# Basic Rural Technology

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## SECTION - B
## BASICS OF ELECTRICITY

### COURSE CONTENT



1

# ELECTRIC SAFETY

## 1.1 INTRODUCTION

Electricity is used everywhere. Electricity is an essential part of our life. Though, the advantages are plenty, dangers also their. Particularly when not safely handled, numerous accidents take place. This is due to several reasons, so we are going to study of safety rules, as per IS-5216 General safety.

## 1.2 OBJECTIVES

After reading this lesson, you should be able to:

1. Explain the Electric Shock.
2. Provide the First Aid.
3. Learn the methods of Artificial Respiration.
4. Know the Electric Fire.
5. Understand the Workshop Safety Rules.

## 1.3 ELECTRIC SHOCK

Electric shock is sudden or unexpected and stimulates the body's nervous system. When a current passes through the body, the effect is involuntary muscular contraction. If it is of low intensity, the victim is easily release, if it is high the victim can't release himself from the supply. If the chest becomes the path of the current the muscles which control breathing will paralyzed. The victim may still be in contact with the power supply, and may be in an unconscious state. If someone else touches the victim in order to save him, that person will also get a shock.

### SEVERITY OF SHOCK

The severity of shock depends on:

a) Contact area of the body with the supply wire or appliance.

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*Notes*

b) Electric pressure with the supply wire or appliance.
c) Path of current through the body.
d) Whether it is AC or DC.
e) Wet condition.
f) Mental stress at the time of accident.
g) AC is more dangerous than DC.

### REASONS OF SHOCK

a) Touching a bare live conductor.
b) Touching a poorly insulated conductor.
c) Open or short circuit due to equipment failure.
d) Static electricity.
e) Use of non-standard material.
f) Not following the Safety Rules

## 1.4 NECESSITY TO KNOW FIRST AID

Dear friends, we don't know how to treat the electrical accident to somebody, may be at home, office, industry or anywhere. It is always better and necessary to know how to give first aid to such victims before sending him to the doctor. To pull him other side use any non - metallic tool or any instrument.

**First Aid:**

1) Immediately lay down the victim on a soft blanket. Allow fresh air to reach him.
2) Apply some cold cream or coconut oil on the burn parts.
3) Artificial respiration procedure should be applied gently.
4) Sprinkle his face with water.
5) Smell any scent or scented thing regularly to victim.
6) Do not give any food or liquid to the victim without consult with the doctor.
7) The victim should always be kept warm.

### INTEXT QUESTIONS 1.1

1) What is electric shock?



2) On what factor severity of shock depends?

3) What are the reasons of shock?

4) Define the first aid?

## 1.5 ARTIFICIAL RESPIRATION

There are two different methods of applying artificial respiration -

a) Schaffer's Method.

b) Sylvestr's Method.

**a) Schaffer's Method** - Lay the victim on his belly with one arm extended directly overhead and the other arm bent at elbow, with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing, pull the tongue forward, but do not hold it.

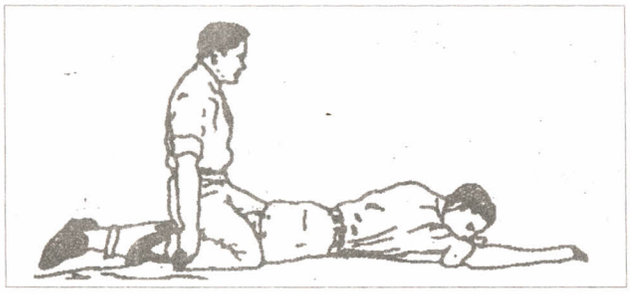


Fig.1.1 : Schaffer's Method-step 1.

Kneel, straddling on the victim's thighs, with your hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position and the tips of the fingers just out of sight.

Keep your arms straight, lean forward slowly over the victim bringing the weight of your body gradually to bear on the victim for about 2–3 seconds, release the pressure slowly and return to the first position by sliding your palms sideways as shown in fig 1.2

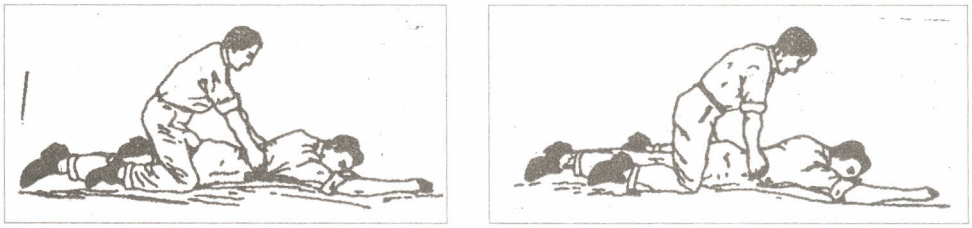


Fig.1.2 : Schaffer's Method-step 2 and 3.

Repeat this procedure about 12–15 times a minute. It will help victim to restore breathing gradually. A victim may require 1–3 hours to re-establish the natural breathing.

After the victim starts natural breathing, the artificial respiration should be stopped, keep a watch on the victim till he breaths naturally.

**b) Sylvester's Method** - Place the victim on his back. First loosen his clothes around the chest and stomach. Remove false teeth, if any and put a pillow under the shoulders, so that his chest will be rise up and head will titled backward. The tongue should be drawn forward.

Fig.1.3 : Sylvester's Method-Step 1.

The rescuer must stand beside the victim in the position shown in fig 1.4. Grasp the victim just below the elbows. Draw his arm over his head until horizontal, retaining them for two seconds.

Next, bring the victim's arms down on each side of his chest and pressing inwards upon it. Leaning upon his arm so as to compress his chest.

Remain in his position for two seconds and then again keep repeating the two motions at the same rate.

If one more person is present, he should be asked to draw out victims tongue at each action of the victim's lungs inflating and deflating.

Be careful in this method to avoid any injury to internal organs resulting from excessive and sudden pressures. Do not give any thing to drink to a victim until he is conscious.



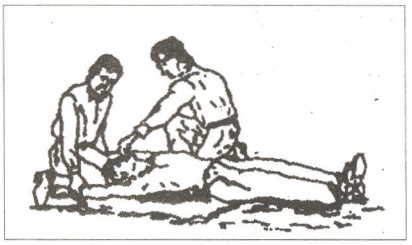


Fig 1.4:Sylvester's Method-Step 2.

## 1.6 ELECTRICAL FIRE

### Causes of Fire

Following are the main causes of fire:

1) Use of incorrect size of fuse wire.
2) Overloading.
3) Poor or loose joints.
4) Combustible material stored near the fuse board.

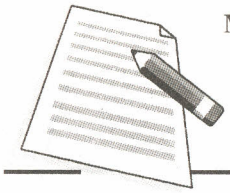
### Precautions to be taken during Electrical Fire

Following precautions are to be taken in case of electrical fire -

1) Switch off the main switch.
2) Extinguish the fire by throwing dry sand on it.
3) Before using a fire extinguisher make sure that it is not out-dated and it is of Carbon-di-Oxide type.
4) Don't use water to extinguish the fire if the main-line is live.

Dear friends, you are welcome to this workshop, where the electrical appliances or machines are tested & repaired. This place is known as electricity workshop/lab. While doing the work you should know the safety to prevent minor or major accidents. Following are the safety rules which are based on Indian Standard Safety procedure:

(1) Always use PVC or wooden table & stool for repairing job.
(2) Connect any instrument /appliance in the presence of a supervisor.
(3) Always obey the safety instructions given by instructor.
(4) Do not renew a blown fuse until the switch is off?
(5) Keep the workshop floor clean & tools in good condition.
(6) While working on live circuits always use rubber gloves rubber mat & insulated tools.
(7) Replace fuses only after switching off the circuit off the circuit switches.





(8) Use accessories in good conditioned.

(9) Always use 3 pin plug socket, plug top 3 core wire for appliances.

(10) Connection in electrical apparatus should be tight.

(11) After switching off the supply, grip the plug top carefully & pull it.

(12) Always used plug pin top for connecting appliances to the supply.

## 1.7 WHAT YOU HAVE LEARNT

In this lesson you have learnt about an Electric Shock, Severity of Shock, Reasons of Shock, Necessity to know First Aid and Artificial Respiration.

## 1.8 TERMINAL QUESTIONS

1) Explain the Schaffer's method of artificial respiration?

2) Describe the Sylvester's method of artificial respiration?

## 1.9 ANSWER TO INTEXT QUESTIONS

1) Electric shock is sudden or unexpected and stimulates the body's nervous system.

2) It depends upon-

   a) Contact area

   b) Supply pressure

   c) Path of current

   d) Type of current

   e) Whether condition

   f) Duration

3) Reasons of electric shock-

   a) Touching a bare live conductor.

   b) Touching a poorly insulated conductor.

   c) Open or short circuit due to equipment failure.



d) Static electricity

e) Use of non-standard material.

4) First aid means an action which is instant to a victim to cure from any accident.

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# BASIC TOOLS

## 2.1 INTRODUCTION

In previous lesson, we studied safety rules for electrical workers. Now we are going to study the useful wiring tools. We need many tools to start electrical installation. Here is a list of those tools you can add as you feel the need for them. Do not confuse by many brands, sizes, makes and kinds that you see in market. As a thumb rule one reliable make is as good as another and size is generally not very important providing that you do not get a tool which is too large or too heavy for you. The great thing is to buy good quality tools. You may not need super quality tools, but those you do get must be reliable.

## 2.2 OBJECTIVES

After reading this lesson, you will be able to:

1) State how tools are specified.
2) Identify the different types of tools.
3) State the application of each tool.
4) Explain the maintenance of the tools.

## 2.3 LIST OF BASIC TOOLS

| S.No. | Name of tools |
|---|---|
| 1. | Pliers |
| 2. | Wire Stripper OR Electrician Knife |
| 3. | Push Pull Steel Tape |
| 4. | Try Square |

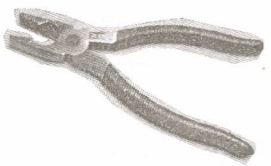


5. Plumb Bob with Nylon thread
6. Tenon Saw (Back Saw, Devetail Saw)
7. Hack Saw (Adjustable Frame type)
8. Firmer Chisel
9. Cold Chisel
10. Trimming Knife
11. Hammer
12. Hand drill machine with twist drill & Masonry drill
13. Electrician's Screwdriver
14. Test Lamp
15. Tester

## 1. PLIER

There are different types of pliers. Pliers specified by its length of legs, its type, insulation material. Here Electricians plier, Diagonal Cutting Pliers, Long Nosed Plier is discuss.

### (a) Electrician's Plier



Name : Electrician's Plier, Lineman's Plier, Combination Plier etc.

Material : Steel, Plastic hand covers.

Use : To cut, to grip and twist the wires.

Care : Always keep the plier properly insulated. Do not cut hard substance with it. Never use it as a hammer.

### (b) Diagonal Cutting Plier

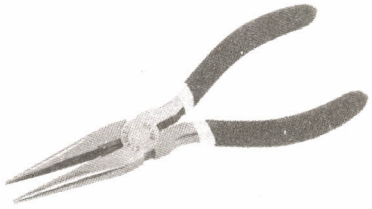
Name : Diagonal cutting plier, Side cutting plier

Material : Steel, Plastic hand covers

Use : To crop metal wire close to a surface.

Care : Diagonal cutting pliers are designed for cropping metal only. They should not be used as standard pliers to grip wire.

### (c) Long Nosed Plier



Name : Long Nosed Plier

Material : Steel, Plastic hand covers

Use : To grip small objects in confined spaces; to crop soft wire

Care : Long nosed pliers are manufactured in a variety of shapes and proportions but they all have serrated tapering jaws to work in confined spaces. Some models have side cutters to crop soft wire.

## 2. ELECTRICIAN'S KNIFE

Name : Electrician's Knife

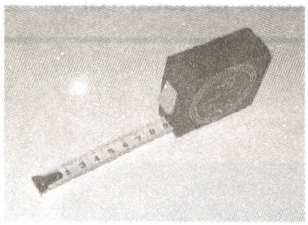
Material : Handle - Plastic, Rosewood Blade - Stainless Steel

Use : Removing insulation of wires and cables.

Care : Used it properly without touching the blade.



## 3. PUSH PULL STEEL TAPE



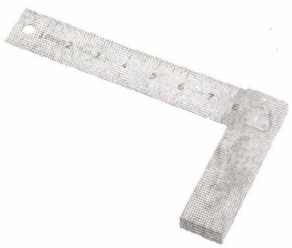
Name : Push Pull Steel Tape OR Flexible Rule

Material : Tape - Steel, Fiber Glass Case - Steel, Plastic

Use : To determine the size of a work piece or to survey an area.

Care : Check periodically that the hook has not become too loose.

## 4. TRY SQUARE



Name : Try Square

Material : Blade - Steel Stock - Cast Iron, Hard-wood

Use : To work out or check the work for square.

Care : Never try and use the stock of a square as a hammer.

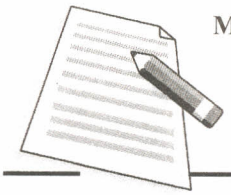
### INTEXT QUESTIONS 2.1

**Fill in the blanks:**

1) Electrician's plier is used for _____.

2) Always keep the plier properly _____.

3) The tool used for crop metal wire close to a surface is _____.



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4) The tool used to grip small objects in confined space is _____.

5) The push pull steel tape is used for _____.

## 5. PLUMB BOB

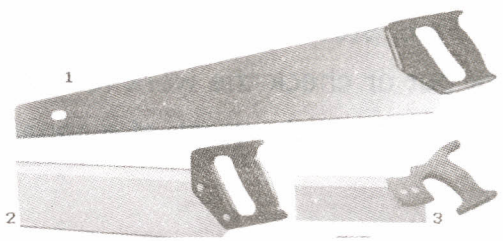
Name : Plumb Bob

Material : Bob - Brass, Plastic, Lead, Steel Line(Cord) Nylon, Silk

Use : To line out electrical installations on the walls & ceilings of the buildings

Care : Before marking lines the thread should be rubbed or the red ochre or same colored material to get a clean line out. The thread must not be free while lining out the thread must be stretched fully to avoid the sag. For marking purpose grip the thread at the centre with your pinch and then leave it at once for getting straight and clear marking.

## 6. TENON SAW




Name : Tenon Saw, Back Saw

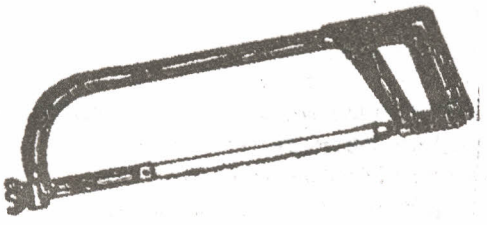
Material : Blade - Steel, Handle - Beech, Plastic

Use : To cut joints.



Care : Great care should be taken to start the cut correctly. The teeth of the tenon saw must be kept very sharp. For the purpose of sharpening the teeth always use a triangular file. The cutting angle of each tooth must be the same as the previous one. After resharpening set the saw properly saw set is used for springing the set.

## 7. HACK SAW



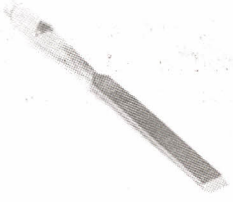
Name : Hack Saw

Material : Blade - Steel, Handle - Alloy, Plastic, Wooden

Use : To cut the metals

Care : While working with the hack saw see that cuts are very straight otherwise due to the bending the blade may break causing the unnecessary delay in the work. Before starting the work the blade should be cleaned and placed properly in the proper position.

## 8. FIRMER CHISEL



Name : Firmer Chisel

Material : Blade - Steel Handle - Wood, Plastic

Use : To trim and chop wood

Care : When a chisel becomes stubby in must be reground and resharpened.

## 9. COLD CHISEL

Name : Cold Chisel

Material : Steel

Use : To cut metai

Care : When a chisel becomes stubby it must be reground and resharpened.

## 10. TRIMMING KNIFE

Name : Trimming Knife

Material : Blade - Specifically treated carbon Steel Case - Alloy body with blade store

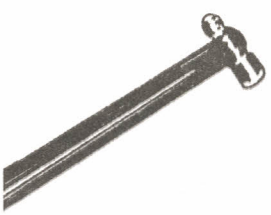
Use : To remove insulation from heavy duty cables.

Care : To cut the cable properly.

## 11. HAMMER

Hammers are used in various parts of the world under different names and a variety of shapes and sizes. They are Hammer Ball Pein, Hammer Cross Pein, and Hammer Club Pein etc.

### a) Hammer Ball Pein



Name : Hammer Ball Pein

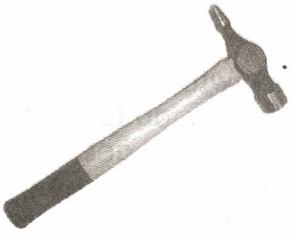
Material : Head - Steel
Shaft - Wood, Bamboo

Use : To drive punches and cold chisels to form metal

Care : To hammer that object only which you have to stuck it.



### b) Hammer Cross Pein



Name : Hammer Cross Pein

Material : Blade - Steel
Handle - Wood, Bamboo

Use : To drive punches and cold chisels to form metal

Care : To hammer that object only which you have to stuck it.

### c) Hammer Claw

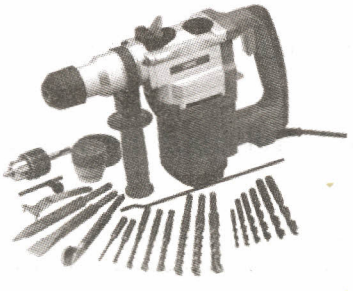
Name : Hammer Claw

Material : Blade - Steel
Handle - Wood, Bamboo

Use : To reopen the screws and to drive the punches.

Care : To hammer that object only which you have to reopen it.

## 12. HAND DRILL MACHINE WITH TWIST DRILL AND MASONRY DRILL (8)



Name : Hand Drill machine

Material : Body - Cast iron Aluminum

Use : To drill holes in wood & metal.

Care : Do not jerk while drilling. Always place a wooden piece below the job to be drilled, Otherwise the bit will hit the floor & get damaged. Hand drill combines hand driven and gear ratio to provide a convenient speed. A larger gear wheel drives one or two pinions which apply torque to the chuck. The chuck has usually 3 self centering jaws.

## 13. ELECTRICAL SCREW DRIVER

Name : Ele

Material : Blade - Steel;
Handle - Plastic.

Use : To tight or loose slotted screws.

Care : Always use a Screw driver of proper size for a particular work. Never sharpen the blunt edge.

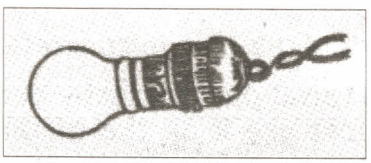
## INTEXT QUESTIONS 2.2

Fill in the blanks:

1. To lineout electrical installation on the wall _____ is used.
2. The Hack saw is used to _____.
3. Trimming knife is suitable for removing the installation from _____.
4. The body of hand drill machine is made up of _____, _____ & _____.
5. To tight or loose slotted screws _____ are used.



## 14. TEST LAMP



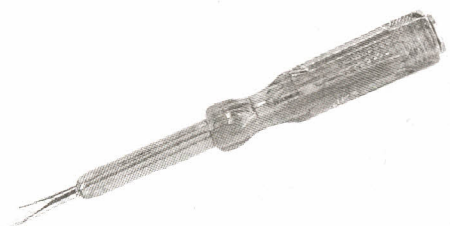
Name : Test Lamp

Material : Bakelite pendent holder, wires and lamp.

Use : To test the electrical circuits i.e. to find out short circuits, open circuits and to test earthing.

Care : Do not keep the test lamp along with the other tools. Never test supply voltage between two lines with single lamp.

## 15. LINE TESTER



Name : Line Tester

Material : Case - plastic
Blade - Steel

Use : To test the phase or live wire only.

Care : Generally do not use the line tester as a screw driver. Never test high voltage by the line tester.

## 16. RAVAL PUNCH

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Notes

Name : Raval punch

Material : Iron

Use : It is use to dig a hole in concrete wall.

Care : Hold the rawal punch exactly perpendicular to the wall. Do not use it on the metallic parts to avoid breakage.

## 2.4 GENERAL TOOL CARE

The simplest & best way to care for hand tools & hand power tools is to use them in the proper way & only for their intended purposes. e.g. the proper size of conventional screw-driver should be used to apply torque to a slotted screw; the screw driver should not be used to open paint pans, bang holes in a lid, pry out bent nails or to chip rock proper use ensures that the tool is always in the best condition to enable its use, completion of a job accurately, rapidly & precisely. It also ensures longetivity of the tool.

Tools should be kept clean & sharp at all times. Burrs & dirt or other foreign matters should be removed immediately. Tools should be stored either by hanging or by placing them in drawers. If tools with cutting edges such as chisels, files, punches, knives or saws are kept in drawers or a toolbox. They should be kept from touching each other. Keep metallic tools thinly coated with light oil. If tools are to be stored for a long period of time (more than one month) apply a rust preventative, such as a light grease, to all metal parts. If one of your tools because worn or dull the most practical solution is usually to buy a new one. Keep the old tool to use for a task for which you would rather not employ a good tool. Some tools such as screwdrivers, punches, chisels & pliers, cutters can be reground. Specific procedures are discussed in the applicable care of each tool.

