are used in a building, the owner of such conductors shall–
  a) Ensure that they are inaccessible;Danger Notices- The owner of every medium, high and extra-high voltageinstallation shall affix permanently in a conspicuous position a danger notice inHindi or English and the local language of the district, with a sign of skull andbones onevery motor, generator, transformer and other electrical plant andequipment together with apparatus used for controlling or regulating the same;
  b) Use all supports of high and extra-high voltage overhead lines which can beeasily climbed-upon without the aid of a ladder or special appliances; such asrails, tubular poles, wooden supports, reinforced cement concretepoles without steps, I-sections and channels, that shall be deemed as supports which cannot be easily climbed upon for the purposes of this clause.
  c) Use luminous tube sign requiring high voltage supply, X-ray and similar high frequencyinstallations.



CHECK YOUR PROGRESS

Q.3. What is Indian Electricity Act?

.....

.....



4.7 LET US SUM UP

- Safety is a primary concern for all of us. Whether at home or in workplace safety is a must.
- Electricity is very useful and is essential in our everyday life. But electricity can be dangerous even life threatening if proper safety precautions are not taken.

- Safety signs are standard symbols, pictures or signs. They are displayed to inform about the status of some items or locations.
- Accidents and injuries may occur from the misuse of the extension cord.
- There are laws, regulations, rules, norms and guidelines for carrying out the tasks involving electricity. These are specified by the government and non-government agencies and local, state level, national level and international level organisations.
- Indian Electricity Act governs the relations between the consumer and the supplier of electrical energy.
- Electricity can be dangerous if proper adequate precautions are not taken.
- Throwing of water on electrical fire can be dangerous and involves risk of electric shock
- A person gets an electric shock when he comes in direct contact with live wire or voltage source and current passes through him.
- First Aid kits are a must at workplace. In the event of an accident, injury or emergency First aid is to be administered so that the situation does not worsen till proper medical care is reached.
- THE INDIAN ELECTRICITY ACT governs matter relating to the supply and use of electrical energy.



4.8 FURTHER READINGS

1) Bhatnagar J.P., *Electricity Manual*, Orient Law House.
2) Bangalore Electricity Supply Co. Ltd, *Safety Manual,* http://www.besom.org.
3) *Emergency Handbook,* Red Cross.



4.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : a) handle, b) electrical safety, c) ground wire, d) Bureau of Indian Standards.

Ans. to Q. No. 2 : a) sterile, b) cold water, c) not recommended, d) artificial respiration

Ans. to Q. No. 3 : The Indian Electricity Act governs matter relating to the supply and use of electrical energy.



4.10 MODEL QESTIONS

Q.1. Write about the general steps to ensure safety in the use of electricity.

Q.2. Mention some of the safety steps as prevention to electrical dangers.

Q.3. Discuss electrical hazards. How can these hazards be checked

Q.4. Write about Importance of First Aid.

Q.5. Discuss the Indian Electricity rule.

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UNIT 5 : ELECTRICAL WIRING AND TOOLS

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Wiring and its Types

- 5.3.1 Cleat Wiring
- 5.3.2 Batten Wiring
- 5.3.3 Casing Capping Wiring
- 5.3.4 Conduit Wiring

5.4 Wiring Diagrams

5.5 Tools

- 5.5.1 Screw Driver
- 5.5.2 Files
- 5.5.3 Chisel
- 5.5.4 Marking Punch
- 5.5.5 Calipers
- 5.5.6 Gauge
- 5.5.7 Hacksaw
- 5.5.8 Bench Vice
- 5.5.9 Hammer
- 5.5.10 Taps
- 5.5.11 Wrench
- 5.5.12 Crimping Tool
- 5.5.13 Drilling Machine

5.6 Let Us Sum Up

5.7 Further Readings

5.8 Answer to Check Your Progress

5.9 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- know the principles behind wiring and its types.
- learn about wiring diagrams.
- understand the importance of tools.
- describe what are the wiring accessories.

5.2 INTRODUCTION

In this unit, you will learn the basic the principles behind wiring and its types. You will also lean about wiring diagrams and characteristics. The technician requires a ranges of tools to make proper of of the electrical instruments. The commonly used screw driver, hacksaw, hammer etc are required by the technician to fix an electrical problem. Similarly there are tools for cutting wood, metal etc. This unit provides a brief introduction about these tools as well.

5.3 WIRING AND ITS TYPES

Electrical wiring is a system through which electricity is distributed from a source to appliances. Electrical wirings maybe different with the field of application. Normally electricity is used for domestic, commercial and industrial purposes. Wiring considerations also vary according to these requirements. The wiring requirements for domestic appliances are very much different to that of industrial applications. Similar differences exist between the requirements of commercial and domestic applications.

The electricity reaches to a household through the distribution system (Figure 5.1a). Generally the power stations step up three phase 11KV supply to 132KV and distribute it through transmission grids till it reaches a substation where it is stepped down to 11KV and send for domestic consumption. Next, from such a supply, a connection for domestic consumption is terminated at an electric pole. From this termination pole two insulated copper wires come to the household connection from where the electricity is distributed among the appliances. A high potential of 220

V at 50 Hz is given to one of these wires. It is called **live wire** and is denoted by L. A wire having red-coloured insulation is used as a live wire for domestic connection. The other wire is held at ground potential of zero volt and is known as the **neutral wire**. It is represented by N. Any wire except with red and green colour maybe used as neutral wire. The domestic appliances are connected in parallel to these two wires from which they draw electric power. An arrangement for a typical household circuit is shown in Figure 5.1b.

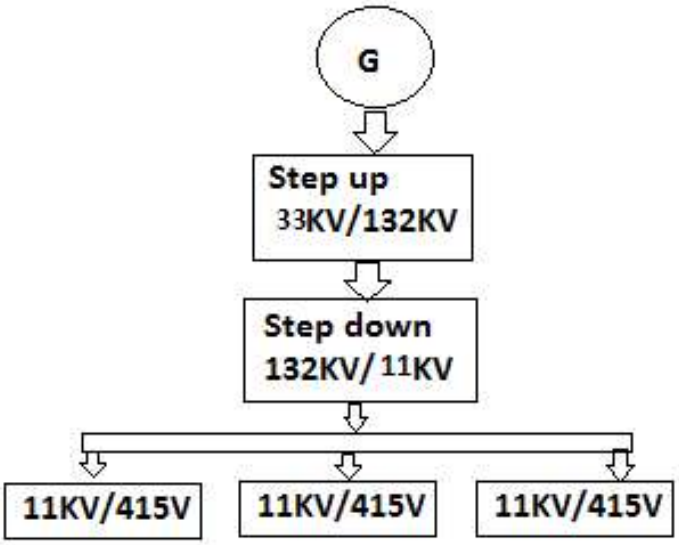


Fig. 5.1a : Electricity from generator to home

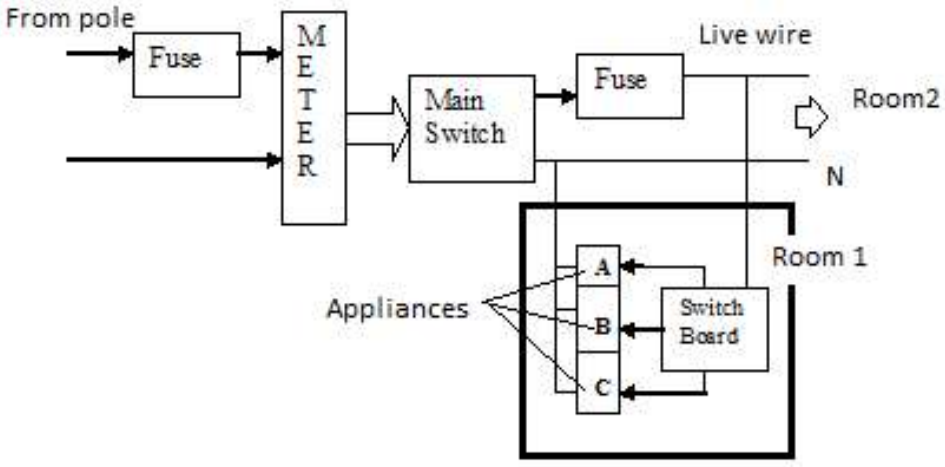


Fig. 1.1b : Domestic connection from pole

For domestic consumption electricity is available in two pin or three pin outlets.

