GOVERNMENT OF TAMIL NADU

HIGHER SECONDARY - FIRST YEAR

VOCATIONAL EDUCATION

Basic Electrical Engineering

THEORY & PRACTICAL

A publication under Free Textbook Programme of Government of Tamil Nadu

Department of School Education

Untouchability is Inhuman and a Crime

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Preface

Basic Electrical Engineering text book has been written primarily as a text book for the students and is designed to serve the introductory part of the electrical engineering in school education under vocational stream. The basic concepts of electrical topics are explained with neat diagrams for better understanding of the learners.

The Basic Electrical Engineering text book has been written with an inspiration and for the interaction of scholars in electrical fields in India and abroad. The resource materials and ideas for making this book are obtained from experts in the field of electrical engineering in and around the country to meet the curriculum to national standards. The design of this book is based on Bloom's Taxonomy which is a learning tool for all students. The theory and problems available in this text book motivates the students for better understanding. The contents of this book are mainly confined to the content of syllabus fulfilling the objectives.

In the current digitalized world all the things are interconnected and dependent with electrical sciences. In the forthcoming years, the demand of electrical source of energy will multiply due to the advancement of updated technology. Nowadays, affordable knowledge is essential in the field of electrical sciences for better understanding of the day to day innovative electrical appliances.

This book has been revamped by SCERT in collaboration with Tamil Nadu Skill Development Corporation in order to get immediate employment opportunities for the vocational students in the Industrial Sectors in future. The skill certificate for practical assessment is given to every student by concerned Sector Skill Councils (SSCs) which are accredited by National Skill Development Corporation (NSDC) and TNSDC.

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Assessment

Basic Electrical Engineering

THEORY

LESSON 1

Introduction to Electricity

LEARNING OBJECTIVES

The objective of this lesson is to know about electricity, the methods of power generation. fundamentals of AC and DC, electric circuit and laws.

Table of Content

1.1 Introduction
1.2 Origin of electricity
1.3 Fundamental terms in electrical circuits
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1.1 INTRODUCTION

The Basic Electrical Engineering subject is introduced in the higher secondary level for students. In this subject, students learn that the basic concepts in Electrical Engneering, maintenace and repair of electrical appliances.

1.2 ORIGIN OF ELECTRICITY

1.2.1 History of electricity

In 1752, an American Scientist Benjamin Franklin wanted to do a small experiment in lightning. He took a kite during a thunder storm and he got the string of the kite. Then he put a metal key at the end and then he made the kite to float up into the storm. At that time he felt a small electric shock. During this experiment, he felt that lightning contains electricity. Scientists felt that electricity can be produced from lightning.

1.2.2. Basic of Electricity

Everything in the world is made up of atoms (even human body). It cannot be destroyed. It consists of three particles namely,

1.Protons
2.Electrons
3.Neutrons

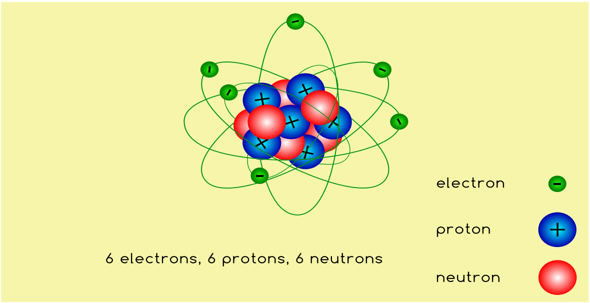


Fig 1.1 Atomic Structure

Protons are the positively charged particle, the electron is a negatively charged particle and the neutron is a neutral charged particle which has no charge. The protons and neutrons are bound together to form the central part called Nucleus as shown in the fig 1.1. Electrons are revolving around the nucleus in a definite path called orbit.

If the balancing force between protons and electrons are disturbed by an external force, an atom may gain or lose an electron. When electrons are lost from an atom, the free movement of these electrons constitutes an electric current.

The flow of free electrons due to the voltage applied is said to be electric current.

1.2.3. Classification of materials based on the conductivity

Based on the conductivity, the materials are classified into three types, namely,

Conductors

Conductors are the materials that allow an electric current to pass through it easily. Example gold, silver, copper etc, are good conductors of electricity.

Insulators

Insulators are the materials that does not allow an electric current to pass through it. Example are rubber, glass, plastic, etc.

Semiconductors

The semiconductors are the materials that have the electrical conductivity which lies between the conductors and insulators. Example: Silicon and germanium.