When tool such as screw-driver, punches, chisels or plier cutters are ground to resharpened or resharp them, the tool should be dipped frequently in cold water to keep it cool. Too much heat can cause loss of temper of the metal; this condition is usually indicated by the appearance of a blue color on the metal.

### GENERAL SAFETY

Always concern yourself and others with safety. Hand & power tools can be very harmful and can harm a person permanently. Sharp tools are the easiest to use and the safest.

### DO'S AND DON'TS

**Do's**

1. Do take your time in working with all tools.
2. Do plan ahead.



3. Do wear rubber soled shoes when working on electrical work, cutting metal and chiseling.
4. Do take work breaks to reduce Fatigue.
5. Do follow the manufacturer's recommendations.
6. Do store your tools properly.
7. Do keep your tools sharp.

**Don'ts**

1. Don't wear neckties, long sleeved shirts or shorts while working in the shop.
2. Don't work when you are tired.
3. Don't allow your children to use sharp tools or power tools unless you are supervising them closely.

## 2.5 WHAT YOU HAVE LEARNT

In this lesson you have learnt description of tool,uses and how to care of them which tools used in electrical field.

## 2.6 TERMINAL QUESTIONS

1. List the basic tools. Describe any two tools with approproate Figure.
2. Write an essay on Basic tools.

3

# ELECTRICAL / GRAPHICAL SYMBOLS

## 3.1 INTRODUCTION

Dear students in last lesson, we learned about wiring tools, their specification and their uses. Whenever we want to start electrical installation work at houses, shops, malls, small scale industries & big industries we need electrical wiring drawing. After discussion with customer, electrical engineer makes drawing while uses ISI symbols. He start work at site, he uses electrical plan which is finally designed by engineer. Symbols are represented by Bureau of Indian Standard (B.I.S.) which are recognized. Actually, there are many electrical symbols. Now, we learn symbols which are recommended in our syllabus.

## 3.2 OBJECTIVES

After reading this lesson you will be able to:

- Learn the electrical/graphical symbol.
- Understand how these symbols are used.

## 3.3 SYMBOLS

Symbols use in wiring are given below.

| Items | Symbols |
|---|---|
| **Switches & switch Outlets** | |
| 1. a) Single Pole |  |
| b) Two Pole (Double pole switch) |  |
| c) Three Pole (Triple pole switch) |  |



2. Single Pole Pull Switch 

3. Multiposition Switch 

4. Two Way Switch 

5. Intermediate Switch 

6. Pendent Switch 

7. Push Button or Bell Push 

**Socket Outlet:**

1. Socket Outlet, 6A 

2. Socket Outlet, 16A 

3. Combined Switch & Socket Outlet, 6A 

4. Combined Switch & Socket Outlet, 16A 

5. Interlocking Switch & Socket Outlet, 6A 

6. Interlocking Switch & Socket Outlet, 16A 

**Lamps:**

1. a) Lamp or Outlet for lamp 

   b) Group of Three 40W lamps 

2. Lamp, mounted on a wall or light bracket 

3. Lamp, mounted on ceiling 



4. Bulk-head lamp 

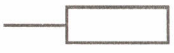
5. Watertight light fitting 

6. Batten lamp holder (mounted on the wall) 

7. Floodlight 

8. Fluorescent lamp 

**Electrical Appliances**

1. General, if necessary use designation to specify 

2. Heater 

**Bells, Buzzers & Sirens**

1. Bell 

2. Buzzer 

3. Siren 

4. Horn or Hooter 

5. Indicator (at 'N' insert number of ways) 


**Fans**

1. Ceiling Fan 

2. Bracket Fan 

3. Exhaust Fan 

4. Fan Regulator 



**Earthing**

1. Earth Point 

2. Fuse 

## 3.4 WHAT YOU HAVE LEARNT

In this lesson we learnt the graphical symbols of electrical field. Now we can prepare any drawing or diagram for the wiring purpose. These symbols are standardized by Bureau of Indian Standard (B.I.S.).

## 3.5 TERMINAL QUESTIONS

Answer the following questions and draw the Figures also.

1. Which symbols are used in electrical technology?
2. Draw the symbols according to IS for following -
   a) Single pole push switch
   b) Bell push
   c) Plug socket
   d) Lamp
   e) Fluorescent lamp
   f) Heater
   g) Fan regulator
3. State the names of symbols:
   a) 
   b) 
   c) 
   d) 

4

# BASIC ELECTRICITY

## 4.1 INTRODUCTION

In previous lesson we have studied symbols and their uses in electrical theory. In this lesson, we are going to learn about basic electricity. Your entire study of electricity is based on electron's theory. The electron theory assumes that all electrical & electronic effects are due to movements of electrons from one place to another place.

All effects of electricity take place because of the existence of tiny particle called the 'Electron'. Since no one actually has seen an electron, but only the effects it produces, we call the laws governing its behavior, the electron theory. Before working with electricity we must know what is an electron & causes in the material for movement.

## 4.2 OBJECTIVES

After the reading this lesson, you will be able to understand:

- Atomic structure of matter,
- Electricity,
- Current,
- EMF,
- Resistance,
- Electrical power,
- Electrical energy
- Simple examples of power & energy



## 4.3 MATTER

A body which has a definite weight and which occupies some space is called 'Matter'. It is found in 3 states: solid, liquid & gas.

**Matter is made up of tiny particles.**

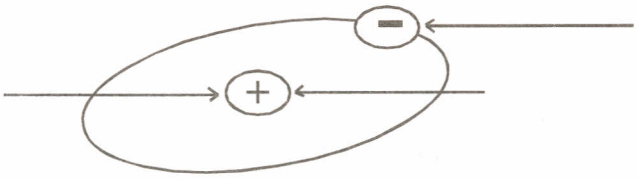
## MOLECULE

Matter can be divided into tiny particles. The smallest particle of a matter which contains all the physical & chemical properties of the matter is called molecule.

## ATOM

The smallest particle of a matter which can take part in a chemical reaction but cannot exist freely is called an atom.

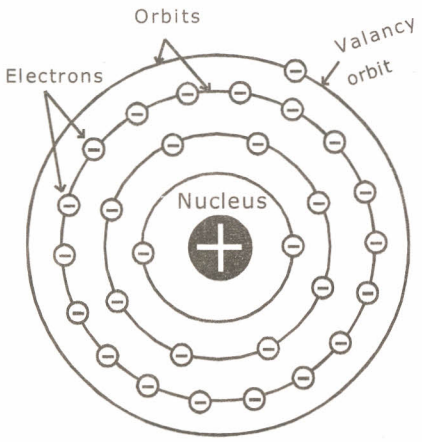
The Atom is consisting of electrons, protons and neutrons.



In an atom, a nucleus surrounded by electrons.

## ATOMIC STRUCTURE

In an atom the total number of negatively charged electrons circling around the nucleus exactly equals the number of extra positive charges in the nucleus. The positive charges are called protons. Besides the protons, the nucleus also contains electrical neutral particles called neutron. These are like a proton & an electron bonded together.





Atoms of different elements contain different number of neutrons within the nucleus, but the number of electrons spinning about the nucleus. Always equals the number of free protons (or positive charges) within the nucleus.

Electrons in the outer orbits of an atom are attracted to the nucleus by comparatively less force than electrons whose orbits are near the nucleus. These outer electrons are called 'Free electrons' and may be easily forced from their orbits, while electrons in the inner orbits are called 'bound' electrons. Since they cannot be forced out of their orbits easily. It is the motion of the free electrons that makes up an electric current.

**Nucleus**

The nucleus is the central part of the atom. It contains the protons and neutrons of an atom. The number of protons & neutrons in the nucleus varies. For the different elements depends on the particular atom involved.

**Proton**

The proton has a positive electrical charge. It is almost 1840 times heavier than the electron & it is the permanent part of the nucleus. Protons do not take an active part in the flow or transfer of electrical energy. Protons repeal each other but have a force of attraction for the negative electron.

**Electron**

It is a small particle revolving around the nucleus in an atom. The electron is three times larger in diameter than the protons. Protons = no. of electron, due to its orbital speed, around the nucleus, carrying a considerable amount of energy.

Since all electrons are negative in charge, they will repeal other electron & have a force of attraction for the positively charged protons.

**Neutron**

A neutron is actually a particle by itself and it is generally thought of as an electron & proton combined. It is electrically neutral. Since neutrons are electrically neutral, they are not important to the electrical nature of atoms.

**Electricity**

The effect of electrons is moving from point to point in a material is called electricity.

**Negative Charge**

The excess of electrons in one material is known as a negative charge.

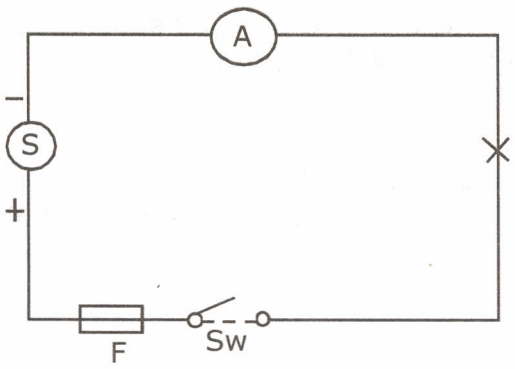


### Positive Charge

The absence of electrons in the other material is called positive charge.

### Current

The flow of electrons in one direction, negative to positive is called Current. Its symbol is 'I' & it's unit is 'ampere', symbol is 'A'. Ammeter is used for measuring current. It is connected in series with load & supply.




S = Source
F = Fuse
SW = Switch
L = Lamp
A = Ammeter

Fig: 3 Connection of ammeter.

Electron theory current flow & conventional current flow. According to the electron theory, current flow is always from a negative charge (–) to a positive charge (+).

Before the electron, theory of matter was discovered, this concept of current flow is called conventional current flow. For your study of electricity, current flow is concluded to be the same as convential current i.e. Current flows from positive terminal of the source to the negative terminal of source through the load.

### UNIT AMPERE

One ampere of current is said to flow through a conductor when one coulomb of charge flows per second of charge flows per second across a cross-section of the conductor. (1 ampere = 1 coulomb / 1 second)

### ELECTROMOTIVE FORCE

When the current flows, the electrical energy of the charges is utilized to move electrons/ charges from positive to negative terminals. This electrical energy is called electromotive force. Symbol is e.m.f. The unit of e.m.f. is volts & its symbol is 'V'. In other words when electrons/ charges move from one terminal to another terminal as current flows the moving force is Electromotive force. Voltmeter is used for measuring e.m.f.

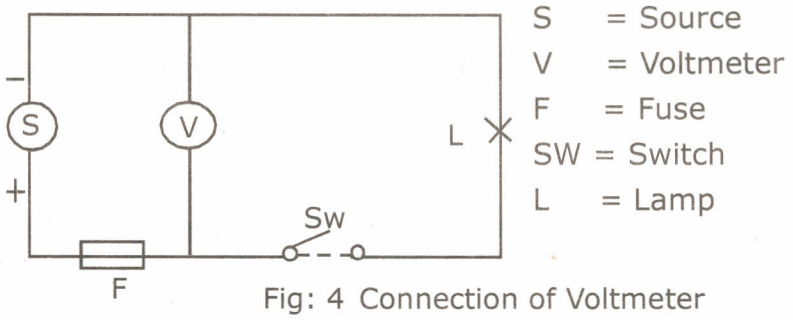



Fig: 4 Connection of Voltmeter

## POTENTIAL DIFFERENCE

The difference in the electric potentials of two charged substances is called Potential Difference. Its unit is 'Volt' & symbol is 'V'.

## UNIT VOLT

A potential of 1 Volt at a point means that 1 Joule of work is done in bringing a positive charge of 1 coulomb from infinity to that point.

1Volt = 1 Joule/ 1 second.

## RESISTANCE

The opposition to current flow is not the same for all material. Current flow itself is the movement of 'free' electrons in a material determines its opposition to current flow. Atoms of some materials give up their outer electrons easily & such materials offer little opposition to current flow, while other materials hold on to their outer electrons & such materials offer considerable opposition to current flow. Every material has some opposition to current flow, whether large or small & this opposition is called resistance.

OR

The property of a substance which opposes the flow of current through it is called resistance. Its symbol is 'R'. The unit of resistance is 'ohm' & its symbol is $\Omega$

## UNIT OHM

One ohm is defined as resistance of that conductor which allows a passage or a current of one ampere through it when a potential difference of one volt is maintained across its ends.

## INTEXT QUESTIONS 4.1

a) Fill in the blanks:

1. A body which has definite weight & which occupies some space is called _____.



2. Smallest particle of a matter is known as _____.
3. Electrons consist of _____ charge.
4. The flow of electrons in one direction is called _____.
5. Unit of current is _____.

b) State True or False:

1. Protons consist of negative charge. ( )
2. Ammeter is connected in parallel. ( )
3. The unit of EMF is Volt. ( )
4. Opposition to the current is known as resistance. ( )
5. Ohm is unit of resistance. ( )

## 4.4 ELECTRICAL POWER

Power means rate of doing work. Whenever, voltage causes electron movement, work is done in moving electrons/ charge from one point to another. The rate at which work is done is called electric power. Its symbol is 'P'. The basic unit of power is the Watt, which equals the voltage multiplied by the current. Its symbol is Watt. The wattmeter is used for measuring power.

To find the power, following formula is used -

$$P = E \times I$$

Where,

P = Power, in watt,

E = Voltage, in volt,

I = Current, in ampere.

Ex. 1 An electric resistance iron takes a current of 4 ampere at a e.m.f. of 230 Volts, calculate the power of lamp?

Ans: $P = E \times I$

$= 230 \times 4$

$= 920$ Watts

Horsepower–It is a unit of measurement of mechanical power.Its symbol is hp

$1hp = 75mkg / s$

$= 75 \times 9.81$

$= 735.5$ Nmls or watt. (1 kg weight = 9.81N).

Module-4

Notes

## INTEXT QUESTIONS 4.2

1. Define the electrical power?

2. An electric heater takes a current 4.35 ampere at EMF of 230 volts calculate the power of electric heater?

## 4.5 ELECTRICAL ENERGY

Capacity for doing work is called energy. That means energy required for electrical work done in a particular time period is called electrical energy. Its symbol is 'E'. The unit of electrical energy is kilowatt hours and its symbol is Kwh. If 1 kwh power is used in 1hour the energy consumed is 1 kilowatt hour. Or Board of Trade Unit ( B.O.T.V.)

$$Kwh = \frac{I \times E \times H}{1000}$$

Where,

Kwh = Kilowatt in units

E = E.m.f, in volt

I = Current in ampere

h = hour

Ex. 1 A motor running on 230-v mains is takes 35 amperes current, for period of 50 hours per week. If the cost of power is Rs. 4 per unit find the cost of running, this motor for 5 hours working.

$$= \frac{230 \times 80 \times 30 \times 4}{1000}$$

$$= \frac{230 \times 35 \times 50}{1000}$$

= 402.5 units.

Bill = Kwh × Rate per unit

= 402.5 × Rs. 4

= Rs. 1610



## INTEXT QUESTIONS 4.3

1. What is energy?

2. A motor running on 230V. Mains take 80 amperes current from the mains. It is used 4 hours per day. If it is used 30 days & rate is Rs. 3 per unit, calculate the bill.

## 4.6 WHAT YOU HAVE LEARNT

- In this unit you have learnt about basic terms of electricity.
- Basic term of current its symbol, unit.
- Basic term of EMF & its symbol unit.
- Connection of Ammeter & voltmeter.
- Definition of resistance & its unit.
- Definition of power & its unit.
- Definition of energy & its unit.
- Simple examples of power & energy.

## 4.7 TERMINAL QUESTIONS

1. What is Matter? Explain in detail.

5. Write a short notes on the Following:

a) Atom

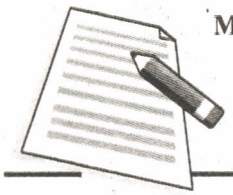
b) Molecule

c) Nucleus

d) Proton

e) Neuteron

f) Electron





## 4.8 ANSWER TO INTEXT QUESTIONS

### 4.1

a) Fill in the blanks:

1. Matter
2. Atom
3. Negative
4. Current
5. Ampere

b) True or False:

1. False
2. False
3. True
4. True
5. True

### 4.2

1. Power means rate of doing work.

2. $$P = \frac{E \times I}{1000}$$

$$= \frac{230 \times 4.35}{1000}$$

$$= 1Kw$$

### 4.3

1. Capacity for doing work is called energy.

2. $$Kwh = \frac{E \times I \times H \times D}{1000}$$

$$= \frac{230 \times 80 \times 30 \times 4}{1000}$$

$$= 2208 \text{ units.}$$

$$Bill = 2208 \times Rs.\ 3$$

$$= Rs.\ 6624$$

5

# CIRCUITS & OHM'S LAW

## 5.1 INTRODUCTION

In earlier lesson we have studied the basic electricity. Now you are well aware of voltage, current, resistance etc. In this lesson we will discuss about circuits, their types, uses etc. & ohm's law.

## 5.2 OBJECTIVES

After reading this lesson you will be able to:

- Understand the Electric circuit.
- Know the types of circuit with its respective effects.
- Define the Ohm's law
- Understand Laws of resistance.
- Classify the circuits:

  Series circuit , Parallel circuit & Series- Parallel circuit

## 5.3 ELECTRIC CIRCUIT

Basically, an electric circuit consists of a power source, a safety device, controlling device and a device & wires to connect each other.

### Simple Circuit

In this figure circuit consisting of only one lamp having resistance, safety device like fuse, controlling device like one way switch, & the voltage source and the connecting wires, it is called simple circuit.

In this circuit D.C. generator, battery, or mains are sources and fuse is a safety device which is used to protect generator from heavy current.

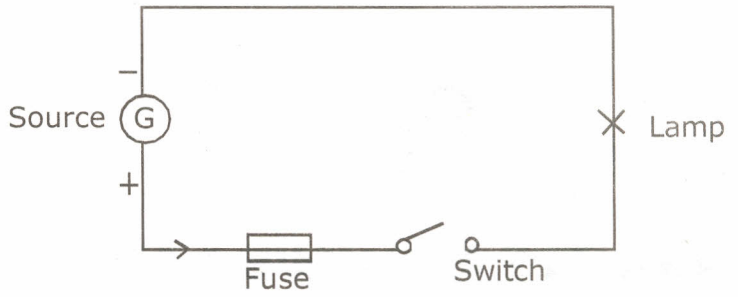



Fig: 5.1 Simple Circuit

Switch is used as controlling device to break the path of current i.e. to make on/ off lamp.

A Lamp is a device which converts electrical energy into light energy as a device. We can use fan, tubelight, motors etc.

In this circuit, when supply voltage is applied to the electrical device conventional current flows from positive terminal (+) of generator through the fuse element. Thereafter, it reaches one terminal of the switch, if switch is on it goes to second terminal of switch, next it goes to one terminal of lamp, current travels through the filament of lamp then it returns to negative terminal of generator through negative wire. This is complete path of electrical current.

**Closed Circuit**

In close circuit, when supply voltage is applied to the electrical device, conventional current start to flows from positive terminal (+) of generator through positive wire. It reaches one terminal of fuse & come out from another terminal of switch through the fuse element. Next it reaches one terminal of the switch, if switch is on it goes to second terminal of switch, next it goes to one terminal of lamp, current travels through one filament of lamp then it returns to negative terminal of generator through negative wire. This is complete path of electrical current. Resistance of close circuit is always medium & some power is wasted in this circuit.

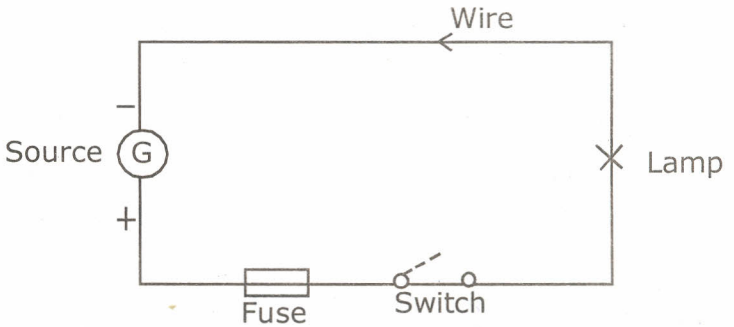
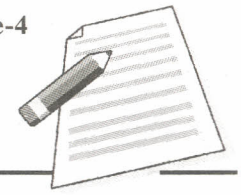



Fig: 5.2 Closed Circuit





## Open Circuit

You already know that for current to flow through a circuit, a closed path must be provided between positive (+) & negative (–) terminals of the voltage source any, break in the closed path open the circuit & stops the flow of current.