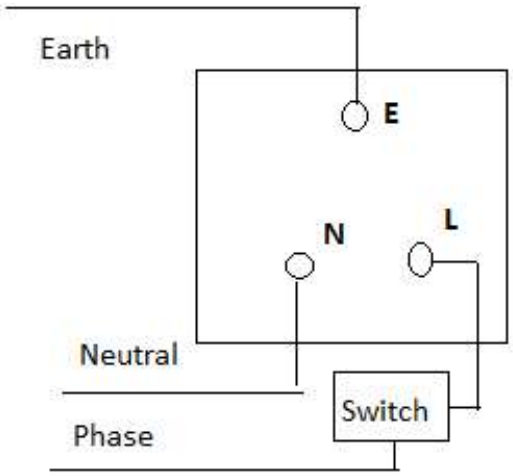


Fig. 5.1c : Phase neutrality in a 3-pin outlet

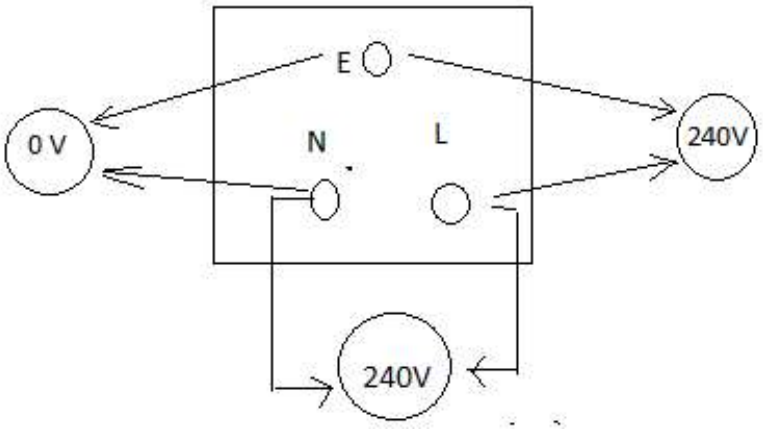


Fig. 1.1d : Voltage distribution in a 3-pin outlet

The phase line should be connected through a single pole on/off switch. Phase should always be to the right side of the socket and should be connected through a switch. The voltage distribution as shown in Figure 5.1d should be ensured for safe working of the electrical appliances.

The types of wiring to be adopted is dependent on various factors, viz, durability, safety, appearance, cost, consumer's budget etc. Generally following are the types of wiring observed in terms of wiring – practice to fulfill domestic, commercial and industrial applications:

- Cleat Wiring
- Batten Wiring
- Casing capping wiring
- Conduit Wiring

5.3.1 Cleat Wiring

Cleat wiring is a cheap wiring method and is most suitable for temporary wiring. This wiring can be quickly installed, easily inspected and altered. When not required, this wiring could be dismantled without damage to the cables, cleats and accessories.

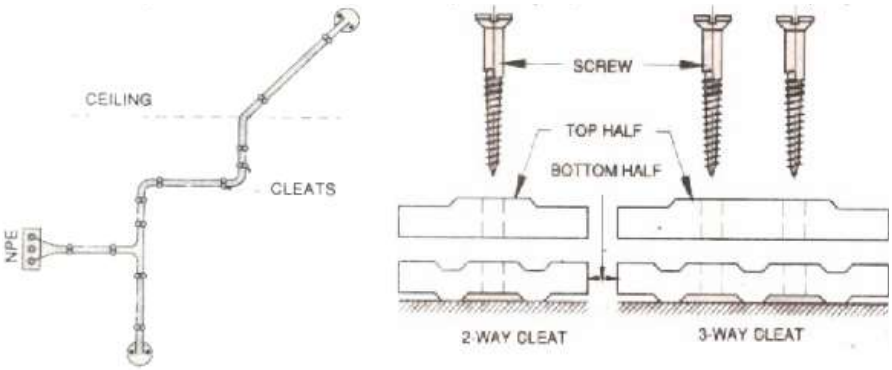


Fig. 5.2 : Cleat wiring

This wiring is not employed for wiring on damp walls or ceilings unless precautions are adopted for effectively preventing dampness and thus the deterioration of the insulation of the conductors. Vulcanized rubber insulted cables, PVC and polythene insulted cables, braided or unbraided insulted cables are used with further safety and protection considerations.

Where cleat wiring is laid along an iron made structure, porcelain cleats are inserted either with varnished wood fillets or varnished wood clamps securely fixed so as to prevent the conductors from coming in contact with the metal along witch they are passing.

No cleat wiring is to be left unprotected up to 1.5 m above the floor level. When brought through the floor it is enclosed in a conduit.

5.3.2 Batten Wiring

This type of wiring is suitable on wooden battens. Tough rubber-Sheathed (T.R.S.) or PVC-Sheathed cables are suitable

for batten wiring. Varnishing of teak wood batten is done before wiring. There are proper methods for securing the battens. The wiring must consider how the conductors are passed through the walls and cables are securely held. Special link clips are used to tie up conductors used in batten wiring. Link clips are made of tin or brass-coated tin or aluminium.

5.3.3 Casing Capping Wiring

This system of wiring is suitable for low voltage installation. Cables surrounded by vulcanized rubber, insulated cables or plastic insulated cables are use in this type of wiring. These wires are carried within the casing enclosures. Casing maybe made of wood or PVC. The wood casing wiring is not used in damp places and in ill-ventilated places, unless suitable precautions are taken. Wood casing used should have special consideration. All casing should be made of first class, seasoned teak wood or any other approved hardwood free from knots, shakes, saps or other defects, with all the sides with a smooth finish, and all sides well varnished, both inside and out side. The casing should have a grooved body with a beaded or plain-moulded cover.

The size of casing and capping to be used for various sizes of 250 volts grade insulated cables in a groove must be in accordance with recommendations.



Fig. 5.3 : Wooden casing wiring

Nowadays PVC casing is also used. Domestic PVC casings come in 1-inch, ¾ - inch and ½ - inch sizes through which wires pass. The casings are securely fixed on walls.

5.3.4 Conduit Wiring

A conduit is a type of a tube or channel. Tubular conduit is the most commonly used material in electrical installations. When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.

There are four types of conduits used for wiring.

1. Rigid steel conduit
2. Rigid non-metallic conduit
3. Flexible steel conduit
4. Flexible non metallic conduit.



CHECK YOUR PROGRESS

Q.1. Find True or False :

a) Cleat wiring is a cheap wiring method and is most suitable for permanent wiring.

b) Special link clips are used to tie up conductors used in batten wiring.

c) Casing capping system of wiring is suitable for low voltage installation.

d) When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.

5.4 WIRING DIAGRAMS

An electrical wiring diagram is an installation plan required to set-up an electrical system which can be used for domestic, commercial and industrial purposes as per requirements. The diagram consists of details of different connections relative distances, wires to be used, number of sockets and switches to be used, distribution box location, electrical taps etc. It also contains details of wire characteristics and types, types of wiring

to be used etc. A wiring diagram is different from a schematic diagram. Wiring diagrams use more symbolic notation to emphasize interconnections over physical appearance. A pictorial diagram shows more details of the physical appearance unlike a wiring diagram. Wiring diagrams are full of electrical symbols of sockets, switches, fans, panel boards etc. The electrical symbols not only show where something is to be installed, but also what type of device is being installed. A set of wiring diagrams may be required by the electrical inspection authority to approve connection for domestic, commercial or industrial purposes taken from a public electrical supply system. A wiring diagram is an important aid for trouble shooting can help in locating where a fault can be.