1.3 FUNDAMENTAL TERMS IN ELECTRICAL CIRCUITS

Understanding the concepts of electricity requires knowledge in the following electrical terms.

Current

Flow of electron in a conductor is called as current. It is represented by the letter 'I' and the unit is called ampere(A). Current can be measured by ammeter.

1 Ampere: "One coulomb charge crossing over the area of cross section of the conductor in one second is called 1 ampere.

1 Coulomb: A collection of $2\pi \times 10^{18}$ electrons has a charge of one coulomb.

Voltage

The electric pressure which is used to move electrons from one end to another end is called as voltage. It is represented by the letter 'V' and the unit is volt. It is measured by voltmeter. The other parameters termed as volts are EMF, Potential and Potential Difference.

Electro Motive Force (EMF)

It is the force which causes the flow of electrons in any closed circuit. It is represented by volt.

Potential and Potential Difference

The work done in bringing unit positive charge from infinity to that point against the application of electric field is called potential. It is also represented in volt.

The difference of potential between any two points in a electrical circuit is called potential difference and is expressed in volt.

Resistance

Resistance may be defined as the property of a substance to oppose the flow of current through it. It is represented by the letter R and the unit is ohm(Ω). It is measured by ohm meter. Mega ohms value is measured by using megger.

Laws of resistance

The resistance of a conductor in a circuit depends upon the following:

- It depends upon the resistivity of the material used (ρ)
- The value of resistance directly proportional to the length of the conductor.(R)
- It is inversely proportional to the area of cross section of the conductor.(A)
- Temperature of the conductor.

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

Work, Power and Energy

Here we are going to study about the work, power and energy and their relationship.

Work

Work is said to be done by Force 'F' when the point of its application moves through a distance 'S'.

Mathematically, Work = Force × distance = F × S =FS.

The unit of force is Newton (N). If 1 Newton force moves a body to a distance of 1 metre, then the work done is 1Nm (Newton - metre)

In an electric circuit, if 1 volt electric potential causes 1 coulomb of electric charge to pass through it, then the work done is equal to 1 joule.

1 joule = 1 volt × 1 coulomb

Coulomb = Ampere × time

i.e $J = V \times I \times t$

Power

Power is rate of doing work. The power is obtained by the following expressions.

$P = V \times I.$

P = Power

V = Applied voltage

I = Current

Its unit is watt (W).

$$\text{Power} = \frac{\text{Work done}}{\text{time}} = \frac{\text{Joule}}{\text{time}} = \frac{V \times I \times t}{t}$$

$$\text{Power } P = \text{VI watt } [V = IR,\ P = I^2R]$$

$$1 \text{ KW} = 1000 \text{ watt}$$

$$1 \text{ HP} = 746 \text{ watt}$$

iii) Energy

The amount of work done by an equipment during a time period of 't' seconds. The unit of energy is joule.

Energy = Power × time / watt sec

The energy spent for the appliances in 1 kwh is called as one unit i.e

1 unit = 1 kwh

The power of iron box is 1000 watt. when used for 1 hour, the energy consumed is, 1000 watts × 1 hour = 1000Wh = 1kwh = 1unit.

Example: 1

The resistance of a lamp is 10Ω and 2A current is flowing through it. Calculate the power of the lamp.

Solution:

Resistance (R) = 10Ω
Current (I) = 2A
Power = I^2.R
=2^2 × 10 =40W

Example: 2

In a factory, the following appliances are used:

a) 3Hp motor works 5 hours per day.
b) 100W capacity of 40 lamps glow 8 hours per day.
c) 1500W capacity of heater works 6 hours per day.

Calculate the cost of energy consumed in 30 days. (1unit cost is Rs. 6.00)

Solution:

a) 3Hp motor works 5 hours per day

$$\text{Energy} = \frac{3 \times 746 \times 5}{1000} = \frac{11190}{1000}\text{Wh}$$
$$= 11.190 \text{ kwh} = 11.190 \text{ unit}$$

b) 100w capacity of 40 lamps glow 8 hours per day

$$\text{Energy} = \frac{100 \times 40 \times 8}{1000} = \frac{32000}{1000}\text{Wh}$$
$$= 32\text{kWh} = 32 \text{ units per day}$$

c) 1500w heater works 6 hours per day

$$\text{Energy} = \frac{1500 \times 6}{1000} = \frac{9000}{1000}\text{Wh}$$
$$= 9\text{kWh} = 9 \text{ units per day}$$