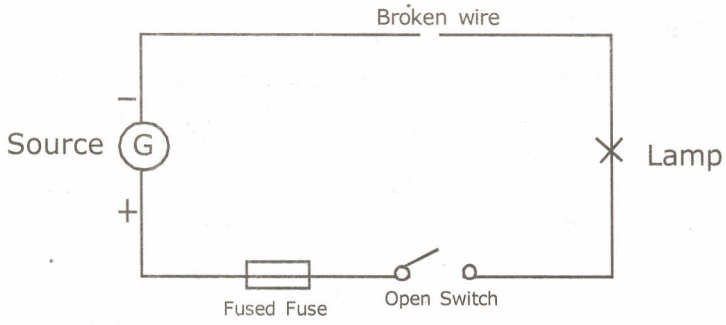



Fig:5.3 Open Circuit

Any break in the circuit is known as open circuit. Open switch, a wall socket, broken wire, fused lamps, switch off are examples of open circuit. In an open circuit, there is an infinitely high resistance in the circuit; there is no voltage drop across the load. There is also no power used by the load & so the total power consumed in a circuit is zero.

## Short circuit

You have seen how an open circuit prevents current flow by breaking the closed path between terminals of the voltage source.

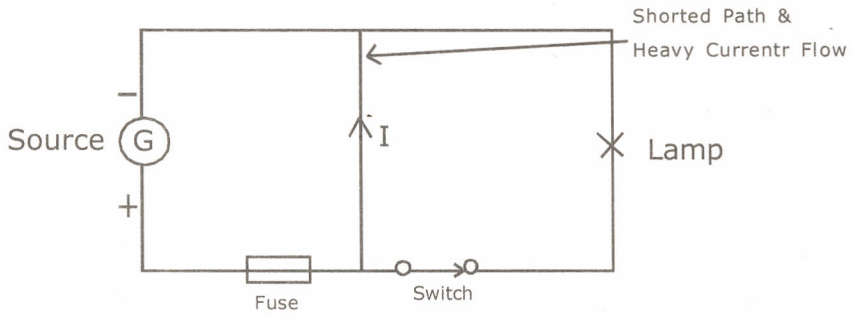



Fig: 5.4 Short Circuit

A short circuit produces just the opposite effects. A short circuit occurs whenever, the resistance of a circuit or part of circuit drops from its normal value to essentially zero resistance. This happens if two terminals of a lamp in circuits are directly connected, the voltage source leads contact each other or two current carrying uninsulated wires touches or the circuit is improperly wired these types of shorts are called short circuit.



The resistance of the circuit becomes so very low that a very high current flows through the circuit. It causes to damages wiring, equipment or source.

Circuits are usually protected against excessive current flow, by the use of fuses.

## 5.4 OHM'S LAW

You have seen that if a certain current flows in a circuit, it flows because a certain electromotive force & that the amount of current is limited by the resistance of the circuit. The amount of current depends upon the amount of electrical pressure & amount of resistance. This fact was discovered by a George S. Ohm & now it is famous as Ohm's law which is the fundamental equation of an electrical science. Since it was first started in 1827. Ohm's law is that the current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance. Following formula's used to find out current, resistance, voltage.

$$I = \frac{E}{R},\ R = \frac{E}{I},\ E = I \times R$$

Where,

I = Current, in ampere

E = Voltage, in volt

R = Resistance, in Ohm

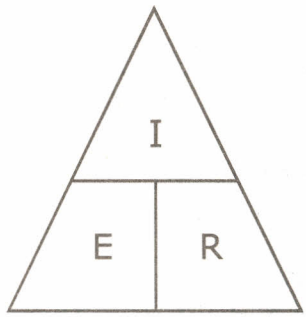



Fig: 5.5 Triangular of
Voltage, Current, Resistance

An aid to remembering the Ohm's law relationship is shown in the divided triangle.

If you know the voltage & resistance of the circuit, you can find out current, then by simply applying the following equation -

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



Ex - 1. A 100 Ohms resistance is connected across 230 volts DC.Supply. Calculate the current flowing through the circuit?

Ans- Given- E = 230 V. R = 100 Ohms

$$\frac{E}{R} = \frac{230}{100} = 2.3A$$ ...Ans.

If you know resistance & current of the circuit, you can find out voltage, by applying the following equation -

$$E = I \times R$$

Ex - 2. A current of 5 ampere of flowing through resistance, Calculate supply voltage?

Ans- Given

I = 5A R = 50 Ohms

$E = I \times R = 5 \times 50 = 250$ Volts

E = 250 Volts

...Ans.

If you know the voltage & current of the circuit, you can find out resistance by applying the following equation -

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

Ex - 3. A resistance is connected across 230 volts DC supply if current passing through the resistance is 12.5 ampere. Calculate the value of resistance?

Ans- Given

I = 12.5 ampere E = 230 Volts

$$R = \frac{E}{I} = \frac{230}{12.5}$$

R = 18.4 Ohms ...Ans.

## INTEXT QUESTION 5.1

**(A) Fill in the blanks:**

1. Fuse is a _____ device.
2. Lamp is a device which converts _____ energy in _____ energy.

3. In simple circuit power source device & _____ device & _____ device are used.
4. A complete path of electrically current is _____ circuit.

**(B) State True or False:**

1. The lamp is the power source.
2. Piano type switch are used as controlling device.
3. In a close circuit current flows from positive terminal of source to the negative terminal of source through given resistance.
4. The relationship between voltage, current, resistance is given ohm's law.
5. To find out infinity value of current flowing through circuit then ohm's law used.

**(C) Match the pairs**

| | |
|---|---|
| a) Voltage | 1) Switch |
| b) Current | 2) Volts |
| c) Resistance | 3) Fuse |
| d) Controlling device | 4) Ohm |
| e) Safety device | 5) Ampere |

## LAW OF RESISTANCE

You have seen that the current flowing through the circuit depends upon voltage & current. Now we are going to see on which factors resistance depends, these factors are known as laws of resistance.

1. The resistance of the conductor to varies directly with its length. The longer length, greater the resistance, shorter the length, lower the resistance.

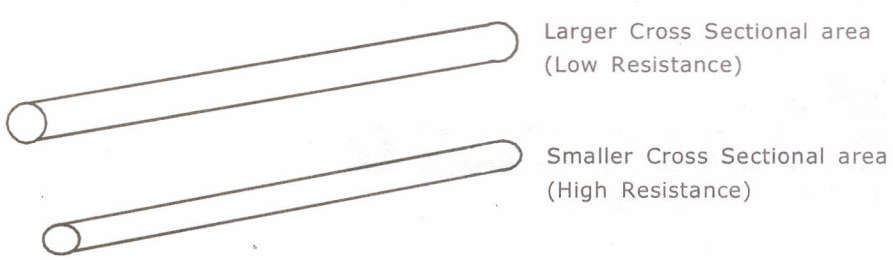



Fig: 6 Relation between resistance and cross sectional area



Ex 1. The resistors of 10 ohm's, 15 ohm's, and 30 ohm's are connected in series across a battery, what is the total resistance?

Ans- Given,

$R_1$ = 10 ohms $R_2$ = 15 ohm

$R_3$ = 30 ohm

$R_T = R_1 + R_2 + R_3$

$R_T = 10 + 15 + 30$

$R_T$ = 55 Ohm ...Ans.

In a series circuit there is only one path for current flow, this means that all the current must flow through each resistance in the circuit.

Ans- $I_T = I_1 + I_2 + I_3$

where,

$I_T$ = Total current, in ampere

$I_1 + I_2 + I_3$ = Individual current of each resistance in ampere.

Ex 2. A series circuit consists of 3 resistors having values of 20 ohms, 30 ohms and 50 ohms respectively calculte the current flowing through the circuit and current flowing through each resistance if it is connected 200 volts supply?

Ans- Given,

$R_1$ = 20 ohms $R_2$ = 30 ohms

$R_3$ = 50 ohms E = 200 Volt

First we calculate $R_T$

$R_T = R_1 + R_2 + R_3$

$= 20 + 30 + 50$

= 100 ohms.

Now we calculate current ( total)

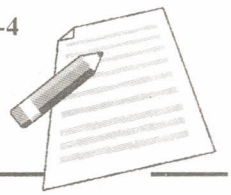
$$I_T = \frac{E}{R_T} = \frac{200}{100} = 2A$$ ...Ans.

The resistance are connected in series so current flowing through

$R_1$, $R_2$, $R_3$ is = 2A

therefore, $I_1$ = 2A, $I_2$ = 2A, $I_3$ = 2A

In series circuit the sum of the resistance voltage drop must equal to source voltage.





2. The resistance of the conductor is inversely proportional to its cross-sectional area. The larger cross sectional area of a conductor, smaller the resistance & the smaller cross-sectional area, higher the resistance.
3. The resistance of the conductor depends upon the material. Each material offers a different resistance to the movement of electrons. Silver, Copper, Gold, Aluminum material has low resistance, with respective its resistance.
4. The resistance of conductor depends on the temperature of the conductor. At higher or lower temperature, the resistances of all material changes. In most cases, the temperature of a material goes up, its resistance also goes up, but with some other material, increased heat causes the resistance to go down the amount that resistance is affected by each degree of temperature changed is called temperature co-efficient.

## 5.5 CLASSIFICATION OF CIRCUITS

We seen a simple circuit in which source, fuse, switch & lamps are connected in series with the help of wires. In this circuit only one lamp was connected. However, you will often find that a circuit has more than one load. It may have 2, 3, 4 or a number of lamps or resistance. They may be connected in series or parallel.

### Series Circuit

Whenever you connect resistances end to end they are said to be series connected. If all the resistances around a circuit are connected in end to end so that there is only one path for current flow. They form a series circuit. In series circuit total resistance equals, the sum of the individual resistances. There total resistance of series circuit we can calculate by following equation-

$$R_T = R_1 + R_2 + R_3$$

where,

$R_1$, $R_2$, $R_3$ = Individual Resistance; in ohms

$R_T$= Sum of individual resistances; in ohms.

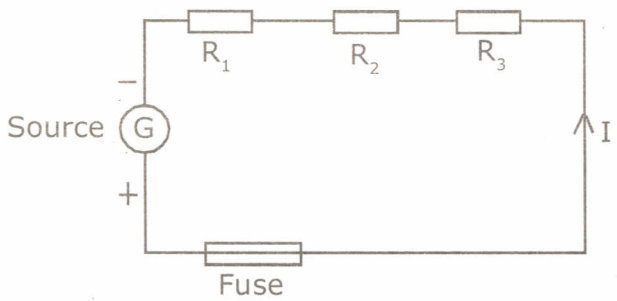



Fig: 5.7 Series circuit



Example - 2. A series circuit consist of 3 resistors having values of 20, 30 & 50 ohms respectively. Find the applied voltage, if the current through circuit is 2 ampere?

Ans- Given,

$R_1$ = 20 ohms, $R_2$ = 30 ohms, $R_3$ = 50 ohms, I = 2A

Let us calculate voltage drop across each resistance.

$V_{R_1} = I \times R_1 = 2 \times 20 = 40$ V

$V_{R_2} = I \times R_2 = 2 \times 30 = 60$ V

$V_{R_3} = I \times R_3 = 2 \times 50 = 100$ V

therefore, $V_{R_1} = 40$ V, $V_{R_2} = 60$ V, $V_{R_3} = 100$ V

Once individual voltage drops are known they can be added to find total or applied voltage.

therefore, $E_1 = V_{R_1} + V_{R_2} + V_{R_3}$

$= 40 + 60 + 100$

$= 200$ V

$E_1 = 200$ V ...Ans.

The total voltage drop across a resistor in a circuit is proportional to the ohmic value of the resistors.

## OPEN CIRCUIT IN SERIES

You already know that a current to pass through a circuit, a closed path is required, so any break in the series circuit causes an open circuit, & stops current flow. There is no power wastage in circuit.

If more than 2 lamps are connected in series and if one of them is fused then there is no current flowing through the circuit and so one lamp will light.

## SHORT CIRCUIT IN SERIES

If the short circuit created in series circuit the total resistance will be reduces & a large current will flow through the circuit.

### Uses of series circuit:

1. Decorative
2. Fan regulator which is connected in series with fan can reduce the speed.
3. To measure circuit current with the help of ammeter.
4. The fuse used for protection of electrical installation.
5. To control the speed of DC Motors.
6. To increase the battery voltages.

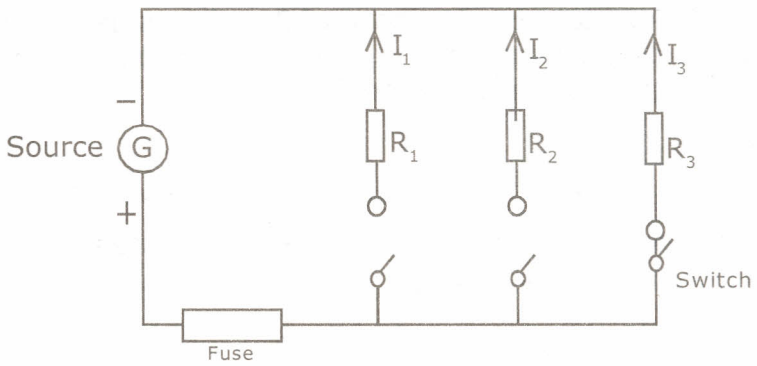



Fig: 8 Parallel Circuit

## Parallel Circuit

When you connect resistances side by side with the ends connected, they are parallel connected. A parallel circuit is one in which there are one or more points where current divided & flows different paths.

When circuit connected in such a way that they provide different current paths it is to be said that connected in parallel. In parallel circuit, total resistance is not the sum of individual resistances. More resistances there are the lower is the total resistance & total resistance is smaller than any of the individual resistance. The total resistance can be find out by a $\frac{\text{Product}}{\text{Sum}}$ or product over the Sum method to use this method you first multiplied the values of two resistances to get their product then added the values of two resistances to get there sum. Finally you divide the $\frac{\text{Product}}{\text{Sum}}$, & the result is total resistance following equation may be used.

$$R_T = \frac{\text{Pr oduct}}{\text{Sum}} = \frac{R_1 \times R_2}{R_1 + R_2}$$

This method can be used only for two parallel resistances. This method is not suitable for more than two resistances which are connected in parallel.

Combinations of 3 or more unequal resistances in parallel are sometimes used. To find the resistance of such combinations, you first find the total resistance of any two of the resistances. Combine this total in the same way with another of the resistance values & you have total for 3 resistances. Continue to combine the total with additional resistances until all of the resistances has been combine to give the total resistance of all parallel resistances.

You can apply another method also, to find out the effective resistance of the parallel circuit.

therefore, $\frac{1}{\text{Reff}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$



The reciprocal of the resistance $\frac{1}{R}$ is known as the conductance of a circuit. Using this term,

you can state that the combined conductance of a number of conductors in parallel is equal to sum of their separate conductance.

e.g. 1. 4 ohms, 2 ohms & 6 ohms respectively 3 resistors are connected in parallel. Calculate the combined resistance ( Reff.) of the circuit.

Ans- Given,

$R_1$ = 4 ohms

$R_2$ = 2 ohms

$R_3$ = 6 ohms

$$\frac{1}{Reff} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{4} + \frac{1}{2} + \frac{1}{6}$$

$$= \frac{3+6+2}{12} = \frac{11}{12}$$

Reff $= \frac{12}{11}$ = 1.1 ohms therefore, Reff = 1.1 ohms

## Parallel circuit voltages

In this type of circuit the voltages across each branch resistance is equal to that across the other. In other words, in a parallel circuit, the same voltage is present across the resistors of a parallel group. This voltage is equal to the applied voltage.

therefore, $V_T = V_{R_1} = V_{R_2} = V_{R_3}$

e.g. 1. 3 resistors of 4ohms, 2 ohms , & 6ohms respectively are connected in parallel. If current flowing through 4 ohms resistance is 2.5 A, current flowing through 2 ohms resistance is 5 A & current flowing through 6 ohms resistance 1.68 A, calculate voltage across each resistance & supply voltage?

Ans: Given-

$R_1$ = 4 ohms

$R_2$ = 2 ohms

$R_3$ = 6 ohms

$V_{R_1} = I \times R_1 = 2.5 \times 4 = 10$ V

$V_{R_2} = I \times R_2 = 5 \times 2 = 10$ V

$V_{R_3} = I \times R_3 = 1.68 \times 6 = 10$ V

$V_T = V_{R_1} = V_{R_2} = V_{R_3}$

1 = 10 = 10 = 10 = 10V

therefore, $V_T$ = 10 V

**Current in Parallel Circuit:**

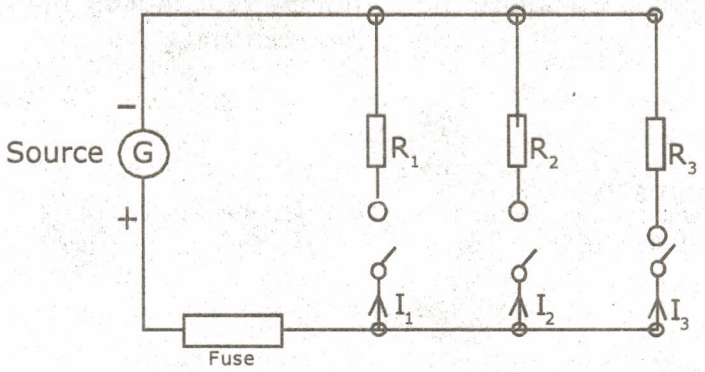



Fig: 9 Current in parallel Circuit

Current divides among the various branches of a parallel circuit in a manner depending on the resistance of each branch. However source current in a parallel circuit divides among the available paths in relation to the value of resistors in the circuit for a given voltage current varies inversely with resistance.

e.g.1. Three resistances of 10 ohms, 20 ohms & 30 ohms respectively are connected in parallel across 50 volts DC supply calculate the current flowing through each circuit & total current of the circuit?

Ans- Given

$R_1$ = 10 ohms

$R_2$ = 20 ohms

$R_3$ = 30 ohms

E = 50 V

$I_{R_1} = \frac{E}{R_1} = \frac{50}{10} = 5$ A

$I_{R_2} = \frac{E}{R_2} = \frac{50}{20} = 2.5$ A

$I_{R_3} = \frac{E}{R_3} = \frac{50}{30} = 1.67$ A

$R_3$ 30

therefore, $I_{R_1}$ = 5 A, $I_{R_2}$ = 2.5 A, $I_{R_3}$ = 1.67 A

Let us calculate circuit current:

$I_{R_T} = I_{R_1} + I_{R_2} + I_{R_3}$



$= 5 + 2.5 + 1.67$

$I_{R_T} = 9.17$ A

### Short in Parallel Circuit

The equivalent resistance of the straight wire & the resistors, all connected in parallel, will be less than the resistance of the straight wire. This follows from the fact that the total resistance of a parallel circuit is always less than the smallest resistance in the branch. Since a complete path still exists to permit current flow, & the equivalent resistnce is effectively zero, the current will rise rapidly until the current capacity of the fuse is reached. The fuse will then open the circuit causing the current to stop flowing. A short usually causes components to fail in a circuit which is not properly used or otherwise protected. The failure may take the form of burned out resistor, damaged source or a fire in the circuit components & wiring.

Uses of parallel circuit

1. In general lighting ( house, shops, offices)
2. Ammeter shunt.

### Series - Parallel Circuit

Circuits consisting of three or more resistors may be connected in, partly series, & partly parallel one in which a resistance is connected in series with a parallel combinations & the other in which one or more branches of a parallel circuit consist of resistances in series. While solving circuit first solve parallel circuit first solve parallel circuit & then series circuit by applying parallel circuit & series circuit laws respectively.

## 5.6 WHAT YOU HAVE LEARNT

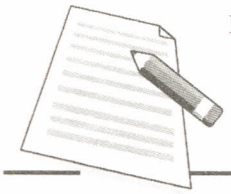
In this unit you have learnt about circuits & ohms law. We also learn the simple circuit i.e. electric circuit. Close circuit, open circuit, short circuit are the types of circuit. Ohms law founded by George S.Ohm.

This is the Formula of to find out the voltage, current resistance. We studied:

the Laws of resistance and Classification of circuit.

## 5.7 TERMINAL QUESTIONS

1. Which factors consist by an electrical circuit?
2. What do you mean by close circuit?
3. What are the examples of open circuit?





4. What is the meaning of short circuit?
5. State the ohm's law?
6. State ohms law with equations?
7. What is simple circuit? Explain with neat diagram
8. Write a short note on series circuit
9. Write a short note on parallel circuit
10. State the uses of series circuit parallel circuit & series parallel circuit?

## 5.8 ANSWER TO INTEXT QUESTIONS

**(A) 5.1**

1. Safety
2. Electrical, light energy
3. Safety, controlling
4. Closed

**(B) True or False:**

1) True
2) True
3) True
4) False
5) True

**(C)**

(a) - 1
(b) - 2
(c) - 4
(d) - 1
(e) - 3

6

# WIRE & CABLES

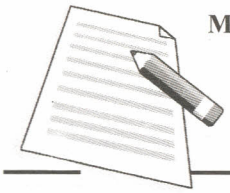
## 6.1 INTRODUCTION

In previous lesson we have studied about simple circuit, types of circuit, their characteristics, ohm's law & its applications, series and parallel circuit. Do you know that we always need some types of conductors and insulators to produce electricity, to transmit, to distribute and to use the electricity. We will discuss the conductors, insulators, wire and cables in this lesson.