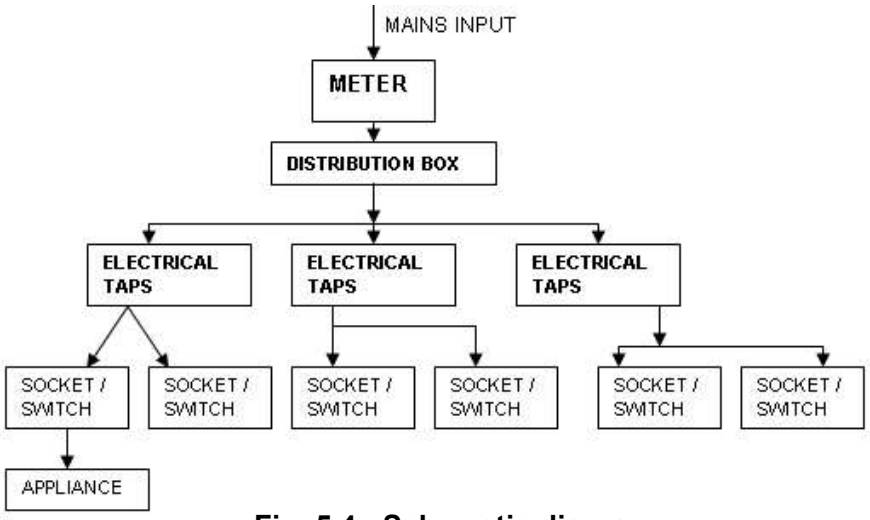


Fig. 5.4 : Schematic diagram

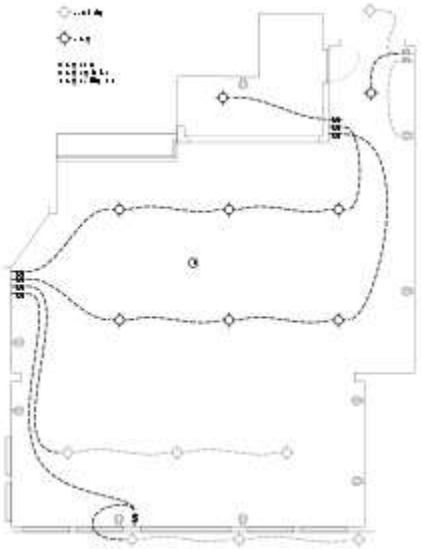


Fig. 5.5 : Wiring diagram



CHECK YOUR PROGRESS

Q.2. Find True or False :

a) An electrical wiring diagram is an installation plan required to set-up an electrical system.

b) A wiring diagram is different from a schematic diagram.

c) Wiring diagrams are full of electrical symbols of sockets, switches, fans, panel boards etc.

5.5 TOOLS

Electrical tools are the aids with which the technician can make the electrical appliances operational. Without the help of the tools the user cannot make the electrical instrument ready to do some useful work. Tools are required even during testing and maintenance of electrical appliances. The technician always carries a set of tools commonly required to make an electrical appliance operational. Even the user should possess a selective set of such tools to carry-out some initial work before or after installation of an electrical appliance. Some of the commonly required tools are described below.

5.5.1 Screw Driver

Screw driver is a tool used to tighten and loosen screws and electrical machines. Screw drivers come in different shapes and sizes as per the requirement and types of screws. Screw drivers used for electrical applications are insulated to prevent accidental shock. The appearance of a screwdriver is constituted by a head or tip. The tip comes in contact with a screw. The screw driver also has a facility to apply force by rotation of the tip. It also has some way to fix the position with the screw and support the screwdriver with a cylindrical handle approximately similar in size and shape to

be held by a human hand. An axial shaft is fixed to the handle. The handle ends in a tip which is shaped to fit a particular type of screw. The combination of the handle and shaft allow the screwdriver to be positioned and supported. These two also allow force to be applied when rotated.



Fig. 5.6 : Screw drivers of different shapes

5.5.2 Files

File is a tool used to cut a fine piece of metal from a bigger metal block. A file can have an all metal handle, a sharp ridge called tooth. The tooth maybe sharp and is used to cut metal. The tooth may come in different shapes and sizes as per the requirement.

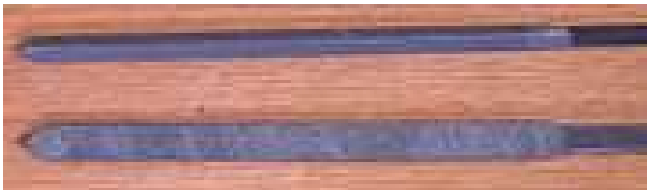


Fig. 5.7 : Set of two files

5.5.3 Chisel

A chisel is a tool used to cut wood. It is formed by a handle that has a sharp cutting edge or a blade at one of its end. The other end of the handle is formed by a head which maybe metallic or wooden. The sharp edge or blade is placed over wood and manual force applied using a mallet or hammer. Some chisel maybe used to cut metal as well.

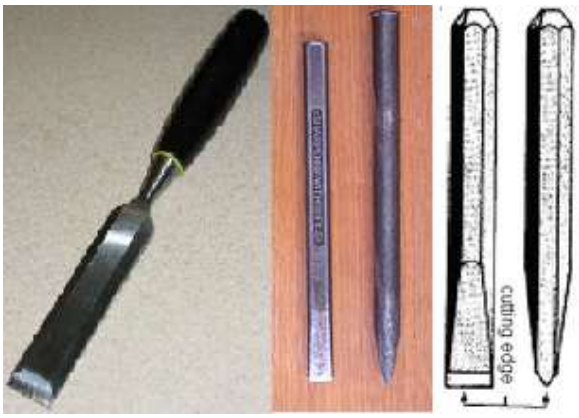


Fig. 5.8 : Set of chisels

5.5.4 Marking Punch

Marking punches can be used as a center punch or to permanently mark parts or equipment using number or letter punches. Such marks are required for identification purposes. Also, punching is done to identify a location where a drilling is to be done. It may also be done to position dividers and make dimensional changes in a container. Punchers are made of hardened steel with a narrow tip on one end.



Fig. 5.9 : Marking punch

5.5.5 Calipers

A caliper is used to find the distance between two ends of a object such that the measurement can indicate very finer differences. The tips of the caliper can be moved freely so to hold the points across which the measurements are to be made. The caliper has one ruler which contains a scale to record the distance between the points.

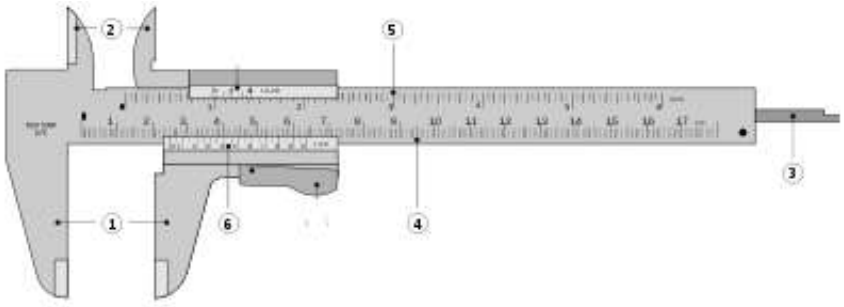


Fig. 5.10 : Caliper

Parts of a vernier caliper:

1. *Outside jaws* find external diameter or width of an object.
2. *Inside jaws* are used to measure internal diameter of an object
3. *Depth probe* determines the depths of an object or a hole
4. *Main scale* is used to mark the measurement in inches and fractions
5. *Vernier* gives values scaled to 1/10 mm or better
6. *Retainer* blocks the movable part to permit recording of a measurement

5.5.6 Gauge

In electrical measurement gauge is related to the wire. The diameter of an electrical wire is fixed by the American Wire Gauge (AWG) standard which with different numbers means varying diameters of wires. Varying diameters of wires represent varying current carrying capacity. As gauge numbers increase from 0 to 36, the diameter and circular area decreases. Higher wire gauge indicates thinner wire sizes. The circular are doubles for every three gauge sizes. For example No. 7 gauge wire has approximately twice the area of No. 10 wire gauge.