## 6.2 OBJECTIVES

After the reading this lesson, you will be able to:

- Understand Conductor, Conductance, Resistance.
- Classify of conductors.
- Explain use of conductors.
- Know types of wires and its uses.
- Standard Wire Gauge.
- Identify the Cables, types of cable.
- Use of cables.
- Understand the Current carrying capacity of wire and cable.
- Learn the Conductors splices and terminals connections.
- Know Types of terminal.



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## 6.3 CONDUCTOR

A conductor is a wire or combination of wires not insulated, suitable for carrying electric current is called Conductor.

### Conducting Material

The material / substance which permit the free motion of electric current through it is known as conducting material. From these conducting material we makes round and strip shape conductors which are suitable for carrying current in electrical work.

### Conductance

The ability of substance which allows to flow of current through it is called' conductance".

Its symbol is 'G'.

The unit of conductance is 'Mho' and its symbol $\mho$. It is exactly opposite of resistance.

### Resistance

It is a property of material which opposes the flow of current through it is called resistance.

Its symbol is 'R'.

The unit of resistance is ohm.

## CLASSIFICATION OF CONDUCTORS

A conductors are classified in:

**(1) With respective Physical Appearance**

a) Solid conductor.

b) Stranded conductor.

c) Multistranded conductor.

d) Flexible conductor.

**(2) With respective material used**

a) Bright electrolyte grade copper.

b) Electrical grade aluminum conductor.

**(3) With respective of their property**

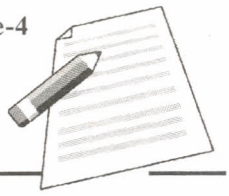
a) Good conductor.

b) Bad conductor.

c) Non conductor (Insulators).

**(4) With respective their shapes**

a) Round shape.





b) Strip shape.

c) Rod shape.

d) Rope shape.

**(1) With respective Physical Appearance:**

**a) Solid conductor**

A single wire is known as solid conductor. They are used in cable, over head wiring and house wiring. It is available in different diameters.

Usually the conductor is made up of copper, aluminum and steel.

**b) Stranded conductors**

The group of conductors having small diameter with respective solid conductors are known as stranded conductors. They are used generally because of their increased flexible and consequent case in handling. In stranded conductors 1, 7, 19, 37 strands having 1.13 to 3.73 mm diameter are used.

**c) Multistranded conductors**

Conductors having smaller diameter with respective stranded conductors are known as multistranded conductors. This type of conductors are used in multistranded wires and cables. In multistranded wires 14, 22, 24,84 strands having 0.2 or 0.3 mm diameter are used.

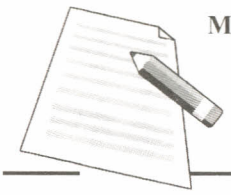
**d) Flexible conductors**

Conductor having smallest diameter with respective multistranded conductors are known as Flexible Conductor. This type of Conductor is used for domestic appliances. In Flexible Conductors 14, 23, 40 strands having diameter of less than 0.2 are used.

**(2) With respective of material used**

**a) Electrical grade copper –** Copper has a higher conductivity. It can be drawn out, has relatively high stencil strength and it can be easily soldered. It is more expensive and heavier than aluminum. It is used for wires, cables, bus bars. Now a days, copper wire must be used in house wiring, ranging from 1.5 sq.mm., 4 sq.mm., 6 sq.mm.

**b) Electrical grade aluminum –** Aluminum has lower conductivity about 60% of copper. It is cheap and lighter than copper. Generally, it is used in transmission and distribution line, bus bar and body of motor etc. They are available in 1 sq.mm. 5 sq.mm., 4 sq.mm.,6 sq.mm. sizes.



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**c) G. I. Wire –** G. I. Wire has a lowest conductivity. It can be drawn out in small gauge. It has very high stencil strength. It is heavier than aluminum and it is used in transmission line, in over-head line and to give strain to pole.

**(3) With respective of their property**

**a) Good conductors –** Those conductors which offer very low resistance are called good conductors. Such as silver, copper, aluminum etc. They are used for carrying current from one place to another place.

**b) Bad conductors –** Conductors which offer medium resistance are called bad conductors. Tungsten, Eureka, Nicrome and Carbon are the bad conductors. They are used for converting electrical energy in heat, light, chemical sound effects.

**c) Non conductors –** The substances which offers very high resistance to the flow of electric current are called non conductors or insulator.

Porcelain, bakelite, asbestos, glass, rubber and pvc are examples of non conductors. They are used for covering the conductors.

## USES OF CONDUCTORS:

1. To carry the current from one place to another place.
2. Making bus bar.
3. For strengthening the pole.
4. Making fuse wire.
5. Making heating wire.
6. Making a connection of appliances to supply.

### 6.4 Wire: Wire is used to carry the current from one place to another

**Types of wire**

**1. According to insulation -**

**Old type**

a) V. I. R. wires.

b) C. T. S. wires.

c) T.R.S. wires.

d) Lead cover wire.

**New type**

a) PVC wires.



b) PVC FR wires.

c) PVC F.R.L.S. wire.

**2. According to conducting material -**

a) Copper conductor wires.

b) Aluminum conductor wires.

**3. According to voltage grade -**

a) Low Voltage grade wires.

b) Medium voltage grade wires.

c) High voltage grade wires.

**4. According to uses-**

a) Domestic wires.

b) Industrial wires.

c) Winding wires.

d) Heating wires.

**1) According to insulation**

**(a) V.I.R. wires-(Vulcanized India Rubber)**

In this type of wire a tinned copper conductors or aluminum conductors are used. The conductors are covered by Vulcanized India Rubber. It is then covered with cotton tape and cotton braiding. Finally, it is dipped in bitumen compound. The copper conductor is tinned to provide protection against corrosion due to presence of traces of sulphur, zinc oxide and other mineral ingredients in the V.I.R. It is available in single cotton covered, double cotton. It is available in 1/18, 3/20, 3/22, 7/20, 7/22, 7/16, 19/22, 19/16 sizes. It is suitable for indoor conduct wiring, casing capping wiring and cleat wiring. This type of wire is available in single core only. It is suitable for low and medium voltage supply only.

**(b) C.T.S. wire-(Cabe Tyre Sheath wire)**

In this type of wires, a tinned copper conductors are used. These conductors are covered by red and black color rubber. It is then coated with a layer of hard rubber. It is available in sizes 1/18, 3/20, 7/22 etc. It does not absorb moisture. It is used in batten wiring service lines and short distance overhead lines. It is available in 250/440 voltage grade only.

**(c) T.R.S. wires-(Tough Rubber Sheath)**

V.I.R., C.T.S., T.R.S. wires are old types wires which are not used in market.

### (d) PVC wires

In this type of wire, copper or aluminum conductors are used. Conductors are covered by polyvinyl chloride insulation. It is available in sizes $1mm^2$, $1.5mm^2$, $2.5mm^2$, $4mm^2$ etc. It is available in single core, twin core and three core. Now a days PVC wires are widely used. Its life is long. It can be used in PVC conducts PVC casing capping, overhead wiring etc. These are not sensitive to mild dose of water, heat, oil, acid, alkalis, sunrays, ultraviolet rays etc. It is available in 600, 660, 1100 Voltage grade. F.R. wires and F.R.L.S. wires are widely used, because current carrying capacity and voltage rating is more than old PVC wires.

### Uses of wires

1. Multistranded wires are used in domestic wiring.
2. Stranded wires are used in domestic and small industries wiring.
3. Solid wires are generally used in domestic wiring.

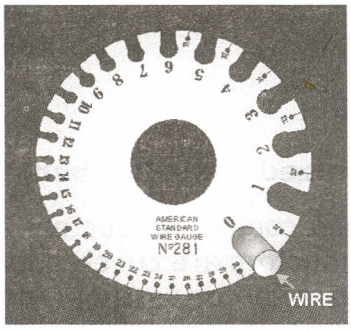



Fig: 6.1 Standard Wire Gauge

## STANDARD WIRE GAUGE

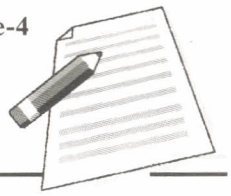
The standard wire gauge (SWG) is an instrument used for determining the size of a conductor of the wire and cable. It is a thin circular plate of steel with a number of slots on its circumference. Each slot is marked with specific number denoting gauge. Holes are provided at the end of each slot for removing the wire easily.

## INTEXT QUESTIONS 6.1

**1) Fill in the blanks:**

1) The conductors which offer very low resistance are called _____.

2) The conductors which offer medium resistance are called _____.





**2) Match the following:**

| | | | |
|---|---|---|---|
| 1) | Good conductor | a) | Size of conductor |
| 2) | PVC Wire | b) | Silver |
| 3) | Non conductor | c) | Porcelain |
| 4) | Standard Wire Gauge | d) | Polyvinyl Chloride |

## 6.5 CABLES

A cable is either a stranded conductor ( single-conductor cable) or a combination of conductors insulated from one another. The term cable is a general one and in practice it is usually applied only to the larger sizes of conductors. A small cable is more often called a stranded wire or cord. Cables may be bare or insulated. The insulated cables may be covered with lead, or protective armor.

### Types of Cables

Cables can be classified according to various factors given below:

**1) According to insulation:**

a. Cotton covered Cable.

b. Silk coated Cable.

c. Asbestos covered Cable.

d. Rubber coated Cable.

e. PVC coated Cable.

**2) According to conductors material:**

a. Copper.

b. Aluminium.

**3) According to their shapes:**

a. Round shape.

b. Flat shape.

**4) According to cores:**

a. Two core.

b. Three core.

c. Three and half core.

**5) According to mechanical protection:**

a. Unarmored.

b. Armored.

**6) According to voltage grade:**

a. Low voltage grade.

b. High voltage grade.

**Uses of cables:**

1. Small industries.
2. Big industries and factories.
3. Distribution lines.
4. Transmission lines (High voltage cable).
5. Low voltage cables are used in domestic wiring for appliances.

## CURRENT CARRYING CAPACITY OF WIRE OR CABLE

It is a maximum safe value of current in amperes which can pass through a cable without generating heat above room temperature. Any excess current flowing above safe value will result in heating of cable in a very short duration which will damage the insulation and if persists for a long period will result in short circuit. Any insulation will always have a short time over current capability but it's not recommended to use this capability under normal operating conditions.

## CONDUCTOR SPLICES AND TERMINAL CONNECTIONS

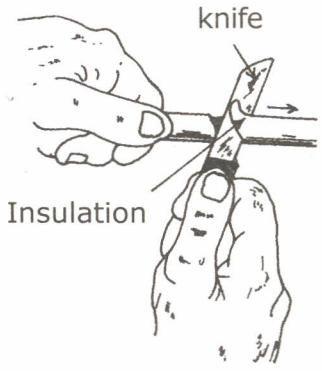
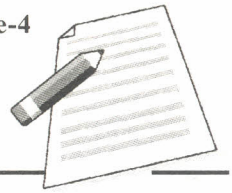



Fig: 6.2 Striping Insulation

Conductor splices and connections are an essential part of any electric circuit. When conductors join each other, or connect to a load, splices or terminals must be used. It is important that they be properly made splice or connection both mechanically and electrically as strong as the conductor or device with which it is used.

## STRIPING THE INSULATION

The first step in making a splice is preparing the wires or conductor. Insulation must be removed from the end of the conductor and





the exposed metal cleaned. In removing the insulation from the wire, a sharp knife is used in much the same manner as in sharpening a pencil. That is, the knife blade is moved at a small angle with the wire to avoid "nicking" the wire. This produces a taper on the cut insulation, as. The insulation may also be removed by using a pliers like hand operated wire stripper. After the insulation is removed, the bare wire ends should then be scraped bright with the back of a knife blade or rubbed clean with fine sand paper, when you removing insulation you should be take care of do not cut insulation near at right angle this will be very bad practice. Probably it causes nicking of insulation and conductor. A nicked conductor became so weak, after be in bend a few times, it will almost certainly break.

## 6.6 TERMINATING

The entry of a cable end into a accessory is known as a termination. In the case of a stranded conductor, the strands should be twisted together with pliers before terminating. Care must be taken not to damage the wires.

### Types of terminal

There is a wide variety of conductor terminations. Typical methods of securing conductors in accessories are pillar terminals, screwheads and nuts, washers.

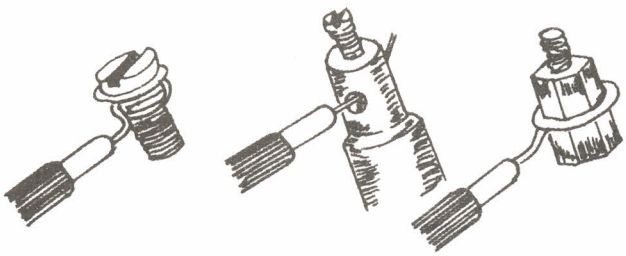
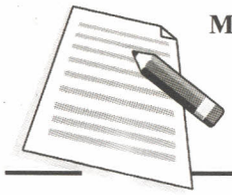


Fig: 6.3 Types of termination

A pillar terminal has a hole through its side into which the conductor is inserted and then secured by a set screw. If the conductor is small in relation to the hole, it should be doubled back when two or more conductors are to go into the same terminal, they should first be tightly twisted together. In the case of flexible cord terminations, the strands must be twisted up (and then bent back if room permits) before being entered into the terminal.

When fastening conductors under screwheads or nuts, it is best to form the conductor end into an eye by means of the roundnosed pliers. The eye should be slightly larger than the screw shank, but smaller than the outside diameter of the screwhead, nut or washers. The eye should be placed in such a way that rotation of the screwhead or nut tends to close the joint in the eye. If the eye is put the opposite way round the motion of the screw or nut will tend to untwist the eye, and will probably result in inperfect contact.



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## 6.7 WHAT YOU HAVE LEARNT

In this lesson we read conductors and insulators as well as wire and cable. Now we have known the types of conductors and can classify them and also use them. Wires and cables are being used in house wiring, home appliances, and in electrical Instuements, apperatus etc in our daily life. Since we are living in Modern era or Science's era So Eleetricity and its appliances play an important role in our life.

## 6.8 TERMINAL QUESTION

1) Describe the uses of following materials

   a) Conductor

   b) Cable

   c) Standard Wire Gauge

## 6.9 ANSWER TO INTEXT QUESTIONS

**6.1**

Fill in the blanks

   i) Good conductor

   ii) Bad Conductor

**6.2**

Match the pair

i) b ii) d iii) c iv) a

7

# ELECTRICAL WIRING ACCESSORIES

## 7.1 INTRODUCTION

In previous lesson, we have studied mainly about wire & cables. In this lesson, we are going to discuss an electrical controlling, holding safety, outlet & general accessories.

## 7.2 OBJECTIVES

After reading this lesson, you will be able to:

- Understand the Electrical Accessories.
- Learn about Identify & use of the Switches, Bell push, Double Pole Switch, Plug Socket, Pin Socket, Ceiling Rose, Adaptor, Connector, Fuse etc.

## 7.3 ELECTRICAL ACCESSORIES

An electrical domestic accessory is a basic part used in wiring either for protection & adjustment or for the control of the electrical circuits or for a combination of these functions.

### Rating of accessories

The standard current ratings of the accessories are 6, 16 & 32 ampere. The voltage rating is 240V AC as per B.I.S 1293–1988.

### Construction of accessories

These accessories should be provided with complete enclosures, which shall afford adequate protection against accidental contact with all live parts. The parts & the materials normally used are shown in the following Table:

| Parts | Materials |
|---|---|
| 1. Base | Vitrified Ceramic material or non-ignitable, molded insulating material e.g. Bakelite |
| 2. Covers, Cover plate & actuating member | Tough non ignitable insulating materials e.g. Bakelite |
| 3. Springs | Corrosion – resistance metal |
| 4. Terminals | Plated Brass terminal posts & screws |
| 5. Attachment fitting screws & other non current carrying parts | Mild Steel, aluminum alloy or insulating material. |

## 7.4 SWITCHES

A manually operated device for closing & opening a circuit is known as switch. It may be categorised as following.

Switches

Single Pole Switch  Two way Switch  Bill Pus  DoublePole Switch

One way switch (single pole), two way switch, Bell push, double pole switch.

### (1) Single Pole Switch

Flush, will mounting or switches is the most popular switches in domestic wiring. The flush (piano) switch must be fixed on a PVC gang box or on wooden box. The gang boxes ate available in 1gang 2, 3, 4, & 6 gang according to no. of switches. Standard gang boxes are designed so that the switch is fixed by screw directly or indirectly.

One way switch have current rating 6amperes. These are used for light & fan point rating of power switches is 16 amperes & are used for freeze, mixer, washing machine, geezer, etc.

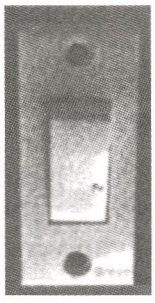


Fig:7.1 S.P. switch

### (2) Two-way switch

This type of switch have 3 terminals. Centre terminal is known as common terminal (c). Above terminal of common terminal is Upper terminal (u) & below of the common terminal is Lower terminal (L). Two way switch has current rating 6 amperes only. These are used for stair case wiring, godown wiring, hospital wiring.



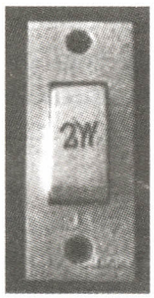



Fig: 7.2 Two-way switch

### (3) Bell push

This type of switch having two terminals with spring loaded push button. When we push it makes the circuit temporarily & attends break position when released. It is used in call bell circuit, current rating is 6 ampere & suitable for 250V only.

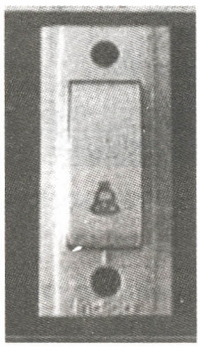


Fig: 7.3 Bell push

### (4) D.P. Switch (Double Pole Switch)

This switch is consisting of double pole switch, fuse, fuse link & neon indicator. These switches are used as main switches to controlled main or branch circuit in domestic installation. They are available in 10 ampere, 16 ampere & 32 ampere & suitable for 250V only.

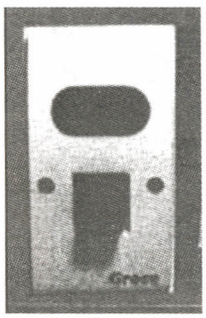


Fig: 7.4 D.P. switch

## 7.5 PLUG SOCKET

Two pin plug socket having only two pins without earth connection. These are suitable only for double insulated appliances. Current rating of two pin plug socket is 6 ampere & suitable for 250V only.

Three pin plug socket has 3 terminals marked as L(Line), N(Neutral) & E(Earth). The L terminal is always on the right hand side, The N terminal of left hand side, & the top is the earth terminal which is larger in diameter & heavy. Dear student you must have connected earth wire to the earth terminal of the socket. This sockets are rated 6 ampere & 16 ampere & suitable for 250V only.

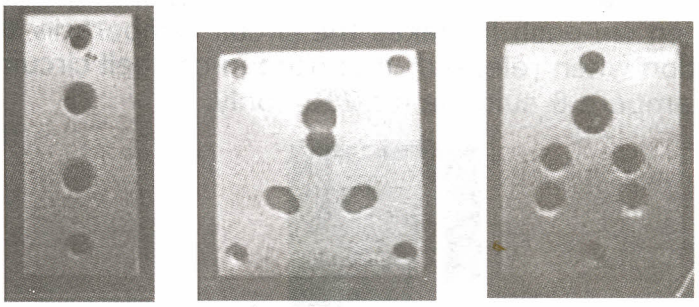


Fig: 7.5 Plug socket

Multi pin sockets are also available, which are suitable for 2 pins & 3 pins having 5 holes in one unit.

## 7.6 PLUG PIN TOP

Two pin plug to is used for taking the supply from the socket. It has got two pins of the same size. It is suitable for 6 amperes & 250V only.

Three pin plug top also used for taking a supply from the socket. It has 3 pins, two are smaller in size & third one is bigger & longer which is for earth. These are rated as 6A 250V or 16A, 250V.

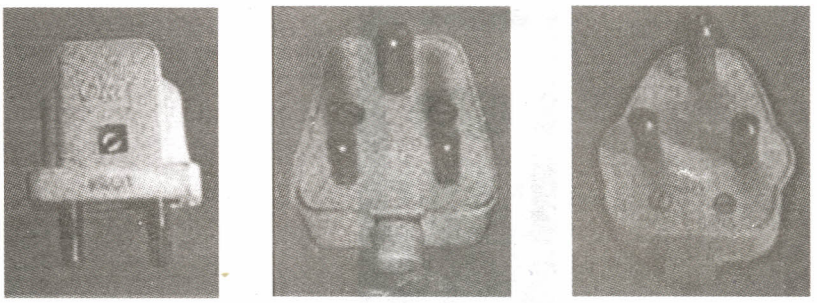


Fig: 5.6 Plug pin top



## 7.8 CEILING ROSE

Two plate ceiling rose is made of PVC & it has two terminals or plates which are separated from each other by a bridge. Each of the terminal plates is provided with a metallic bar & a binding screw on one side through which the circuit wire from the back via the mounting block enters them. The other side of the terminal plate is provided with washer & screw for tap wire connection. It is used for 6A, 250V.

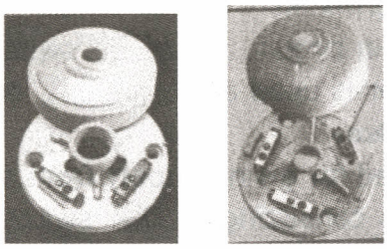


Fig: 5.7 Ceiling Rose

Three plate ceiling rose is also available in market. It has 3 terminals which are separated from each other by a bridge.

## 7.9 ADAPTOR

It is used for taking a supply from a lamp holder for small appliances. They are made of PVC or bakelite material.

## 7.10 IRON CONNECTOR

It is used as female connectors to supply current to electric cettels electrical irons, hot plates, heaters and it is made up of bakelite or PVC. The wires are connected with a twin nickel spring. The cable entry has a rubber protection type.

## 7.11 FUSE

There are the ones mostly used in domestic installations. This Fuse consists of a Porcelain base having two fixed contacts, for connecting the incoming & outgoing cables. The bottom part of the fuse is called the base & the top is called the Fuse-carrier. The line & load wires are connected in the base terminals & the carrier is provided with a fuse. The base is fixed but the carrier is removable.

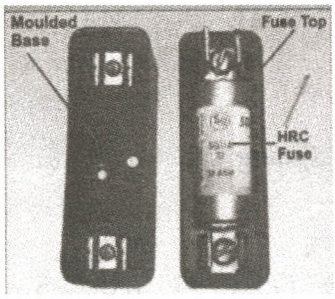



Fig: 5.8 Fuse



## INTEXT QUESTIONS 7.1

a) Fill in the blanks:

1. A manually operated device for closing & opening a circuit is known as _____.
2. Single pole switch fixed on _____.
3. Two way switch has 3 Terminals i.e. _____, _____, _____, terminals.
4. To control main circuit _____ switch is used.
5. Iron connector is used as _____ connectors.

b) State True or False-

1. Adaptor is used for giving supply from small appliances.
2. D.P. Switch is consisting of D.P. switch, Fuse, Fuse link, & neon indicator.
3. Three pin plug socket has 2 terminals.
4. Bell push used in call bell circuit.

5. Electrical accessories use for the protection & adjustment.

## 7.12 WHAT YOU HAVE LEARNT

In this lesson you have learnt about electrical accessories which is a basic part and used in wiring either for protection & adjustment or for the control of the electrical circuits or for a combination of these functions. Such as switches used for on or off a lamp, Single pole or one way switches are used for light & Fan point, stair case wiring, godown wiring etc.

## 7.13 TERMINAL QUESTIONS

1. State the name of electrical accessories. Write a short note on them.
2. Write a short note on Fuse.
3. Write a short note on D.P. Switch.

## 7.14 ANSWER TO INTEXT QUESTIONS

**7.1 (a)**

1. Switch
2. Gang box
3. Common, Upper, Lower
4. Double pole
5. Female connectors

**(b)** 1. False 2. True 3. False 4. True 5. True



8

# FUSE & EARTHING

## 8.1 INTRODUCTION

In previous lesson, you have seen electrical accessories which are used in electrical field. You also know that in simple circuit fuse are used as a safety device. Now in this lesson, we will discuss about their characteristics & uses.

Earthing is also a safety device as a fuse. It prevents to minimize the risk of shock to human beings. In this lesson we are also going to study about purpose of earthing, its functions & types of earthing.

## 8.2 OBJECTIVES

After reading this lesson, you will be able to:

- Explain the purpose of fuse in the circuits.
- Identify the different types of fuses & their uses.

## 8.3 FUSE

**A Fuse is a safety device.** It is connected in series with the circuit & protects the electrical apparatus & equipments from damage, when excess current flows.

There are several types of Fuses used in electrical field, but the Kitkat type fuse is commonly used in domestic installation. While specifying fuses in general, their type, current capacity & working voltage should also be specified.

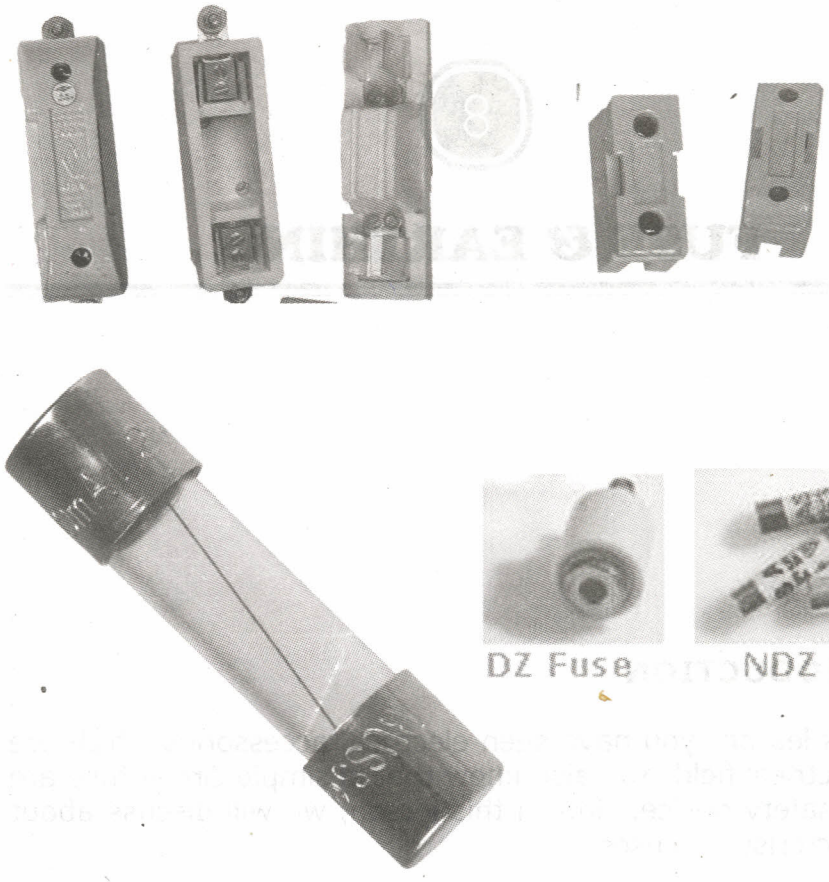



Fig: 8.1 Types of Fuses

A fuse is a safety device used for the purpose of protecting a circuit against excess current. In the event of excessive current, the Fuse element melts & opens up the circuit, there by protecting it from damage.

The fuses can interrupt automatically a circuit with an over current in it for a fixed time. They are mainly used against the short-circuits. They limit the peak value of the fault current.

**Placement of fuses**

In electrical installations, fuses are always connected into the live wires & never into the neutral nor into the protective earth line.

**Types of Fuse**

**(1) Rewirable type fuse**

This type of Fuses are is simple in construction & the initial cost as well as the renewal cost is very low. The fuse element will melt



after approximately 2 minutes when carrying a current rating. Kitkat & Piano type of fuses are the example of rewirable fuses.

### (2) Construction of Kitkat & Piano type fuse

These are mostly use in domestic installation. The fuse base consist of a porcelain or polycarbonate material plastics. Base having silvered heavy brass terminals. The incoming & outgoing positive wire is connected to these terminals. Inside the fuse, carrier two contact terminals are provided. Fuse comer is made up of porcelain or polycarbonate material. It has two brass fuse carrier terminals, having a screw for connecting a fuse element.

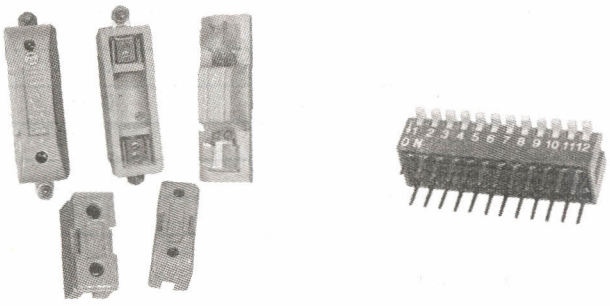


Fig: 8.2 Construction of Kitkat and Piano fuse

In modern type fuse, base contact terminals are made of silver coated brass & fuse carrier also made of tined copper & having a silver fuse.

### Fuse element

Generally, Fuse elements are made of tined copper wire.

### Function / Working of fuse

During normal operations fuse element acts as a conductor and it provides complete path of current. When a short circuit occurs the current flowing through fuse increases sharply. This causes the heating of the fuse element. Fuse element has a low melting point so that it melts at a lower temperature than that of ordinary conductor, when the heat caused by the short circuit current reaches the melting point of the fuse element the element melts & opens the circuit.

### Fuse Rating

The maximum current a fuse can carry before it melts & opens the circuit is called 'fuse rating'. Fuse rating are normally expressed in rated current. The rating of fuse is usually marked on fuse.

The minimum current required to fuse element is called a 'fusing current'.



## Placement of a fuse

Fuse is always connected in series with line. It is always connected to phase wire for safety so that you can work on circuit with security after removing the fuse. When the heavy current passes through the fuse it blows & protects the installation and appliances.

My Dear Friends! always remembe hat fuse should not be connected on neutral wire because it is unsafe & dangerous. The current carrying capacity of the Fuse wire depends on its cross sectional area or SWG. Following table shows capacity of tinned copper wire & its gauge is given below:

| Current Rating (in Ampere) | SWG | Tinned Copper wire (dia. mm) |
|---|---|---|
| 20 | 23 | 0.610 |
| 24 | 22 | 0.711 |
| 30 | 21 | 0.813 |
| 37 | 19 | 1.219 |
| 46 | 18 | 1.219 |
| 53 | 18 | 1.219 |

## Precautions while repairing fuse:

1. Always use a fuse wire of proper capacity of current
2. Always use single fuse wire.
3. Never connect multi strand wire as a Fuse.
4. Keep proper length of Fuse element.
5. Connect Fuse wire properly.
6. Do not use unrecommended metal wires i.e. G.I., Nichrome.

## INTEXT QUESTIONS 8.1

**(a) Fill in the blanks:**

1. A Fuse is a _____ device.
2. A Fuse is used for protecting a circuit against _____ .
3. _____ & _____ type of Fuses are the examples of rewirable Fuses.
4. Fuse rating is usually marked on _____.
5. Fuse are always connected _____.

**(b) State True or False:**

1. In electrical installations, Fuses are connected to the neutral.
2. Fuse is connected in series with the circuit.



3. Fuse carrier has two contact terminals.
4. Fuse rating is expressed in current carrying capacity.
5. Fuse connected on phase wire for safety & security.

## 8.4 EARTHING

### What do you mean by earthing?

The earthing is a safety device which ensures that a person can not get shock.

### Necessity of Earthing:

The necessity for earthing is to ensure that the metalwork of electrical equipment, other than current carrying parts, cannot have a potential above earth in the event of a fault which might otherwise cause danger of an electric shock.

If a fault is developed, causing unearthed metalwork of a piece of electrical equipment; it is charged to a level of dangerous potential. Any person touching the metal & at the same time comes in contact with earth will receive a severe electric shock. Had the metal been effectively earthed, the very low resistance of the circuit would result in a flow of current sufficient to blow the Fuse or to operate the protective device.

In an earth metalwork of a piece of electrical equipment becomes a zero potential due to this; a person does not get a shock.

### Types of Earthing

1) Plate Type Earthing
2) Pipe Type Earthing

### 1) Plate type earthing

A pit is dug in the ground. A copper plate or G.I. plate is buried vertically in the pit. An earth wire is bolted to the earth wire with the help of nut, bolt & washer. The earth wire & the nut, bolts &

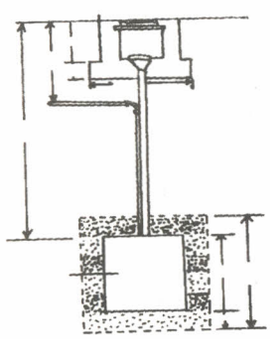


Fig: 8.3 Plate type earthing



washer should be of the same metal that of the plate used. A thick layer of salt & charcoal is placed around the earth plate, so as to reduce the earth resistance & to maintain dampness.

A G.I. Pipe is fitted over the plate. A funnel with a wire mesh cover is placed at the top of the pipe, & the whole arrangement is covered with a cast iron cover. In order to maintain the moistness around the earth plate, 3 or 4 buckets of water are poured in the pipe through the funnel.

### 2) Pipe Type Earthing

In this method a cast iron pipe of 30 – 75 mm diameter and 3meter length is buried in the pit along with the salt and charcoal as shown in Fig. 4 . The pipe should have sufficient holes at its surface, so as to maintain the dampness inside the pipe. An earth wire is tied near the top of the pipe with the help of a clamp. In order to have an effective earth, one or two buckets of water may be poured in the pipe, especially in the summer season.

This method has an advantage that the earth wire can't break easily from the pipe, while in plate earthing method the wire can break due to slight carelessness.

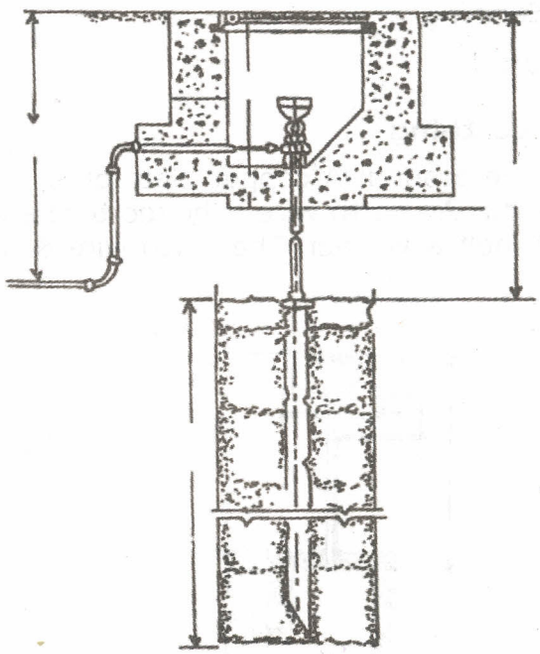


Fig: Pipe 8.4 type earthing



## INTEXT QUESTIONS 8.2

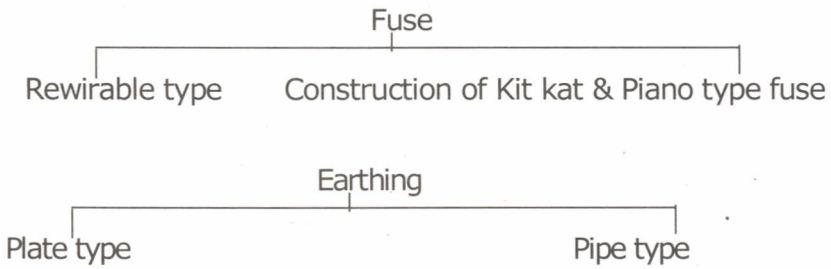
a) Fill in the blanks:

1. Earthing is a _____ device.
2. Earthing ensures that a person cannot get a _____.
3. Eathing prevents the risk of _____ to human beings.

## 8.5 WHAT YOU HAVE LEARNT

In this lesson, You studied the 'Fuse' as well as 'earthing' , their uses and importance also. You know very well now that fuse is a safety device which is connected in series with circut. It protect our electrical apparatus & equipment from excess current. It is two types:

Earthing is also safety device Which ensures that a preson cannot get shock. This is also two types:




## 8.6 TERMINAL QUESTIONS

1. Write a note on fuse & its importance.
2. What do you mean by earting? Describe the pipe type earthing with appropriate figure.

## 8.7 ANSWER TO INTEXT QUESTIONS

**8.1 (a)**

1. Safety
2. Excess current
3. Kitkat & Piano type Fuse
4. Fuse
5. Series with line

**8.1 (b)**

1. False 2. True 3. True 4. False 5. True



**8.2 (a)**

1. Safety
2. Shock
3. Shock

9

# CELLS & BATTERIES

## 9.1 INTRODUCTION

In the previous lesson, we have discussed about fuses and earthling and their uses. We have understand their importance also. In this lesson, we are going to study about Cells and Battery. This source of electricity is commonly used through chemical reaction, housed in electric cells and batteries.

Battery is usually used for emergency and portable electric power. Batteries are the main source of power at present. These are used as emergency equipments.

## 9.2 OBJECTIVES

After reading this lesson, you will be able to:

- Understand the Meaning of cell, principle of a primary cell.
- Know the Properties of cell and remedies of primary cell.
- Learn about Dry cell, its uses.
- Define the electrodes, electrolyte, electrolysis.
- Explain the Battery, its internal construction, chemical reaction of lead-acid cell.
- Charging equipment and Battery testing instruments.

## 9.3 CELL

A cell is an electrochemical device consisting of two electrodes and an electrolyte. The chemical reaction between the electrodes and the electrolyte produces the voltage.

**Generally two types of Cell are found:**

(a) Primary Cell

(b) Dry Cell

## (A) Primary cells

The cell, in which e.m.f. is produced on account of chemical actions, is called a primary cell;

It has two electrodes of different metals such as copper and zinc, immersed in a suitable electrolyte, such as dilute sulphuric acid. If the two electrodes are connected to a torch bulb with two pieces of wires, then a current flows from positive to negative terminal of cell.

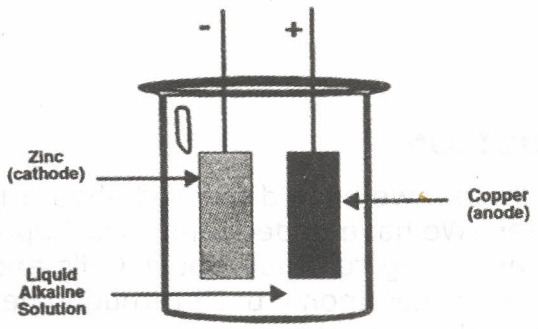



Fig: 9.1 Primary Cell

### Principle of a Primary cell

The first cell was made by Volta, therefore, a primary cell is called a voltaic cell also. It consists of a glass container containing dilute sulphuric acid ( $H_2SO_4$) with copper and zinc rods as electrodes. When two pieces of wires to a torch bulb ( or any other load), then the current starts to flow. Sulphuric acid decomposes into hydrogen and sulphate ion. Negative ions of Sulphate travel towards the zinc rod and make it negative by forming zinc sulphate.

Positive ions of hydrogen travel towards the copper rod and make it positive by forming hydrogen bubbles. In this way, the current flows from zinc to copper to zinc in the external circuit other types of primary cells are made on the above principle using different electrolysis and electrodes.

### Properties of Primary cell:

1. It is an instant e.m.f. supplying device.
2. A cell once discharged fully cannot be recharged again.
3. It is cheap in cost.
4. It is portable.
5. It is suitable for intermittent uses such as bells etc.



### Defects of primary cell and their remedies

There are two main defects in a Primary cell:

1. Local action.
2. Polarization.

### 1) Local action

Normally, zinc consists of many, impurities such as copper iron etc. When a zinc rod is used as an electrode in a primary cell, its circuit becomes complete even current is set up from zinc to copper or iron particles. In this way, it causes a loss of zinc and electrical power. This action is known as local action.

This action can be minimized by amalgamating the zinc rod. i.e. coating the rod with mercury . By this remedy, the impurities are covered by amalgam of zinc and mercury and do not take part in the chemical action. Another remedy is to use a pure zinc rod.

### 2) Polarization

In the working of a cell hydrogen as is produced in the form of bubble, which is collected around the copper electrode. Hydrogen is a bad conductor of electricity and thus it increases the internal resistance of the cell. Therefore, the voltage drop and power loss of the Cell is increased. Sometimes, the flow of current is completely e.m.f. which opposes the flow of current. This effect is known as Polarization.

This action is minimized by using a depolarizer. The common depolarizer. The Common depolarizer is manganese dioxide ($MnO_2$). Which converts the hydrogen bubbles into water. Another remedy is to clean the rod with a brush every now and then, which is a difficult task.

There are so many primary cells available in market but we are going to study only Dry Cell.

## (B) DRY CELL

It is a modification of Lechlanche Cell. It consist of a cylindrical zinc pot, which works as the cathode. A carbons rod is placed in centre

Fig: 9.2 Dry cell



of the pot which is surrounded by a mixture of manganese di-oxide, carbon powder, ammonium chloride and zinc chloride mixed in a ratio of 10.10, 2&1. The paste is surrounded by a canvas or fabric sack. Between the sack and the zinc pot, a zinc chloride and Plaster of Paris is filled. Plaster of Paris makes the paste tough and strong. The cell is sealed with a pitch compound is shown in figure. A brass cap is fitted at the top of Carbon rod. The zinc pot is covered with cardboard etc.