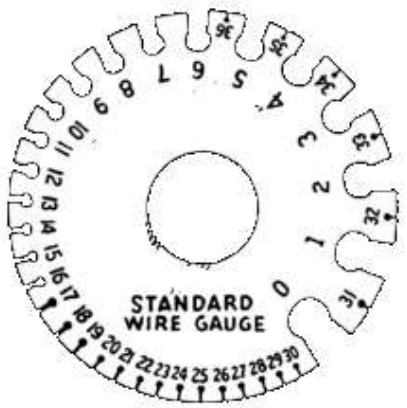


Fig. 5.11 : Wire Gauge

5.5.7 Hacksaw

A **hacksaw** is tool used for cutting metal etc. Domestic hacksaws are found in hand-held forms with a frame holding a specially designed blade under tension. The handle ends in a grip which is suitably designed for holding by the hand to enable application of manual force.

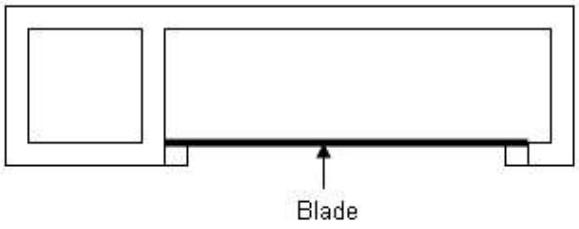


Fig. 5.12 : Hacksaw

5.5.8 Bench vice

A **vice** is metallic apparatus that uses a screw to hold a piece of wood, metal etc to enable cutting or reshaping work to be done using saws, planes, screwdrivers etc. The vice is formed by one fixed jaw and the other a movable. Both of them are parallel. The position of the movable one is altered using a screw. Though common vices are hand-held or can be mounted over benches, there are large mechanical vices as well which can be used for special applications.

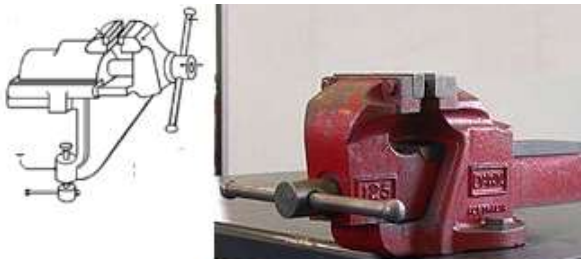


Fig. 5.13 : Bench Vice

5.5.9 Hammer

A **hammer** is a tool used most commonly to force bails inside wood. It is a tool required to apply an impact on an object to change position or alter shape. Other applications of hammer include fitting parts, forging metal etc. Hammers come in different shapes and sizes as per the requirement.



Fig. 5.14 : Hammer

5.5.10 Taps

Taps are used in different ways in electrical applications. They are commonly used to split household circuits to allow multiple devices to use the same electrical outlet. Three- and six-outlet adapters that plug into wall sockets are sometimes referred to as triple-taps and six-taps. Taps are points from where electric connection is established. Tap most commonly refers to a terminal from which certain amount of current can be drawn.

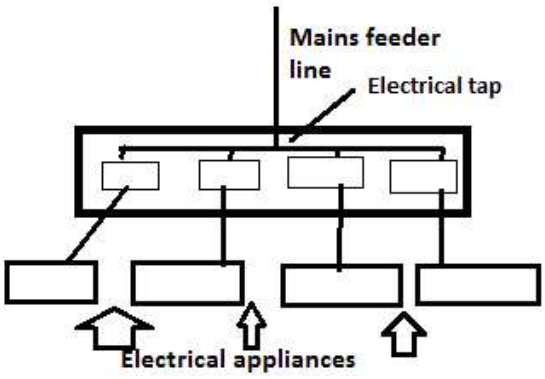


Fig. 5.15 : Electrical tap

5.5.11 Wrench

A **wrench** or **spanner** is used to provide mechanical force to turn objects in rotary forms to fasten nuts and bolts so as to prevent them from turning. Wrenches are made of special quality allows made from chromium – vanadium and are chrome plated. Some wrenches are made for specific nut while adjustable wrenches can be used with any type of nuts.



Fig. 5.16 : Wrench

5.5.12 Crimping Tool

Crimping is the process of joining two pieces of metal or other malleable material by changing the shape of one or both of them to hold each other together. The tool used to carry out this process is called a crimping tool.



Fig. 5.17 : Crimping tool

5.5.13 Drilling Machine

At times holes or gapes maybe required to be created over plastic, wood, concrete walls and metals. For such processes, drilling can be carried out. A hand – held drilling machine is a handy tool which can be used for such purposes. There are power

drilling machines as well but these are costly and a bit complicated. The hand held manual drilling machine safer and quieter than a power drill, and costs much less. The drilling machine has a head on which needles of different sizes and shapes maybe mounted. A hand operated paddle is used to apply force on the surface on which a hole is to e created. As the paddle is moved in a direction, the needle moves inwards and pierces through the surface upto the required depth.



Fig. 5.18 : Hand held drilling machine



CHECK YOUR PROGRESS

Q.3. Find True or False :

a) Screw driver is a tool used to tighten screws and electrical machines.

b) File is a tool not used to cut a fine piece of metal from a bigger metal block.

c) A chisel is a tool used to cut wood.

d) Punching is done to identify a location where a drilling is to be done.

e) A caliper is used to find the distance between two ends of a object such that the measurement can indicate very finer differences.

f) As gauge numbers increase from 0 to 36, the diameter and circular area increases.

g) Domestic hacksaws are found in hand-held forms with a frame holding a specially designed blade under tension.



5.6 LETS SUM UP

- Electrical wiring is a system through which electricity is distributed from a source to appliances.
- Cleat wiring is a cheap wiring method and is most suitable for temporary wiring.
- Batten wiring is suitable on wooden battens.
- Casing capping wiring is suitable for low voltage installation.
- A conduit is a type of a tube or channel. Tubular conduit is the most commonly used material in electrical installations. When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.
- An electrical wiring diagram is an installation plan required to set-up an electrical system which can be used for domestic, commercial and industrial purposes as per requirements.
- Electrical tools are the aids with which the technician can make the electrical appliances operational.
- Screw driver is a tool used to tighten screws and electrical machines.
- File is a tool used to cut a fine piece of metal from a bigger metal block. It can also smoothen a rough metal surface. .
- A chisel is a tool used to cut wood.
- Punching is done to identify a location where a drilling is to be done.
- A caliper is used to find the distance between two ends of a object such that the measurement can indicate very finer differences.
- As gauge numbers increase from 0 to 36, the diameter and circular area decreases.

- Domestic hacksaws are found in hand-held forms with a frame holding a specially designed blade under tension.
- A **vice** is metallic apparatus that uses a screw to hold a piece of wood, metal etc to enable cutting or reshaping work to be done using saws, planes, screwdrivers etc.
- Hammer is a tool required to apply an impact on an object to change position or alter shape.
- Tap most commonly refers to a terminal from which certain amount of current can be drawn.
- Wrenches are made of special quality allows made from chromium – vanadium and are chrome plated. Some wrenches are made for specific nut while adjustable wrenches can be used with any type of nuts.
- **Crimping** is the process of joining two pieces of metal or other malleable material by changing the shape of one or both of them to hold each other together.
- At times holes or gapes maybe required to be created over plastic, wood, concrete walls and metals. For such processes, drilling can be carried out.