Ammonium chloride acts with zinc and produces hydrogen, which in turn acts with manganese di-oxide and produces water. The pitch compound has a small hole to work as an outlet for the ammonia evolved during the chemical actions. An over dried cell can be given a life by dropping a few drops of water at the outlet.

### Use of Dry Cell

It is used in torches, toys, transistor ( radio).

### Definitions

### Electrode

The conductor or terminals through which an electric current enters or leaves is called an electrode. The electrode through which the current enters the linguine is called a positive electrode or anode through which current leaves the liquid is called a positive electrode or cathode.

### Electrolyte

The liquid or solution which undergoes a chemical changes in it on account of the passage of electric current this called an electrolyte salted water, acidic water and a basic solutions are examples of electrolyte.

### Electrolysis

The process of chemical changes due to the passage of an electric current through a liquid or a solution is called electrolysis.

## 9.4 BATTERY

A battery is a group of cells which produce electrical energy from their internal chemical reaction. The battery is a source of steady DC voltage. Where heavy current are necessary, the lead-acid cell is used.

### Construction

The lead-acid cell contains container, plates, cell connecter, sealing compound and electrolyte.



### 1) Container

The container is made of hard rubber bituminous compounds which accommodate plates, separators, electrolyte etc. In it there are ribs at the bottom of the of the cell chamber or mud house the plates rest on these ribs or bridges.

### 2) Plates

Positive and negative these are two types.

a) Plate type.

b) Frame type

**Plate type** - Plates are formed from pure lead by repeated charge and discharge in case of fare type plates are made by paste process active material is passed in lead made grids in the form of paste of red

lead ( $Pb_3O_4$) on the positive plates and immured in dilute $H_2SO_4$ electrolysis takes place when current posses red lead ($Pb_3O_4$) is oxidized to lead peroxide ($Pb_3O_2$) forming the positive plate and negative with age (PbO) is reduce to spongy lead.

### 3) Separators

These are made from especially treated wood performed rubber or cell void and used to insulate the active plates from one another separator should be able to pass through these separators.

### 4) Vent Plug

These are obtained by moldings hard rubber and are used to for easy escape for gas formed in the cell during charge.

### 5) Cell connectors

Cells are connected in series to form battery plates in the cells are so arranged that negative terminal of one cell is to positive terminal of next cell and so on the adjustment terminal posts are then welded.

### 6) Plate Connectors

They are made from pure lead positive and negative plates are welded separated with it forming positive group and negative group post terminals.

### 7) Sealing Compound

It is made from bitumen compound and is used to form and avoid tight joint between the cover and containers so that may not come out while cell is seal.

### 8) Electrolyte

For lead acid cell the electrolyte used is dilute solution of sulphuric acid these usually consists of three parts of sulphuric acid and thus has a specific gravity of 1250 approximately.



## Chemical reaction

The newly battery is not charged so it is necessary to charge before using. A secondary cell is charged by passing direct current through it from positive terminal to negative terminal.

On charge, the reversed direction of the ions flowing in the electrolyte results in a reversal of the chemical reactions. Now the lead sulfate on the positive plate reacts with the water and sulfate ions to produce lead peroxide and sulfuric acid. This action reforms the positive electrode and strengthens the electrolyte by adding sulfuric acid. At the same time, charging enables the lead sulfate on the negative plate to react with hydrogen ions, which also sulfuric acid while reforming lead on the negative electrode.

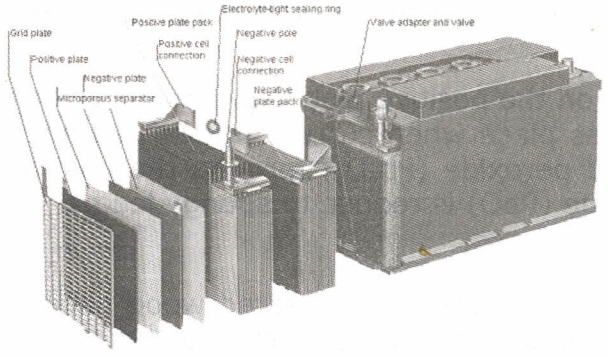



Fig: 9.3 Construction of lead acid cell.

As a result, the charging current can restore the cell to full output with lead peroxide on the positive plates spongy lead on the negative plates and the required concentration of sulfuric acid in the electrolyte. The chemical formula for the lead acid cell is -

On discharge the lead (Pb) and lead peroxide ($PbO_2$) electrodes supply Pb ions that combine with the sulfate ions ($SO_4$) to form lead sulfate ( $PbSO_4$) and water ( $H_2O$). On charge, with reverse current through the electrolyte, the chemical action is reversed. Then the Pb ions from the lead sulfate reform the lead peroxide electrode. Also the $SO_4$ ions combine with the $H_2$ ions to produce more sulfuric acid.

$$= Pb + PbO_2 + 2H_2SO_4 \xrightarrow[\text{Discharge}]{\text{Charge}} 2PbSO_4 + 2H_2O$$

## Indications of charged and discharged conditions

### A) Full charged condition

1. The colours of the positive and negative plates become dark brown and grey respectively.



2. The electrolyte becomes saturate and its specific gravity lies between 1.26 and 1.28.
3. The e.m.f. of the cell becomes 2.1 volt.
4. Plates of the cell evolve gases in the form of bubbles.

**B) Discharged Condition**

1. The colors of the positive and negative plates become white comparatively due to formation of lead sulphate.
2. The electrolyte becomes dilute and its specific gravity lies between 1150 and 1180.
3. The e.m.f. of the cell becomes 1.8 volts.

## INTEXT QUESTIONS 9.1

a) Fill in the blanks:

1. A cell is an _____ device.
2. _____ and _____ are two main defects in primary cell.
3. A group of cells is called as _____.
4. _____ cells once discharged cannot be recharged again.

b) State True or False:

1. Primary cell is also known as voltaic cell. ( )
2. Dry cells can be charged. ( )
3. Battery is a source of steady D.C. voltage. ( )
4. Vent Plug used to cover for easy escape for gas. ( )

### Charging

The battery should be charged as soon as possible after each discharge is completed and the charge should be continued until all the plates are gassing well and the specific gravity and voltage readings remain constant.

### Necessity of charging

After using battery it discharge. After discharging cannot deliver power that's why it is necessary to charge the battery for delivering power again. For this purpose 230 A. C. Volt supply is not suitable. You know that for battery charging low voltage D.C. Supply is required. An instrument which converts A. C. Voltage into required low D.C. Voltage is Known as battery charger.

## 9.5 BATTERY TESTING INSTRUMENTS AND CHARGER

For checking the battery voltage high rate discharge cell tester is used and for checking a gravity of electrolyte hydrometer is used.

In that High rate discharge Cell tester is to give the correct terminal voltage on full load of the battery cell.

Hydrometer is used to test the specific graving of the electrolyte.

**Battery charging equipment** consists of a step down transformer to convert 230V A. C. into low voltage A. C. This voltage is fed to a bridge rectifier which converts it into low voltage d.c. This d.c. voltage is used for battery charging. Ammeter is used to indicate current and voltmeter indicates battery voltage. Fuse is used as safety device.

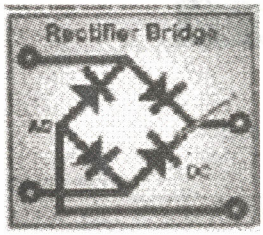



Fig: 4 Bridge rectifier

### INTEXT QUESTIONS 9.2

a) Fill in the blanks:

1. An instrument which converts A.C. Voltage into D.C. Voltage is called _____.
2. Ammeter is used to indicate _____.
3. Voltmeter indicates battery _____.
4. _____ is used for battery charging.

## 9.6 WHAT YOU HAVE LEARNT

In this lesson you have learnt about Cells and Batteries, their types and their uses in our daily life.

Cell is an electrochemical device consisting of two electrodes and an electrolyte. Two types of Cell are generally found:

(1) Primary Cell; and

(2) Dry Cell.

While Batery is a group of Cells which produce electrical energy from their internal chemcal reaction. It is a source of steady DC voltage



## 9.7 TRMINAL QUESTIONS

1. What do you mean by cell. Describe the Dry cell.
5. Write a Method of construction of battery?

## 9.8 ANSWER TO INTEXT QUESTIONS

**9.1**

a)

1. Electrochemical
2. Local action and polarization
3. Battery
4. Primary
5. Set of cells

b) True or False.

1. True
2. False
3. True
4. True

**9.2**

a) Fill in the blanks:

1. Battery charger
2. Charging Current
3. Voltage
4. Battery charger

10

# D.C. GENERATORS & MOTORS

## 10.1 INTRODUCTION

In previous lesson, we studied the cell & batteries its types, indications of charged & discharged cell/ batteries, meaning of charging, its necessity etc. You are all, familiar with flashlights, portable radios & emergency batteries, all of which use the batteries as their source of power. In these applications, the current drawn from the battery is comparatively small & therefore, a battery can supply the current for a long period of time, even without recharging.

Many electrical equipment requires large current at low medium voltage. For example, electric lights & motors require high voltage & current, that cannot be supplied by the battery as a result. We require source of power other than batteries. These large sources of power are supplied by rotating electrical machines called D.C. generator.

## 10.2 OBJECTIVES

After reading this lesson, you will be able to:

- Understand the Electricity generation from magnetism, Principle or operation of generator.
- Describe the Self-excited generator.
- Know the D.C. Motor.
- Classify the D.C. Motors.
- Understand the necessity of starter, 3 point starter.



## 10.3 ELECTRICITY FROM MAGNETISM

Do you know that electricity can be generated by moving a wire through a magnetic field. As long as there is relative motion between the conductor & the magnetic field, electricity is generated. If there is no relative motion between the conductor & the magnetic field, electricity is not generated. The generated electricity is actually a voltage, called an " Induce Voltage", & the method of generating this voltage by cutting a magnetic field with a conductor is called " Induction".

### Principle of operation of generator

You already know that you can generate electricity by having a conductor cut through a magnetic field. This is essentially the principle of operation of any generator from the smallest to the giants which produce kilowatt of power.

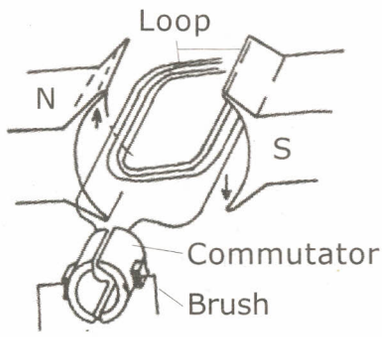



Fig: 10.1 operation of generator

An elementary generator consists of a loop of wire placed so that it can be rotated in a stationary magnetic field to cause an induced current in the loop. Sliding contacts are used to connect the loop to an external circuit in order to use the induced e.m.f.

The pole pieces are the north & south poles of the magnet which supplies the magnetic field. The loop of wire which rotates through the field is called the armature. The ends of the armature loop are connected to rings called "slip rings", which rotate with the armature. Brushes ride up against the slip rings to pick up the electricity generated in the armature and carry it to the external circuit.

### Self - excited DC generator

Self excited generators use part of the generators output to supply excitation current to the field. These generators are classified according to the type of field connection used.

In a "series" generator, the field coils are connected in series with the armature, so that the whole armature current flows through both the field & the load.

If the generator is not connected across a load the circuit is incomplete and no current will flow to excite the field. The series field contains relatively few turns of wire.

"Shunt" generator field coils are connected across the armature circuit, forming a parallel or "shunt" circuit. Only a small part of the armature current flows hrough the field coils, the rest flowing through the load. Since the shunt field and the armature form a closed circuit independent of the load, the generator is excited even under " no load " conditions - with no load connected across the armature. The shunt field contains many turns of fine wire.

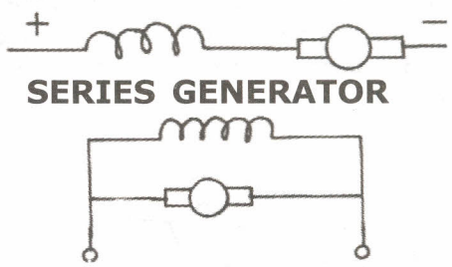



Fig: 10.2 Shunt generator

A " compound " generator has both a series and a shunt field, forming a series- parallel circuit. Two coils are mounted to each pole piece, one coil, series connected and the other shunt connected . The shunt field coils are excited by only a part of the armature current, while the entire load current flows through the series field. Therefore as the load current increases, the strength of the series field is increased.

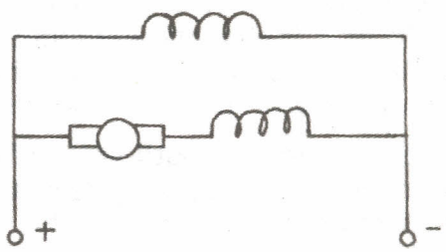



Fig: 10.3 Compound generator

## INTEXT QUESTION 10.1

a) Fill in the blanks:

1. Electricity can be generated by moving a wire through a _____.



2. The generated electricity is called an _____.
3. The method of generating voltage by cutting a magnetic field with a conductor is called _____.
4. The ends of the armature loop are connected to rings called _____.
5. _____ are classified according to the type of field connection used.

b) State true or false:

1. Electricity is generated when there is no motion between conductor & magnetic field. ( )
2. The pole pieces having the north pole and south pole. ( )
3. Shunt generator field coils are connected across the armature circuit only parallel circuit. ( )

## 10.4 DC MOTOR

DC motors & DC generators are essentially the same. In a motor electrical power forces the armature to turn and the moving armature. A DC motor converts electrical energy into mechanical energy.

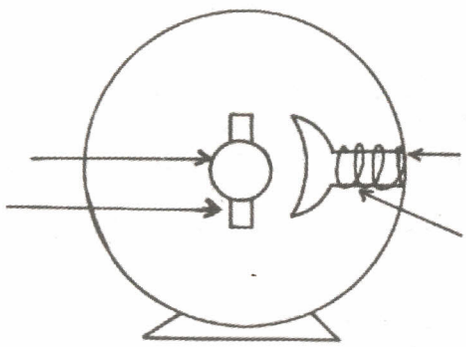


Fig: 10.4 D C Motor

Do you know on what principle motor works? when a current flows through the coils, a coil itself acts as a magnet & the coil is moved by the force between the magnetic field. This is the principle of operation of DC motors.

### Classification of DC motors

There are three main types of motors which are as follows :

1. Series Motor
2. Shunt Motor
3. Compound Motor

### 1) Series motor

The motor in which the field winding is connected in series with the armature, is called a series motor. The field winding consists of a few turn Sothic enameled copper wire as shown in figure:

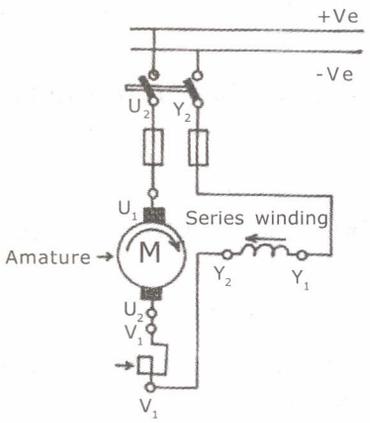
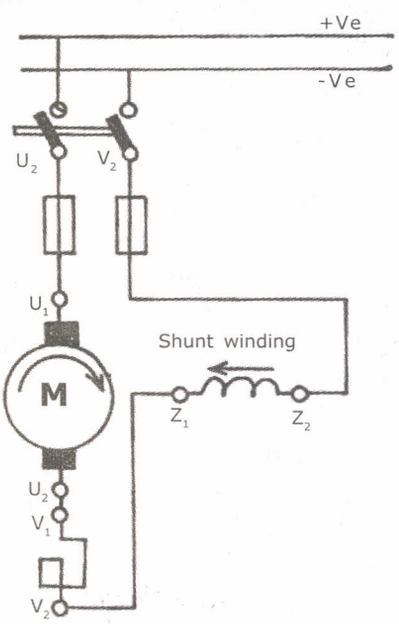


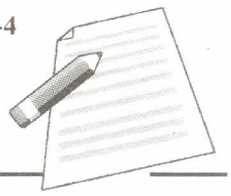

Fig: 10.5 Series Motor

A series motor should not be run without a load is necessary for controlling its speed or otherwise it will run at a very high speed. Therefore, it is used for such jobs in which a load is always present at the meter.

### 2) Shunt motor

The motor in which the field winding is connected across the armature is called a shunt motor. The field winding consists of a large number of turns of fine enameled copper wire to provide a high resistance as shown in figure







The speed of a shunt motor remains almost constant & is not effected by the load variations. The motor cannot be started with a heavy load. It is suitable for stable & light load.

### 3) Compound motor

The motor in which one part of field winding is connected in series & the other part is connected across the armature is called a compound motor.

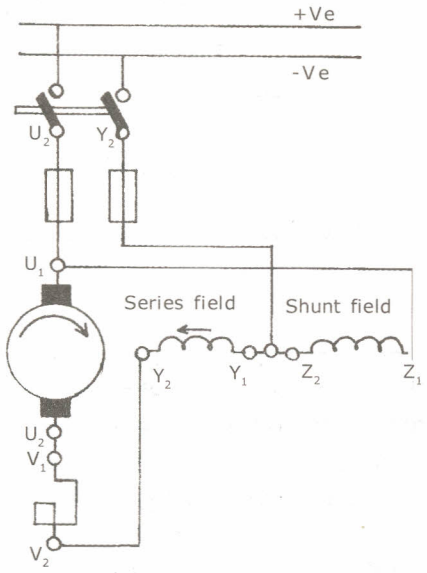



Fig: 10.7. Compound motor

## 10.5 STARTERS

### Necessity of Starter

In the starting of a motor the back e.m.f. is zero. It rises gradually with a rise in speed. In the absence of the back e.m.f. the motor will draw an excessive current which can burn the motor windings. Therefore, it becomes necessary to control the excess flow of current. For this purpose a variable resistor is connected in series with the field. As the motor speeds up the external resistance is gradually cut out of the circuit. At full speed the whole of the variable resistor is cut out of the circuit and the induced back e.m.f. controls the armature & field currents. The current controlling device is termed as a hand starter.

### 3 Point starter

A three point starter is used with shunt motors. It consists of variable resistance no-volt & over load release coil as shown in figure 10.8 :

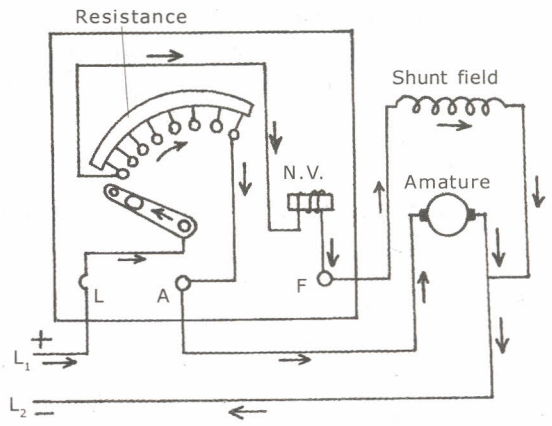



Fig. 10.8. point starter

These two coils are known as protective devices.

### A) No-volt coil

It consists of an electromagnet which is magnetized by the field winding current. The handle of the starter has a piece of soft iron fitted in it. The spring of the handle keeps it in OFF opposition. When the handle is brought to ON position then the electromagnet attracts the handle & holds it firmly against the tension of spring. In the event of supply failure the electromagnet is demagnetized & the handle returns back to OFF position under the action of spring. In this way the whole arrangement protects the motor against any damage which may be caused due to supply failure & the re-establishment of supply.

### B) Overload coil

It consists of an electromagnet which is connected to the line & the handle. Its coil consists of a few turns of thick copper wire. There is a metallic leaf near the electromagnet. It can short circuit current the two N.V.C. terminals close to it. If the load & thus the supply current exceeds release coil attracts the metallic leaf which short circuits the no-volt coil & thus disconnects the motor from the supply.

In neither case can the motor be re-started without the starting resistance being in the armature circuit & therefore, any damage to the motor windings is prevented.

### C) Function of starter

As the starter handle is moved in a clock wise direction it comes into contact with first stud. At this stage the full starting resistance is connected in series with the circuit, which reduces the armature current. The resistance in the armature circuit is gradually cut out as the motor speeds up, & the back e.m.f. replaces the starting



resistance. When the starter handle is at 'ON' the starting resistance is completely cutout of the circuit & by this time the motor achieves its full speed. Now, the starting resistance is no more required. At 'ON Position', the starter handle is attracted by the no volt coil magnet against the spring, & is firmly held by it.

If the supply has failed or the motor is over loaded then the no-volt coil is demagnetized & the starter handle is released to reach at 'off' position, under the action of spring. The motor can be re-started, If the supply has re-stored or the overloading has finished.

### D) Care

The starter handle should be moved gently in the clockwise direction from 'off' to 'ON' positions. The armature winding can burn if the starter handle is rotated quickly.