5.7 FURTHER READINGS

1) Johnson, (1st) (2003), *"Process Control and Instrumentation Technology"*, New Delihi, Pearson Education
2) Swhney K, (11th) (1997). *"Electrical and Electronics Measurement and Instrumentation"*, New Delhi, Dhanpat Rai.
3) 1956, Indian Electricity Rules.



5.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : a) False, b) True, c) True, d) True

Ans. to Q. No. 2 : a) True, b) True, c) True

Ans. to Q. No. 3 : a) True, b) False, c) True, d) True, e) True, f) False, g) True



5.9 MODEL QUESTIONS

Q.1. What is electrical wiring? Why is it necessary? What are its different types?

Q.2. What is conduit wiring? Describe briefly.

Q.3. Write a brief note regarding the importance of wiring diagram.

Q.4. Write a brief note regarding the importance of tools to a technician.

Q.5. Write short notes on the following:

a) Screw drive

b) File

c) Wrenches

d) Calipers

e) Crimping

f) Vice

g) Hacksaws.

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UNIT 5 : ELECTRICAL HOUSE WIRING

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Wiring and its Types

- 5.3.1 Cleat Wiring
- 5.3.2 Batten Wiring
- 5.3.3 Casing Capping Wiring
- 5.3.4 Conduit Wiring

5.4 Wiring Diagrams

5.5 Wires, Cables and their Characteristics

5.6 Terminations and Joints

5.7 Wiring Accessories

5.8 Safety Considerations and Regulations

5.9 Let Us Sum Up

5.10 Answers to Check Your Progress

5.11 Further Readings

5.12 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- know the principles behind wiring and its types.
- learn about wiring diagrams, wire and cable characteristics.
- understand the importance of joints and terminations.
- describe the wiring accessories.
- go through the electrical safety regulations and recommendations.

5.2 INTRODUCTION

In this unit, you will learn the basic principles behind wiring and its types. You will also learn about wiring diagrams, wire and cable

characteristics. The unit highlight the importance of joints and terminations. Besides, wiring accessories, safety rules and regulations are some of the important topics. This unit will focus on to give you a comprehensive idea about house wiring.

5.3 WIRING AND ITS TYPES

Electrical wiring is a system through which electricity is distributed from a source to appliances. Electrical wiring may be different with the field of application. Normally electricity is used for domestic, commercial and industrial purposes. Wiring considerations also vary according to these requirements. The wiring requirements for domestic appliances are much differ from those of industrial applications. Similar differences exist between the requirements of commercial and domestic applications. The types of wiring to be adopted is dependent on various factors, viz, durability, safety, appearance, cost, consumer's budget etc. Generally following are the types of wiring observed in terms of wiring practice to fulfill domestic, commercial and industrial applications:

- Cleat Wiring
- Batten Wiring
- Casing Capping Wiring
- Conduit Wiring

5.3.1 Cleat Wiring

Cleat wiring is a cheap wiring method and is most suitable for temporary wiring. This wiring can be quickly installed, easily inspected and altered. When not required, this wiring could be dismantled without damage to the cables, cleats and accessories.

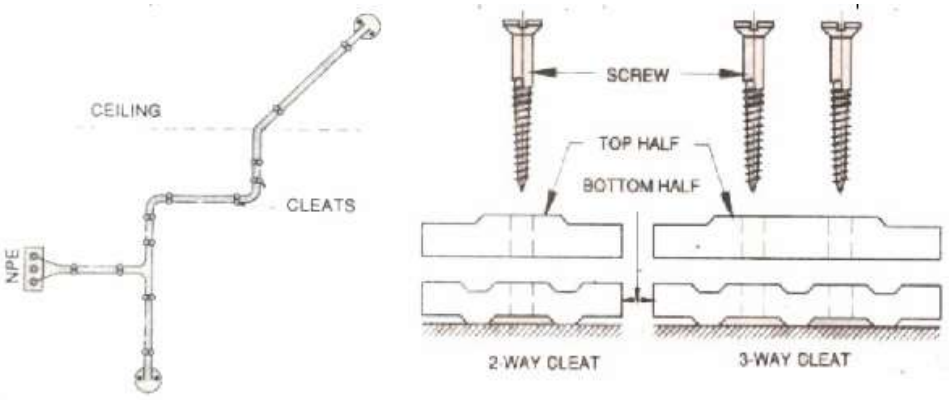


Fig. 5.1 : Cleat wiring

This wiring is not employed for wiring on damp walls or ceilings unless precautions are adopted for effectively preventing dampness and thus the deterioration of the insulation of the conductors. Vulcanized rubber insulted cables, PVC and polythene insulted cables, braided or unbraided insulted cables are used with further safety and protection considerations.

Where cleat wiring is laid along an iron made structure, porcelain cleats are inserted either with varnished wood fillets or varnished wood clamps securely fixed so as to prevent the conductors from coming in contact with the metal along which they are passing.

No cleat wiring is to be left unprotected up to 1.5 m above the floor level. When brought through the floor it is enclosed in a conduit.

5.3.2 Batten Wiring

This type of wiring is suitable on wooden battens. Tough rubber-Sheathed (T.R.S.) or PVC- Sheathed cables are suitable for batten wiring. Varnishing of teak wood batten is done before wiring. There are proper methods for securing the battens. The wiring must consider how the conductors are passed through the walls and cables are securely held. Special link clips are used to tie up conductors used in batten wiring. Link clips are made of tin or brass- coated tin or aluminium.

5.3.3 Casing Capping Wiring

This system of wiring is suitable for low voltage installation. Cables surrounded by vulcanized rubber, insulated cables or plastic insulated cables are used in this type of wiring. These wires are carried within the casing enclosures. Casing maybe made of wood or PVC. The wood casing wiring is not used in damp places and in ill-ventilated places, unless suitable precautions are taken. The wood casing used should have special consideration. All casing should be made of first class, seasoned teak wood or any other approved hardwood free from knots, shakes, saps or other defects, with all the sides with a smooth finish, and all sides well varnished, both inside and out side. The casing should have a grooved body with a beaded or plain- moulded cover.

The size of casing and capping to be used for various sizes of 250 volts grade insulated cables in a groove must be in accordance with recommendations.



Fig. 5.2 : Wooden casing wiring

Nowadays PVC casing is also used. Domestic PVC casings come in 1-inch, ¾ - inch and ½ - inch sizes through which the wires pass. The casings are securely fixed on walls.

5.3.4 Conduit Wiring

A conduit is a type of a tube or channel. Tubular conduit is the most commonly used material in electrical installations. When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.

There are four types of conduits used for wiring.

1. Rigid steel conduit
2. Rigid non-metallic conduit
3. Flexible steel conduit
4. Flexible non metallic conduit.



CHECK YOUR PROGRESS

Q.1. Find True or False.

a) Cleat wiring is a cheap wiring method and is most suitable for permanent wiring.

b) Special link clips are used to tie up conductors used in batten wiring.

c) Casing capping system of wiring is suitable for low voltage installation.

d) When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.