## INTEXT QUESTIONS 10.2

**a) Fill in the blanks:**

1. D.C motor converts electrical energy into _____.
2. D.C motor classified in _____, _____, _____ motor.
3. A Series motor should not be run without _____.
4. Shunt motors speed remains _____.
5. When we start the motor back e.m.f. is _____.

**b) State True or False:**

1. The motor in which field winding is connected across the armature is called series motor. ( )
2. The motor in which the field winging is connected in series with the armature, is called Compound motor. ( )
3. If there is absence of back e.m.f. the motor winding can burn. ( )
4. Overload coil consist of an electromagnet which is connected to the line & handle. ( )
5. Starter handle moved in Clock-wise direction. ( )

## 10.6 WHAT YOU HAVE LEARNT

In this lesson we have understand the principle of operation of generator self-excited generators what is a D.C. motor's principle, what is a starter and how it works, what care should be given while handling the starter.

Module-4

Notes

## 10.7 TERMINAL QUESTIONS

1. Explain the principle of operation of generator with appropriate figure.
2. Write a short note on D.C. Motor and self excited DC generator.
3. Classify the D.C. Motor and describe with figure.

## 10.8 ANSWER TO INTEXT QUESTIONS

**10.1**

a)

1. Magnetic field
2. Induced Voltage
3. Induction
4. Slip rings
5. Self excited generators

b) True or False.

1. False 2. True 3. False

**10.2**

a)

1. Mechanical energy
2. Series motor, shunt motor, compound motor
3. Load
4. Constant

b) True or False

1. False 2. False 3. True 4. True 5. True

11

# A. C. GENERATORS & MOTORS

## 11.1 INTRODUCTION

My dear friends, in previous lesson we have discussed on D.C. Generators and Motors. In present days, D.C. Supply is not generated, transmitted or distributed in our country. So in this lesson we will discuss about AC Generators and Motors.

## 11.2 OBJECTIVES

After reading this lesson, you will be able to understand:

- Alternating current.
- Advantages of Alternating current.
- Elementary Alternator.
- Operation of alternator.
- Working principle of alternator.
- Construction of alternator.
- A. C. Motor - Principle of A. C. Motor.
- Types of A. C. Motor.
- 3- Phase Motor.
- Starter- D. O. L. Starter.

## 11.3 ALTERNATING CURRENT ( A. C.)

In this the direction and amplitude of the current flow change at regular intervals. The current in this type of circuits is supplied from

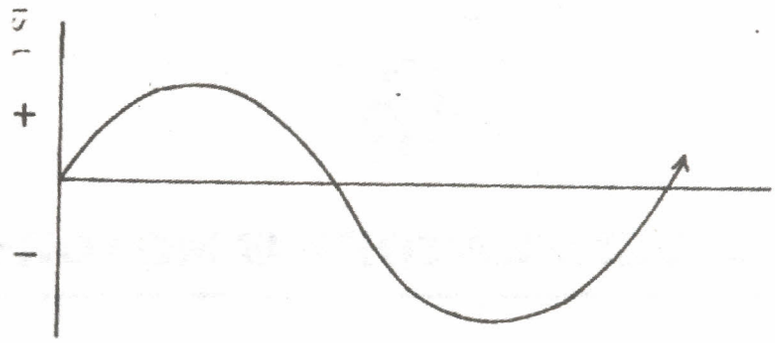



Fig. 11.1 Wave line of Alternating current

an A. C. Voltage source. The polarity of an A. C. Source change at regular intervals resulting in a reversal of the circuit current flow.

### Advantages of A. C. Current

There are many good reasons for the choice of A. C. over D.C. for electric power transmission. Alternating current voltage cannot be change easily, also there are more power losses in D.C. with respective A. C. Supply. It is easy to transmit electric power at very high voltage, with small amount of current.

At the power station, the voltage is stepped up about 400000V by a step up transformer and sent to the transmission line.

Then, the end of another line other transformer step down the voltage values, which can be used in lighting and power.

## 11.4 ELEMENTARY ALTERNATOR

A basic AC generator consists of a loop of wire in a stationary magnetic field. When it is rotated in this magnetic field it causes an induced current in the loop. Sliding contacts are used to connect in order to an external circuit in order to use the induced current.

The pole pieces are the north and south poles of the magnet which supplies the magnetic field. The loop of wire which rotates through the field is called the armature. The ends of the armature loop are connected to rings called slip rings which rotate with the armature. Brushes ride up against the slip rings to pick up the electricity generated in the armature and carry it to the external circuit.

### Operation of alternator

Here is the way the elementary generator works. Assume that the armature loop is rotating in a clockwise direction and that its initial position is at A (zero degrees). In position 'A', the loop is perpendicular to the magnetic field and the black and white conductors of the loop are moving parallel to the magnetic field. If a conductor is



moving parallel to a magnetic field it does not cut through any lines of force and no e. m. f. can be generated in the conductor. This applies to the conductors of the loop at the instant they go through position A - no e. m. f. is induced in them and therefore, no current flows through the circuit. The current meter registers zero.

As the loop rotates from position A to position B, the conductors are cutting through more and more lines of force until at 90 degrees (position B) they are cutting through a maximum number of lines of force. In other words, between zero and 90 degrees the induced e.m.f. in the conductors build up from zero to a maximum value. Observe that from zero to 90 degrees the black conductor cuts down through the field while at the same time white conductor cuts up through the field. The induced e. m. f. in both conductors are therefore in series adding and the resultant voltage across the brushes (the terminal voltage) is the sum of the two induced e. m. f. or double that of one conductor since the induced voltages are equal other. The current through the circuit will vary just as the induced e. m .f. varies being zero. At zero degrees and rising up to a maximum at 90 degrees. The current meter deflects increasingly to the right between positions A and B indicating that the current through the load is flowing in the direction shown. The direction of current flow and the polarity of the induced e. m. f. depend upon the direction of the magnetic field and the direction of rotation of the armature loop. The wave form shows how the terminal voltage of the elementary generator varies from position A to position B. The simple generator drawing on the right is shown shifted in position to illustrate the relationship between the loop position and the generated waveform.

As the loop continues rotating from position B(90 degrees) to position C (180 degrees) the conductors which are cutting through a maximum number of lines of force at position B cut through fewer lines until at position C they are moving parallel to the magnetic field and no longer cut through any lines of force. The induced e. m. f. therefore will decrease from 90 to 180 degrees in the same manner as it increased from zero to 90 degrees. The current flow

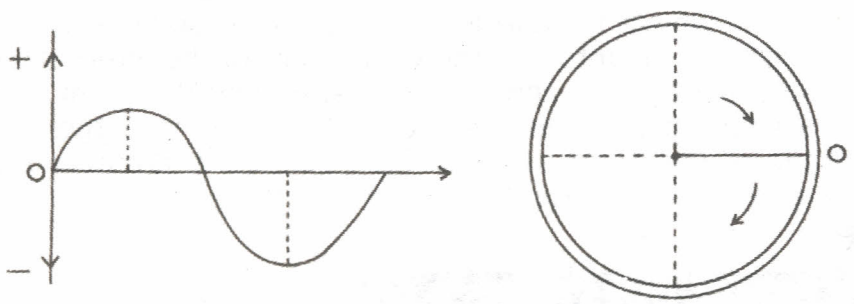
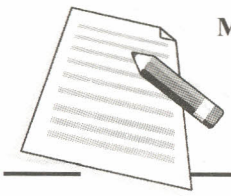



Fig. 11.2 A. C. Cycle





will similarly follow the voltage variations. The generator action at position B and C is illustrated.

From zero to 180 degrees the conductors of loop have been moving in the same direction through the magnetic field and therefore the polarity of induced e. m. f. has remained same. As the loop starts rotating beyond 180 degrees back to position A the direction of the cutting action of the conductor through the magnetic field reverses. Now, the black conductor cuts up through the field and the white conductor cuts down through the field. As a result the polarity of the induced e. m .f. and the current flow will reverse. From position C through D back to position A, the current flow will be in the opposite direction that from positions A through C. The generator terminal voltage will be the same as it was from A to C except for its reversed polarity. The voltage output waveform for the complete revolution of the loop is as shown.

### Working principle of alternator

The alternator works on the same principle of DC that is Faraday's Laws of Electromagnetic Induction.

### Construction of alternator

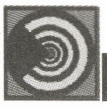
Alternator consists of Rotor, Starter, Exciter.

1) **Rotor -** The rotating part of alternator is known as rotor. It is made from a solid steel piece. To house the field winding slots are cut on the outer surface. The ends of winding are held by retaining ring of non- magnetic steel.

There are silent pole type rotor and cylindrical type rotor is used in alternator.

2) **Stator -** The stator is built of stamping insulated on one side with paper or varnish and housed in a frame which is usually fabricated from steel plates- electrically welded. Slots to take the winding are cut round the inner surface.

3) **Exciter -** The exciter is generally a DC shunt or compound generator whose voltage is up to 250V. In small alternators the exciter is mounted on the same shaft of the alternators. A variable resistance is connected in series with the shunt field of the exciter which varies the exciter voltage to vary the output voltage of the alternator. For high voltage alternators separately excited generators are used.



### INTEXT QUESTIONS 11.1

A) Fill in the blanks:

1. The alternator works on the laws of _____.



2. There are_____and _____ rotor is used in alternator.
3. Exciter has voltage up to _____.
4. The rotating part of alternator is known as _____.
5. It is easy to transmit electric power at very high voltage with small amount of current with the help of _____.

## 11.5 AC MOTOR

The motor which operates with AC supply is called AC Motor. It transfers the electrical energy into mechanical energy.

The Induction motor is the most commonly used AC Motor, because of its simplicity its rugged construction and its low cost. It has a rotor and a stator. The induction motor, rotor is made up of a high grade steel laminated cylindrical with slots in its surface. The squirrel cage winding is made up of heavy copper bars connected together at each end by a metal ring. The air gap between the rotor and stator is very small to obtain maximum field strength.

The stator is made of a laminated slot in it. The two windings are placed in the slot, that windings is known as running winding and starting winding. Both windings are placed at 90 electrical degrees in the slot.

### Principle of AC Motor

When a single phase AC motor is connected to the AC supply the rotating magnetic field generated in the stator induces a magnetic field in the rotor, the two fields interact and cause the rotor to turm.

On the basis of phases, the AC Motors may be divided in two groups:

two groups — Single phase motor
two groups — Three phase motor

### Types of single phase motor

1. Split Phase Induction Motor
2. Capacitor Induction Motor
3. Universal Induction Motor
4. Shaded Pole Induction Motor

### 1) SPLIT PHASE INDUCTION MOTOR

Split phase motor is an AC motor of fractional horsepower and is used to operate washing machine and small pumps. The motor consists of a rotating part called rotor. A stationery part called stator and plates and centrifugal switch. Its rotor is like squirral cage type i.e. having bar winding. Stator has two types of windings knwon as running and starting Winding.

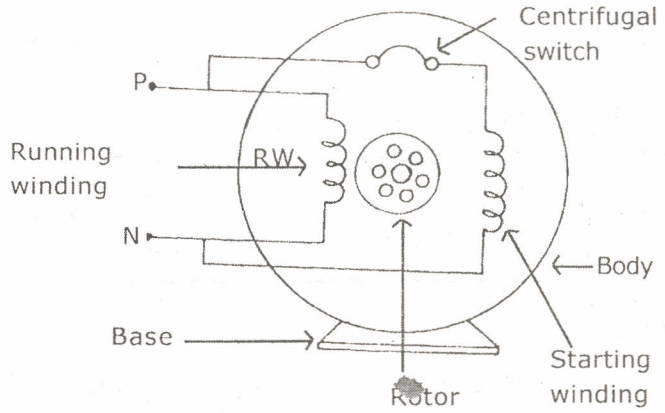



Fig. 11.3 Split phase induction motor

### Working of AC Motor

At the start the current flowing through both the running and starting windings causes a magnetic field to be formed insight the motor. This magnetic field rotates and induces a current in the rotor winding which in turn causes another magnetic field.

This magnetic combine in such manner as to cause rotation of the rotor. A starting winding is necessary at the start in order to produce the rotating magnetic field (RMF) after the motor is running the starting winding is no longer needed and is cut out of the circuit by means of the centrifugal switch.

## 2) CAPACITOR INDUCTION MOTOR

The capacitor motor operates on alternating current and it is available from 1/20 hp to 3 hp. It is widely used to operate refrigerator, compressors, washing machines, pumps and air conditioners.

### Operation of capacitor induction motor

The capacitor start motor is connected to the supply. Current start to flow through the running and starting torque, which in turn to produce rotation of the motor. When the motor reaches approximately 75% of full speed the centrifugal switch opens. This action cut the both the winding and the capacitor from the supply. The motor runs on the running winding only.

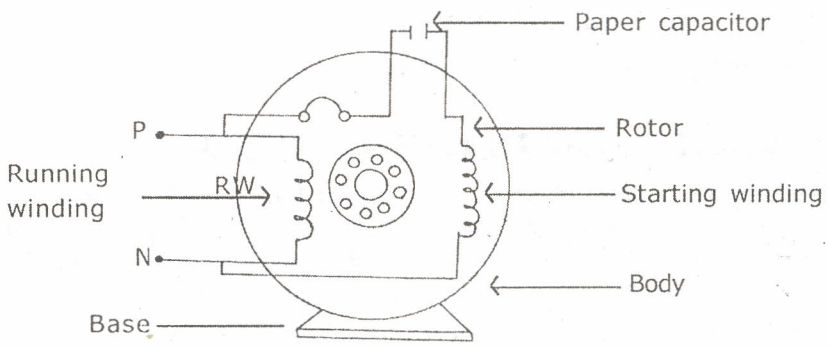



Fig:11.4 Operation of capacitor induction motor



There are three types of capacitor motor:

a. Capacitor start motor

b. Capacitor run motor

c. Capacitor start and run motor

d. In ceiling fan capacitor run motor is used.

## 3) UNIVERSAL MOTOR

A universal motor is one which can be operated on either direct current or single phase alternating current. This motor is used in vacuum cleaner, food mixer, drills and sewing machine.

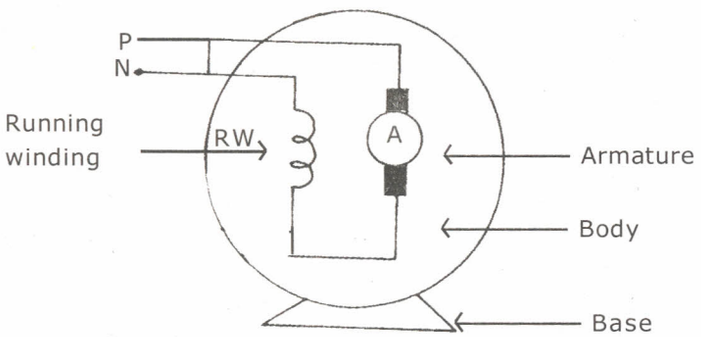



Fig: 11.5 Construction of Universal Motor

## CONSTRUCTION OF UNIVERSAL MOTOR

Universal motor consists of frame which is a rolled steel or aluminum. The field polls are generally held in frame by means of bolts. Field core is constructed of lamination which are tightly pressed together and held by reverts.

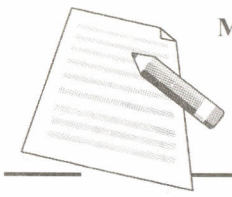
The armature is similar to that of small DC motor. It consists essentially of a laminated core having slots and a commutator to which the leads of armature winding are connected. The end plates are located on the ends of frame and held in place by screw. The plates house the ball bearings or sleeve bearings in which the armature shaft revolves.

### Operation of universal motor

The universal motor is so constructed that when the armature and field coils are connected in series and the current applied the magnetic lines of force created by the fields will react with the lines of force created by the armature and cause rotation. This is true regardless of whether the current is alternating or direct. As it can be operated on A.C. or D.C supply so it is called Universal motor.

## 4) SHADED POLE INDUCTION MOTOR

The shaded pole motor is single phase AC motor varying from approximately 1/100 to 1/20 hp. It is used for applications required very low starting torque such as small fans and blowers.





### Construction of shaded pole motor

It consist of stator or field frame, a rotor and end plates stator is usually of the concentrated field type and has a laminated core consisting of salient field poles on which a coil of wire is placed. The poles are provided with a slot near one end in which a solid copper coil of one turn is placed. This coil is called the shaded coil which act as starting winding. The shaded pole motor have the squirrel cage rotor.

### Operation of shaded pole motor

On starting, a current is induced into the shaded poles from the main poles. The shading coils establish a magnetic field which is out of phase with that established by the main fields and a shifting field is produced sufficient to give the desired starting torque. When the motor reaches speed, the effect of the shading coils are negligible.

## 3. PHASE MOTOR

Three phase AC motors that are designed for three - phase operation. Three phase motors vary from fractional horsepower size to several thousand horsepower. These motors have a fairly constant speed characteristic and are made in designs giving a variety of torque others a low starting torque. Some are designed to draw a normal starting current. They are made for practically every standard voltage and frequency and are very often dual voltage motors. Three-phase motors are used to drive machine tools pumps, elevators, fans, cranes, hoists, blowers and may other machines.

### Construction of 3 - Phase Motor

3-Phase motor consists of stator, windings, rotor and end plates. The stator is consist of a frame and laminated steel core and a winding form of individual coils placed in slots. The rotor may be a dicast aluminum, squirrel cage type. In these types a laminated core pressed on a shaft. Its construction of rotor is same as split phase rotor motor.

The end plates are bolted to each side of the stator frame and contain the bearings in which the shaft revolves.

### Operation of 3 - Phase Motor

When 3-phase winding is connected to the supply it produces the rotating magnetic field this magnetic field induces a current in the rotor winding which in turn causes another magnetic field. These magnetic field combine in such manner as to cause rotation of the rotor.

## 11.6 NECESSITY OF STARTER

If an AC motor is stated on full voltage it will draw from two to six times its normal running current. Because the motor is constructed to withstand the shock of starting no harm will be caused by this



excessive flow of current. However, in very large motors it is generally desirable to take some measure to reduce the starting current otherwise damage may be done to the machinery driven by the motor and line disturbances may be created that affect the operation of other motors on the same line.

**Direct On Line Starter (D. O. L)**

It is a simple and ordinary starter suitable for squirrel cage induction motors having a capacity up to 5 hp. Push buttons are used in place of a hand le. The green push button starts the motor while the red push button switches off the motor. A latch fitted near the red push button can be adjusted over it so that the motor may not be started. This provision is used only when the motor is defective.

Mainly it consists of contact system thermal relay unit and a solenoid coil. The contact system consists of silver tipped contacts which provide a quick ON-OFF system. The bi-metallic elements of the thermal relay protect the motor from overload. The solenoid coil is an electromagnet which works as an operating level for the contact system.

Fig. shows the pictorial view of the D. O. L. starter and its main components.

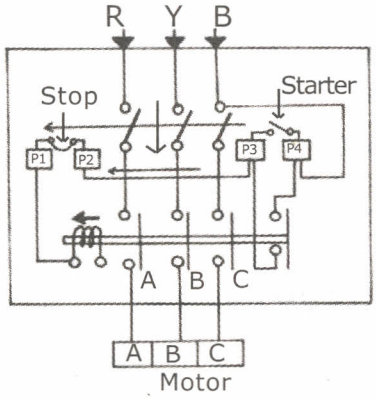



Fig: 11.6 D. O. L. Starter

The solenoid coil or no-volt coil (NVC) is connected across the two phases (it can be connected between a phase and neutral if it is designed to work at 440V) The overload release or thermal relay unit is connected in series with the outgoing ends of each phase from the starter.

On pressing the 'START' button (green push button), the solenoid coil becomes magnetized and it attracts the iron plunger which closes all the contact points. In this way the supply terminals $L_1$, $L_2$ and $L_3$ are connected to the motor terminals $M_1$, $M_2$ and $M_3$ and the motor operates by completing its circuit through the thermal relay coils. To stop the motor, 'STOP' button (red push button) is pressed. It breaks the solenoid coil circuit and finishes its magnetism. As a result, the plunger is released and the contact points become open. The thermal relay protects the motor by breaking the solenoid coil circuit through thermal relay switch which is placed in series with the operating coil.

As the motor becomes overload, it draws more current and the bi-metallic strips of the thermal relay unit brings the thermal relay switch to the 'OFF' position. The size of a starter depends on the hp capacity of the motor

## INTEXT QUESTIONS 11.2

a) Fill in the blanks:

1. The induction motor, rotor is made of _____.
2. Stationary part of motor is called _____.
3. The rotating part of motor is called _____.
4. For refrigerator _____ motor is used.
5. For food mixer _____ motor is used.

b) State True or False:

1. Split phase motor runs on running and starting winding.( )
2. Capacitor is connected in series with running winding. ( )
3. Armature is a part of universal motor. ( )
4. Shaded pole motor has squirrel cage rotor. ( )
5. A thermal relay is used in D. O. L. starter for safety of motor. ( )

## 11.7 WHAT YOU HAVE LEARNT

In this lesson we learnt about A. C. Generators and A. C. Motors and Principles of a motor, operations of A. C. Motor, types of A. C. Motors, necessity of starter, 3-phase motor, D. O. L. starter.

## 11.8 TERMINAL QUESTIONS

1. Write an essay on the AC Generators motor.
2. Explain the operation of alternator with figure.

## 11.9 ANSWER TO INTEXT QUESTIONS

**11.1**

1. Electromagnet Induction
2. Silent type rotor and Cylindrical type rotor



3. 250V
4. Rotor
5. AC Current

**11.2 (a)**

Fill in the blanks

1. High Grade Steel Laminated
2. Stator
3. Rotor
4. Capacitor Motor
5. Universal Motor

**(b)**

1. False 2. False 3. True 4. True 5. True

12

# TRANSFORMER AND SEMI CONDUCTORS

## 12.1 INTRODUCTION

In previous lesson we studied about AC generator and AC motor, which converts the electrical energy into mechanical energy. We have also studied about classification of AC Motors, its construction and operations, 3- Phase motor, starter, D. O. L. Starter etc. Now we are going to discuss the transformer which is used to convert high voltage into low voltage or low voltage into high voltage. We will also talked about semi conductors, diodes transistors and IC's (integrated circuits).

## 12.2 OBJECTIVES

After reading this lesson, you will be able to-

- Describe the Transformer.
- Understand the Working principle of transformer.
- Construct of transformer
- Understand the semi conductors and its types.

## 12.3 TRANSFORMER

**A static device used for transforming electrical energy from one A.C. circuit to another, without any change in the frequency, is called a transformer**

It changes the voltage from high to low or low to high with corresponding increase or decrease in current. If it increases the voltage, then it is termed as step up transformer and if it decreases the voltage, then it is termed as step down transformer. A transformer does not produce electricity and neither it affects the frequency nor the power.



## Working Principle of Transformer

According to the Faraday's Laws of electromagnetic induction, a current carrying conductor is surrounded by a magnetic field. If a switch is placed in the circuit and it is put to ON and OFF alternately, then the magnetic field around the conductor will start to vary. Now if a second conductor connected with a galvanometer is placed near the first conductor, then it will cut the varying magnetic field of the first conductor. Thus, an e. m. f. is induced in the second conductor. Which is verified by the deflection of galvanometer. In other words, the transformer works on the Principle of mutual induction. Hence, P is called the primary and S the Secondary Circuit.

A transformer does not work on D.C., Since the magnetic flux must be varied so as to obtain mutually induced e. m. f. If the Coils are used in place of conductors, then the coil connected to the source of supply is called a Primary Coil, while the other coil from which the output is taken, is called a secondary coil.

If A. C. is supplied to a transformer, then an alternating magnetic field is set up around the primary coil, without making or breaking the circuit by a switch. The Primary and Secondary Coils are wound on laminated cores. The A.C. e.m.f. applied to the Primary Coil produces an alternating magnetic field. The field is cut by the Secondary Coil resulting in an e.m.f. to be induced in it. The secondary voltage depends on the ratio of the secondary turns to the primary turns.

## Construction of Transformer

In this stage we consider about a small transformer, which is known as moonlight transformer or bell transformer. It consist of body laminated iron core, bobbin, two windings.

**Body -** It is made up of bakelite. It is used to hold the terminals and protection for windings. The core is made of high grade silicon steel lamination. In this type of transformer E and I types of laminations are used. The laminations are used to complete the magnetic path, with minimum losses; A Bobbin is made of presto paper, bakelite or nylon. The winding wire is wound on this bobbin. Bobbin is used to support the windings. In this transformer there are two windings. The

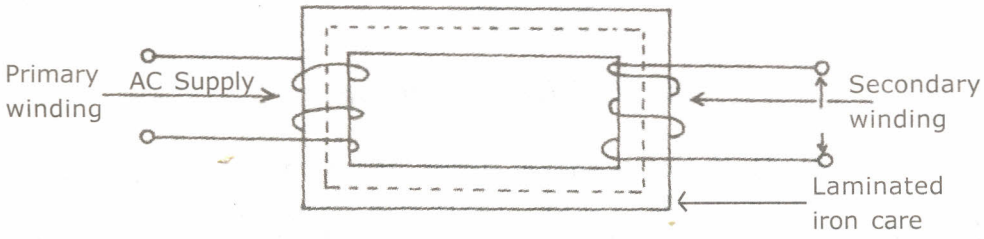



Fig: 12.1 Transformer

windings which is connected to the supply is known as Primary winding and which is connected load is known as secondary winding. 6 V, 3 w lamp is connected 230 V, 50 Hz A. C. Supply. Due to mutual induction 6 V a. c. supply is induced in secondary winding.

The transformer are used to distribute electricity known as distribution transformer which are installed in substation. The power transformers are used in transmission line. The construction of this transformer is basically same as above explained transformer.

## 12.4 SEMI CONDUCTORS

You have studied about conductor and insulator but there is another material which is known as semi conductors. Conducting materials are good conductors and insulating material are bad conductor of electricity. A semi-conductor is a material which has a resistance in between that of a conductor and insulator. In semi-conductors the Valence electrons are normally bond but can be set free by supplying a small amount of energy.

### Atomic Structure

Germanium (Ge) and Silicon (Si) are examples of semi-conductors. Fig 12.2 (A) shows a germanium atom. In the centre is a nucleus with 32 protons. The revolving electrons have distributed themselves in different orbits. There are 2 electrons in the first orbit and 8 electrons in the second orbit and 18 electrons in the third orbit. The four orbit is the outer or Valence orbit which contains 4 electrons.

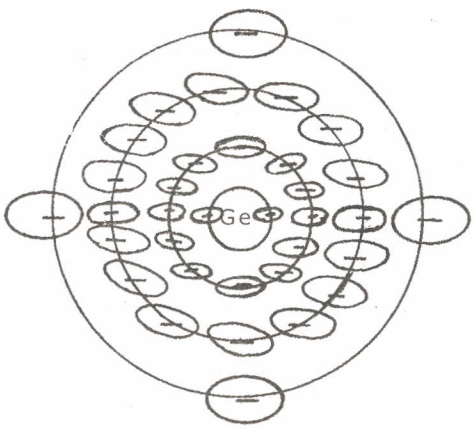



Fig: 12.2 (A) Germanium

Figure 12.2 (B) shows a silicon atom. It has 14 protons in the nucleus and 14 electrons in orbit. There are 2 electrons in the first orbit and 8 in the second orbit. The remaining 4 electrons are in the outer or the valence orbit.

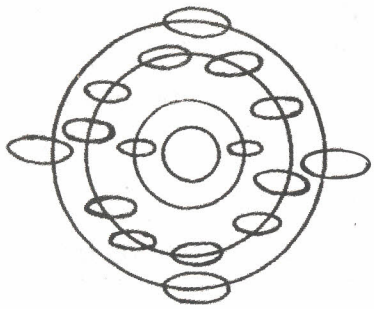


Fig: 12.2 (B)

In semiconductor materials, the atoms are arranged in an orderly pattern called a crystal lattice structure. If a pure Silicon crystal is examined, we find that the four electrons in the outer (Valence) shell of an atom is shared by the neighboring atoms.

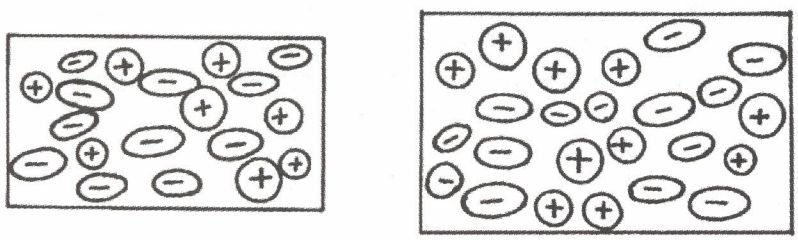


Fig: 12.3 Sharing of Atom

The union of atoms sharing the Valence electron being shared by two adjacent atoms. Each atom appears to have a full outer shell of eight electrons.

### Types of Semi Conductors

A pure semiconductor is called an intrinsic semiconductor. For example, a silicon crystal is an intrinsic Semi conductor because every atom in the crystal is a silicon atom. One way to increase conductivity in a semiconductor is by 'doping'. This means adding impurity atoms to an intrinsic semi conductor. The doped semi-

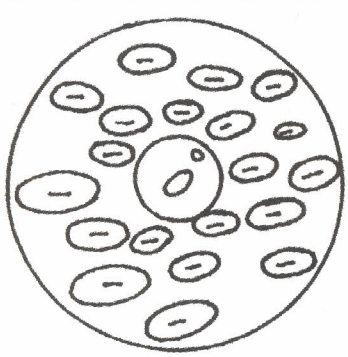


Fig: 12.4 Free electron

conductor is known as an extrinsic semi conductor. It has two types. a) N-type semi conductor b) P-type semi conductor

The residual heat at room temperature (300k) is sufficient to make a Valence electron of an intrinsic semi conductor to move away from the covalent bond and the electron becomes a free electron to move in the crystal.

When an electron breaks a covalent bond and moves away, a vacancy is created in the broken covalent bond. This Vacancy is called a 'hole'. A hole has a positive charge when a free electron is liberated, a hole is created.

**N-type semi conductor**

A semi conductor with excess of electrons is called N-type. To obtain excess free electrons, the element doped with the semiconductor material is arsenic, or antimony or phosphorus. Each of these atoms has five electrons in its outer orbit.

As the outer orbits of the atoms can hold eight electrons, no hole is available for the fifth electron in the arsenic atoms to move into. It, therefore, becomes a free electron. The number of such free electrons is controlled by the amount of arsenic added to the crystal.

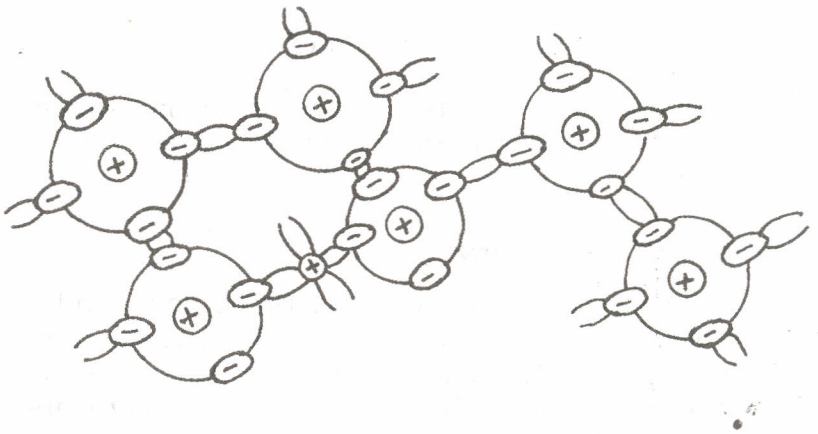


Fig: 12.5 Formation of N-type semi conductor.

In N-type, the free electrons are called majority carriers and the holes minority carriers.

**P-type semi conductor**

To obtain more holes, a pure silicon crystal is doped with elements such as aluminum or boron or gallium. The atoms of each of these elements have three electrons only in their outer orbit. Adding gallium to pure silicon crystals allows the atoms of the two elements to share seven electrons.

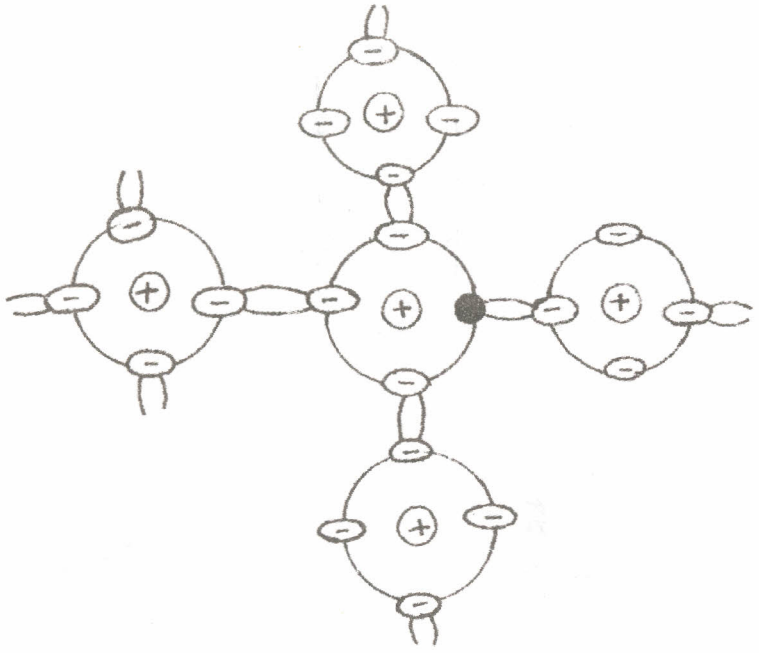


Fig: 12.6 P type semi conductor

A hole is created in the place of the eight electron. Now that the number of holes exceeds the number of free. P-type material. The holes in P-type are the majority carriers and the free electrons are the minority carriers.

**PN Junction**

A PN Junction is formed by combining P and N type materials. The surface where they meet is called the PN Junction.

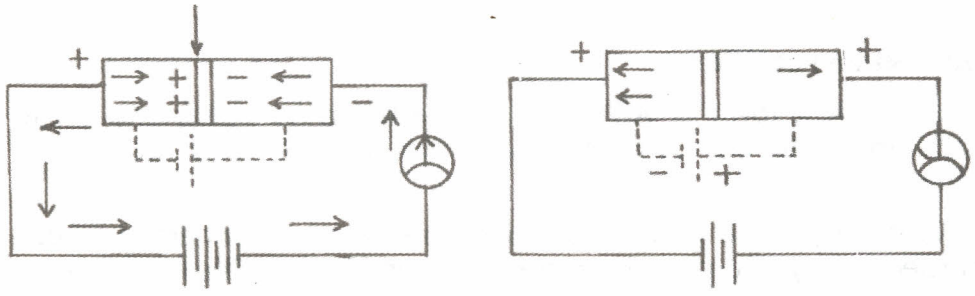


Fig: 12.7 PN Junction

The free electrons in the N-regions diffuse across the junctions into the P-region. The free electrons lose energy and recombine with the holes in the P-region. This recombination when the electron moved from the N-region and diffused across the junction, it leaves the atom to be a positive ion. The positive ion is not balanced by a negative charge in the N-region. The hole is eliminated

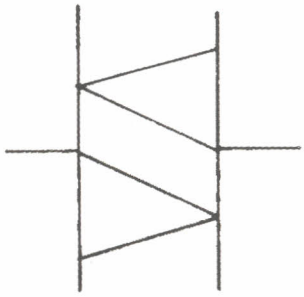


Fig: 12.12 Diac & its sumbol

**Triac**

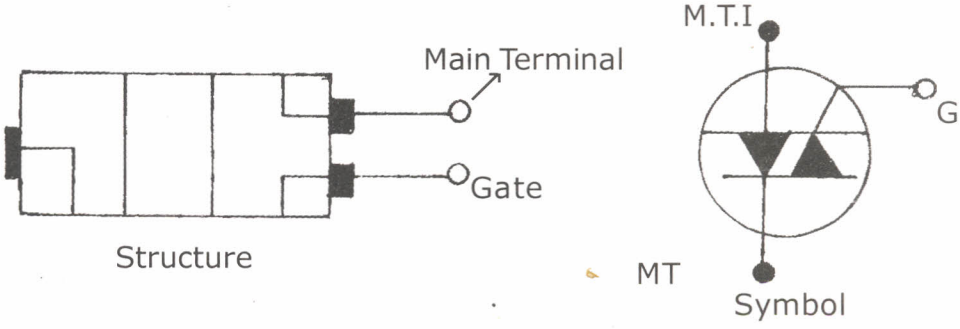



Fig: 12.13 Triac

A triac is also a semi-conductor device with three leads like two SCRs in parallel. The triac can control the circuit in either direction.

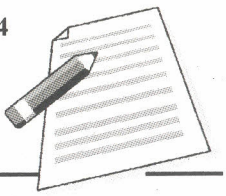
**Bridge rectifier or diode bridge**

It is a single package of four semi-conductor diodes connected in bridge circuit. The input AC and the output DC leads are marked and terminated. It has two doped regions with three leads and has one emitter and two bases.

**Half wave rectifier**

This simplest form of AC to DC converter is by using one diode such an AC to DC Converter is known as half-wave rectifier as shown in.

A diode D, and a load resistance $R_L$ in series are connected across the secondary of a step down transformer (fig 1a). The transformer steps up or steps down the supply voltage as needed. Further the transformer isolates the power line and reduces the risk of electrical shock. During the positive half-cycle of the input line frequency, (fig 1b) the diode anode is made positive with respect to the cathode. The diode D, Conducts because it is forward-biased. Current flows from the positive end of the supply through diode D, and RL. During the negative half cycle of AC input line frequency, the diode is reverse biased. Practially no current flows through the diode and the load $R_L$ and there is no voltage output.





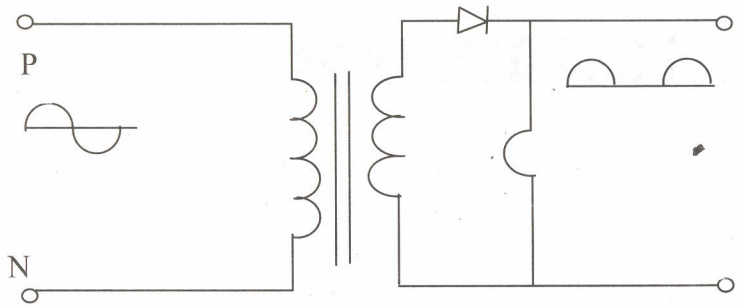



Fig 12.14 Half Wave Rectification

**Full-Ware rectifier (FW)**

A full-ware rectifier circuit is shown in Fig 3. The Secondary winding of the transformer is centre-tapped. The secondary voltage is divided equally into two halves, one end of the load $R_L$ is connected to the centre tap and other end of $R_L$ to the diodes.

It is seen that two half-ware rectifiers conducting on alternate half cycles of the input AC.

During the positive half cycle of the secondary voltage, diode D, is forward-biased and diode $D_2$ is reverse-biased. The current flows through the load resistor $R_L$, diode $D_1$ and the upper half of the secondary winding.

During the negative half cycle of secondary voltage, diode $D_2$ is forward-biased and diode $D_1$ reverse-biased. Therefore, current flows through the load resistor RL diode $D_2$ and the lower half of the secondary winding.

The load current is in same direction during both the half-cycles of the AC input.

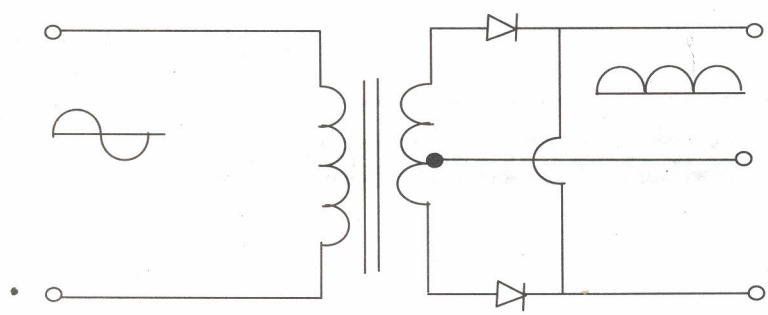
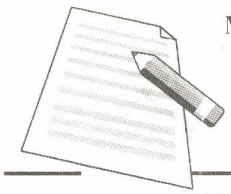


Fig 12.15 Full Wave Rectification





## INTEXT QUESTIONS 12.1

(A) Fill in the blanks:

1. _____and _____ are the examples of semi-conductor.
2. A semiconductor with excess of electrons is called _____.
3. A pure semiconductor is called an _____ semiconductor.
4. Diac is a _____ switching device.
5. Bridge rectifier is a single package of _____ semiconductor diodes.

(B) State True or False:

1. In N-type the free electrons are called minority carriers. ( )
2. A PN junction is formed by combining P and N type materials. ( )
3. The holes in P-type are the majority carriers. ( )
4. Conducting materials are bad conductors. ( )
5. A semiconductor is a material which has a resistance in between that of a conductor and insulators. ( )

## 12.5 WHAT YOU HAVE LEARNT

Semi conductors types of semi-conductors, P-type semi conductor, N-type semi conductor, Active components, Diac, Triac, What is rectifier bridge rectifier, Uni- junction transistor, Field effect transistor, half wave rectifier what is full-ware rectifier, this also we learn.

## 12.6 TERMINAL QUESTIONS

1. Write the short note on N-type semiconductor with figure.
2. Write the short note on P-type semiconductor with figure.
3. What are the active components?
4. What do you mean by Half Ware rectifier and Full Ware rectifier?

## 12.7 ANSWER TO INTEXT QUESTIONS

Fill in the blanks

1. Germanium and Silicon
2. N-type



3. Intisic
4. Bidirectional
5. 4 semiconductor diodes

True or False

1. False
2. True
3. False
4. False
5. True.