5.4 WIRING DIAGRAMS

An electrical wiring diagram is an installation plan required to set-up an electrical system which can be used for domestic, commercial and industrial purposes as per requirements. The diagram consists of details of different connections, relative distances, wires to be used, number of sockets and switches to be used, distribution box location, electrical taps etc. It also contains details of wire characteristics and types, types of wiring to be used etc. A wiring diagram is different from a schematic diagram. Wiring diagrams use more symbolic notation to emphasize interconnections over physical appearance. A pictorial diagram shows more details of the physical appearance unlike a wiring diagram. Wiring diagrams are full of electrical symbols of sockets, switches, fans, panel boards etc. The electrical symbols not only show where something is to be installed, but

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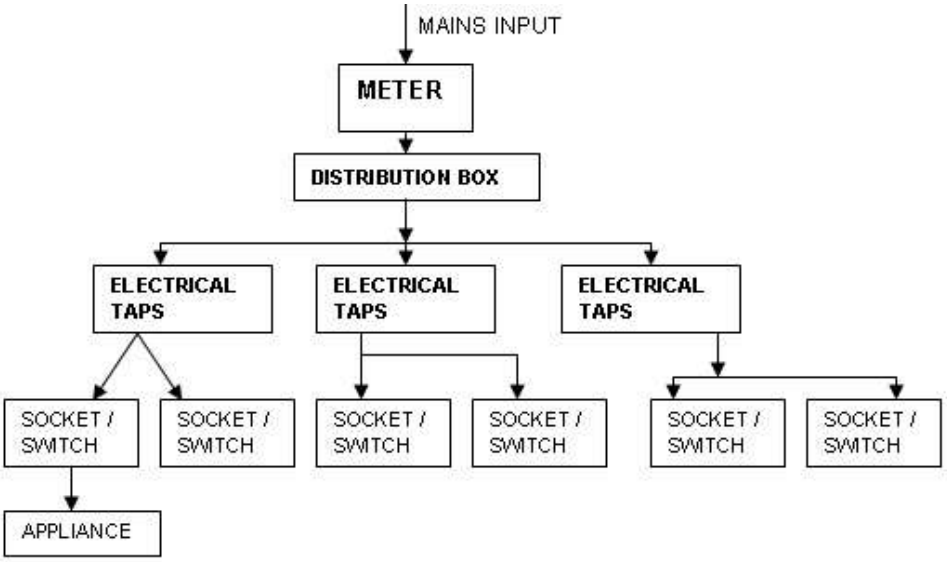


Fig. 5.3 : Schematic diagram

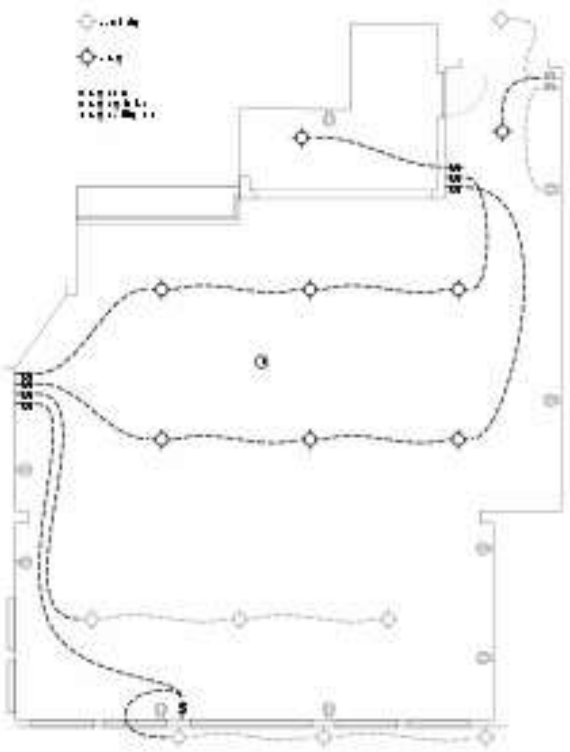


Fig. 5.4 : Wiring diagram (Wiring diagram - Wikipedia)



CHECK YOUR PROGRESS

Q.2. Find True or False.

a) An electrical wiring diagram is an installation plan required to set-up an electrical system.

b) A wiring diagram is different from a schematic diagram.

c) Wiring diagrams are full of electrical symbols of sockets, switches, fans, panel boards etc.

5.5 WIRES, CABLES AND THEIR CHARACTERISTICS

Electrical wires have markings stamped or printed on the outside sheath of the cable which indicate the type and size of wire available for applications. The colour of the wires inside of the sheath, indicates that different colour wires are intended for different purposes.

Black Wires– Black wires are always used for hot wires. These wires may feed a switch or outlet and are often used as switch legs. Black wire is not used for a neutral or ground connection.

Red Wires– Red wires are also used for hot wires, switch legs etc. Another useful application is the interconnect wire between two appliances.

Blue and Yellow Wires– Blue and yellow wires are used as main conductors and are pulled through conduits and casings. The blue wires are used as switch legs to things like lights and fans. Yellow wires are generally used for switch legs and control things like light, fans, and switched outlets.

Green and Bare Copper Wires– Green wires and bare copper wires are used only for grounding. These wires will ground devices and shall be bonded to junction boxes and appliance connections for safety.

Wire Color Exceptions– In certain instances, wire colors may be used for connections that don't follow these general rules. For instance, a white wire in a two-conductor cable may be used for the second hot wire on a 240-volt appliance or outlet connection.

A cable is formed by two or more wires running side by side and bonded, twisted or braided together to form a single assembly. Cables are used to carry special purpose electric signals. Cables have a protective jacket that works as insulation also. When a conductor carries current it radiates an electromagnetic field. It is true with a cable also. Similarly a conductor or cables can also pick-up energy from any existing electro-magnetic field around. These effects are undesirable as it leads to unwanted transmission of energy which is loss making and unwanted pickup of noise which may degrade the desired signal being carried by the cable. It can also corrupt electric voltages being carried by a cable to such an extent as to cause equipment malfunction.

There are particular cable designs that minimize electromagnetic pickup and transmission. These are *shielding, coaxial* and *twisted-pair* geometry used in cables.

Shielding encases the cable for its entire length in foil or wire mesh. All wires running inside this shielding layer is isolated from external electric fields, particularly if the shield is connected to a point of constant voltage, such as earth.

Coaxial design helps to further reduce magnetic transmission and pickup. In this design the foil or mesh shield is perfectly tubular - i.e. with a circular cross section - and the inner conductor is situated exactly at its center. This causes the voltages induced by a magnetic field between the shield and the core conductor to consist of two nearly equal magnitudes which cancel each other.

The *twisted pair* is a result of two wires twisted around each other, forming a pair of intertwined helices. This can be achieved by putting one end of the pair in a hand drill and turning while maintaining moderate tension on the line. Field cancellation between successive twists of the pair considerably reduces electromagnetic pickup and transmission.

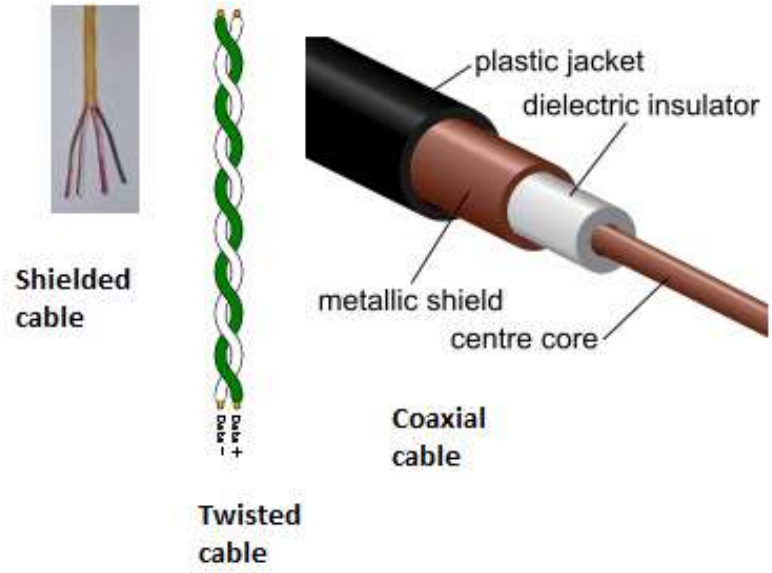


Fig. 5.5 : Shielded, twisted and coaxial cable



CHECK YOUR PROGRESS

Q.3. Find True or False :

a) Black wires are always used for hot wires.

b) Green wires and bare copper wires are used only for supplying power.

c) Coaxial cables help to further reduce magnetic transmission and pickup.

5.6 TERMINATIONS AND JOINTS

In electrical installation and wiring appropriate termination is important to ensure safe operations of the appliances. Terminations ensure that the electric supply reaches the intended end and carries out the required work. An electric termination can be an appliance or a point from which another connection can be made. Without appropriate termination, an electrical connection may not only be dangerous but also prove to be loss making. An electrical termination is a connecting wire or cable or a special terminal or a terminal connector. Terminations are required to

establish appropriate electrical connections. All terminations, therefore, should fulfill the following conditions:

- Physical firmness,
- Appropriate electrical conductivity and zero resistance, and
- Prevention of contact with other metallic part, conductors etc near to it.

If terminations are loose the following may occur:

a) Electrical arching leading to heating of wires and terminals with probability burn out and fire;
b) Increase in electrical resistance leading to unwanted voltage drop;
c) Slipping of live wires from connections leading to electrical shock, short circuits, accidental fire and similar hazardous situations.

Therefore, extra-care must be taken while installing termination. Regular inspection is required to ensure that the terminations are firm and strong enough to withstand physical strain. It can be tested by pulling a terminated wire either by hand or by using a tool. Also close scrutiny is required to prevent any terminating wire from touching some metallic contact that may exist in the vicinity even when the set-up is moved or shaken as part of some application.

There are three types of terminations:

1. Screw type termination
2. Crimp type termination and
3. Solder type termination.

1. *Screw type termination*- In this type of termination, a wire is skinned a bit at its end and wound round a screw to which a nut is bolted and fixed. Over–tightening of the screw should be avoided as it can lead to cutting of the terminating wire. Special purpose nuts-bolts are available with appropriate teeth like arrangement to hold terminating wires firm. This type of connection is suitable for domestic low voltage (< 230 V) applications.



Fig. 5.6 : Screw type termination

2. *Crimp type termination*– This is stronger and a bit better than the screw type due to the fact that it establishes appropriate physical contact between a wire and a termination point. In this type of connection, conductors of a wire is inserted or placed in a crimping fitting or tied around crimp eyelets and reshaped into an arrangement using a crimping tool such that the joint with the termination point becomes securely fastened. It is a one-stroke process. A loosely crimped connection cannot be re-worked but shall require a fresh crimping. To ensure appropriate crimping the exact tool and arrangement is essential.



Fig. 5.7 : Crimp type termination

3. *Soldering type termination*– It is the best way to do a termination. A soldering instrument, material and flux is used to permanently fix

a wire with a terminating point. The soldering iron when heated up using electric power melts the soldering material and fixes the joint.



Fig. 5.8 : Soldering type termination

Joints are required during wiring. Since there are corners and bends in the structures of houses, rooms and similar places where wiring is to be done, a host of joints are available to meet the requirements. A few of them are as shown below:

1. Straight joint.
2. Tee joint.
3. Right- angled joint.
4. Corner joint.
5. Tee-bridge joint.
6. Cross- bridge joint.

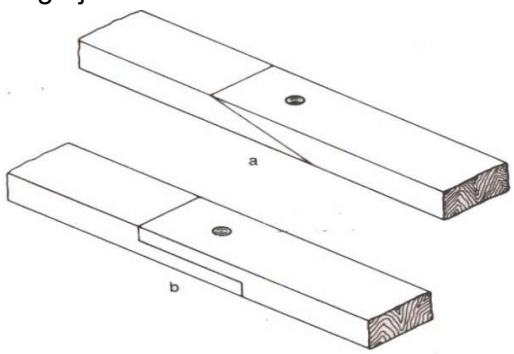


Fig. 5.9 : Straight joint

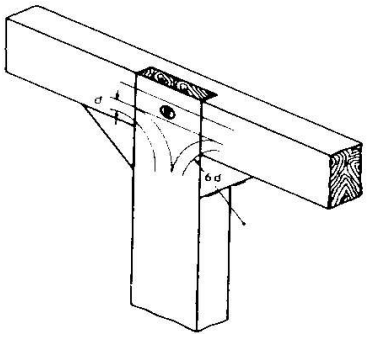


Fig. 5.10 : Tee-joint

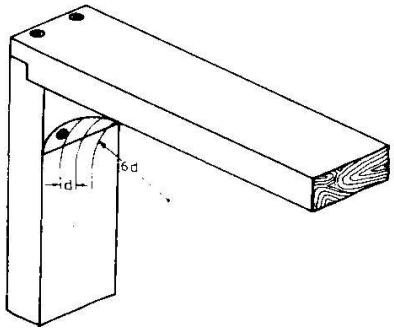


Fig. 5.11 : Right angled-joint

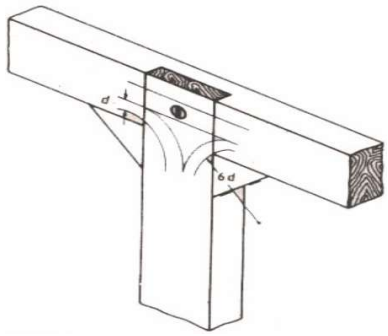


Fig. 5.12 : Tee-bridge joint

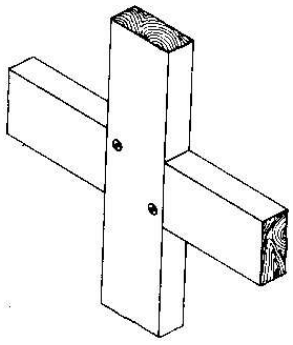


Fig. 5.13 : Cross bridge-joint



CHECK YOUR PROGRESS

Q.4. Find True or False :

a) An electrical termination is a connecting wire or cable or a special terminal or a terminal connector.

b) A termination should have appropriate electrical conductivity and zero resistance.

c) Regular inspection is required to ensure that the terminations are firm and strong enough to withstand physical strain.

d) In screw type of termination, a wire is skinned a bit at its end and wound round a screw to which a nut is bolted and fixed.

e) Joints are required during inspection.

f) A loosely crimped connection can be re-worked.

5.7 WIRING ACCESSORIES

Electric accessories are essential components of the wiring process. Without them wiring remains incomplete. **Junction box** is an important wiring accessory. It is made of either metal, wood or PVC. It has certain dimension and is regularly used to hold wires joined for diversion and extension of connection. Sometimes junction boxes play the rolesof termination points or electrical taps.

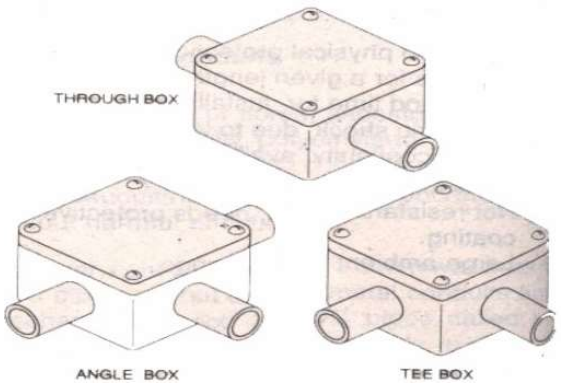


Fig. 5.14 : Junction box

Some other wiring accessories include the following:

1. Couplers
2. Elbow
3. Bends
4. Circular boxes
5. Rectangular boxes.

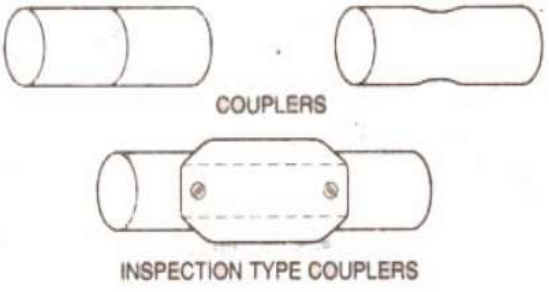


Fig. 5.15 : Couplers

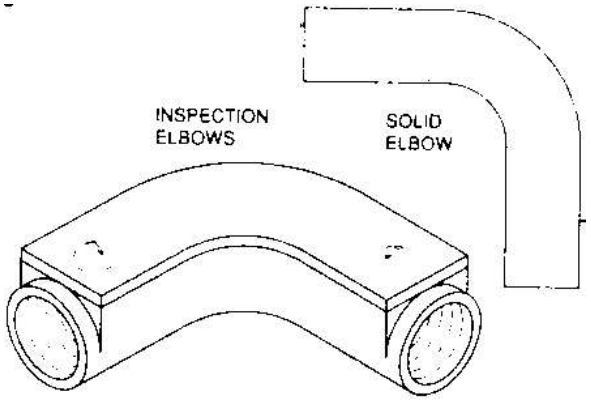


Fig. 5.16 : Elbows

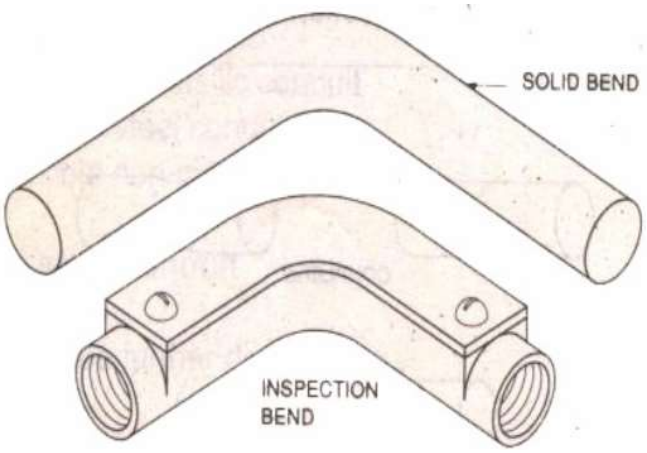


Fig. 5.17 : Bends

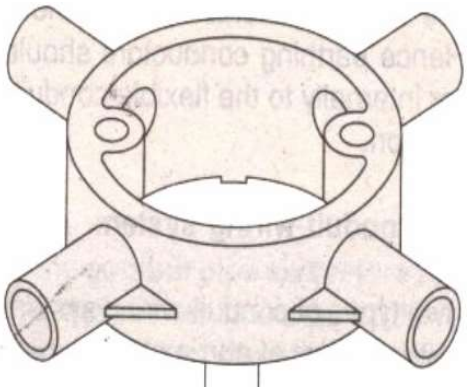


Fig. 5.18 : Circular box

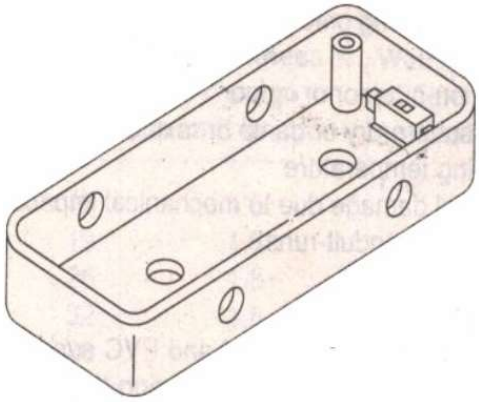


Fig. 5.19 : Rectangular box



CHECK YOUR PROGRESS

Q.5. Find True or False.

a) Junction box is made of either metal, wood or PVC.

b) Junction box is used to hold wires joined for diversion and extension of connection.

5.8 SAFETY CONSIDERATIONS AND REGUALTIONS

Some electrical safety considerations should always be followed for safe operation of the appliances and installation. A few of the safety considerations can be as follows:

- Don't put a lot of connections into one electrical or extension cord. It could damage the electrical system in the premises or even cause a fire.
- Always ask the technician to put safety caps on all unused electrical outlets. It will provide safety.
- Don't pull an electrical cord from the wall. It can damage an appliance, the plug or the outlet.
- Always ensure that all electric cords are installed with casing or concealment neat and tidy. Else pets might chew on electrical cords, and people might trip and fall.
- Always have a line tester to test a supply line before doing any maintenance work. Don't touch a live wire, it can be dangerous.
- While working with electrical appliances using a ladder always ensures that there is no open connection or live conductor around which is carrying current. It can give electric shock on touching.
- Always keep electrical items away from water and fire.
- Do not touch or tamper with any electrical gear or conductor unless it is not conducting electricity and earthed.
- Do not open or close switch or fuse slowly or hesitatingly. Do it quickly and positively.
- Do not use wires with poor insulation. Do not touch any electrical circuit when your hands are wet or bleeding from a cut or an abrasion.

In India, electricity considerations are governed by the provisions of the Indian Electricity Rules, 1956. It contains details of nearly all provisions of electricity generation, distribution, use, safety etc. Also the Electricity Act, 2003 provides a set of laws governing *generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas*, *rationalization of electricity tariff etc.*



CHECK YOUR PROGRESS

Q.6. Find True or False :

a) Some electrical safety considerations should always be followed for safe operation of appliances and installation.

b) Also the Electricity Act, 2003 provides a set of laws governing *generation, transmission, distribution etc.*



5.9 LET US SUM UP

- Electrical wiring is a system through which electricity is distributed from a source to appliances.
- Cleat wiring is a cheap wiring method and is most suitable for temporary wiring.
- Batten wiring is suitable on wooden battens.
- Casing capping wiring is suitable for low voltage installation.
- A conduit is a type of a tube or channel. Tubular conduit is the most commonly used material in electrical installations. When cables are drawn through the conduit and terminated at the outlet or switch points, the system of wiring is called conduit wiring.
- An electrical wiring diagram is an installation plan required to set-up an electrical system which can be used for domestic, commercial and industrial purposes as per requirements.
- Electrical wires have markings stamped or printed on the outside sheath of the cable which indicate the type and size of wire available for applications.
- An electrical termination is a connecting wire or cable or a special terminal or a terminal connector. Terminations are required to establish appropriate electrical connections.

- Electric accessories are essential components of the wiring process. Without them wiring remains incomplete.
- Some electrical safety considerations should always be followed for safe operation of appliances and installation.
- In India, electricity considerations are governed by the provisions of the Indian Electricity Rules, 1956. It contains details of nearly all provisions of electricity generation, distribution, use, safety etc. Also the Electricity Act, 2003 provides a set of laws governing *generation, transmission, distribution* etc.



5.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : a) False, b) True, c) True, d) True

Ans. to Q. No. 2 : a) True, b) True, c) True

Ans. to Q. No. 3 : a) True, b) False, c) True

Ans. to Q. No. 4 : a) True, b) True, c) True, d) True, e) False, f) False

Ans. to Q. No. 5 : a) True, b) True

Ans. to Q. No. 6 : a) True, b) True



5.11 FURTHER READINGS

1) Johnson (1st Ed.) (2003). *Process Control and Instrumentation Technology*, New Delhi, Pearson Education.

2) Sawhney A. K. (11th Ed) (1997), *Electrical and Electronics Measurement and Instrumentation*, New Delhi, Dhanpat Rai & Co.

3) (1956) *Indian Electricity Rules.*



5.12 MODEL QUESTIONS

Q.1. What is electrical wiring? Why is it necessary? What are its different types?

Q.2. What is conduit wiring? Describe briefly.

Q.3. Write a brief note regarding the importance of wiring diagram.

Q.4. Write short notes on the following:

a) Electrical accessories

b) Electrical terminations

c) Electrical Safety Norms