The total number of units consumed in 30 days

$$-(11.190 + 32 + 9) \times 30$$
$$-52.19 \times 30$$
$$-1565.7\text{units}$$

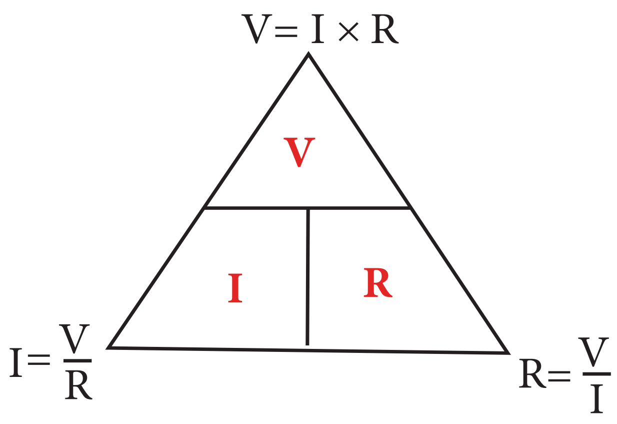
Cost of electricity by for 30 days (1 unit=Rs.6)

-1565.7×6
-9394.2
Cost-Rs.9394

1.3.1. Ohm's law

In an electrical circuit the current, voltage, and resistance are related to one another. The relationship was derived by the scientist ***Georg Simon Ohm***, called Ohm's Law.

Ohm's law states that, *"At a constant* temperature *in any closed circuit, the current is directly proportional to the voltage applied and inversely proportional to the resistance of the circuit."*



i.e $I = \frac{V}{R}$

$\therefore\ V = I\,R$ and $R = \frac{V}{I}$

Where, V = Voltage in volts. I = current in ampere and R = Resistance in ohm

Problems

1) *Supply voltage of the circuit is 240V. The resistance value is 60Ω. Calculate the current flowing through this circuit.*

Voltage (V) = 240V
Resistance (R) = 60Ω
Current (I) = ?
According to ohm's law, $I = \frac{V}{R}$
Current $I = \frac{240}{60} = 4A$

2) *Voltage of the circuit is 230V and current 10A is flowing through it. Find the value of Resistance.*

Voltage (V) = 230V
Current (I) = 10 A
Resistance (R) =?

According to ohm's law, $I = \frac{V}{R}$

i.e $10 = \frac{230}{R}$

$R = \frac{230}{10} = 23\Omega$

1.3.2 Kirchhoff's laws

Kirchhoff derived laws based,

Kirchhoffs laws describes current in a node and voltage around a loop. These two laws are foundation of circuit analysis. They are

i) Kirchhoff's Current Law (KCL)
ii) Kirchhoff's Voltage Law (KVL)

i) Kirchhoff's Current Law (KCL)

The sum of the current flowing towards a point (i.e junction) is equal to the sum of the current flowing away from the point. In other words, the algebraic sum of the currents at any junction of a network is zero.

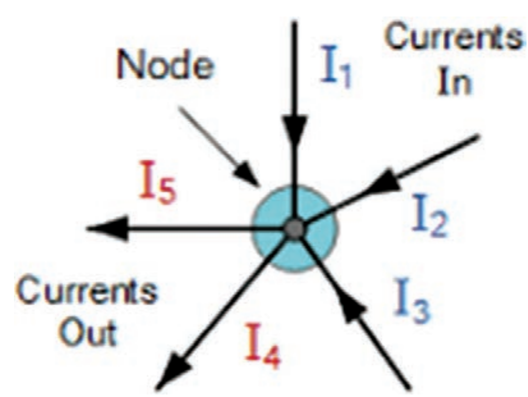


Fig 1.2 Kirchoff's current law

Fig 1.2 represents Kirchhoff's current law. In this, I_1, I_2 and I_3 represent the current flowing towards the junction point I_4 and I_5 represent the current flowing away from the junction point.

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

ii) Kirchhoff's voltage law (KVL)

In any closed electric circuit, the algebraic sum of the potential drop is equal to the supply voltage.

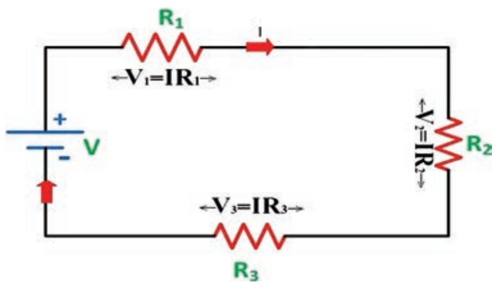


Fig 1.3 Kirchoff's Voltage Law

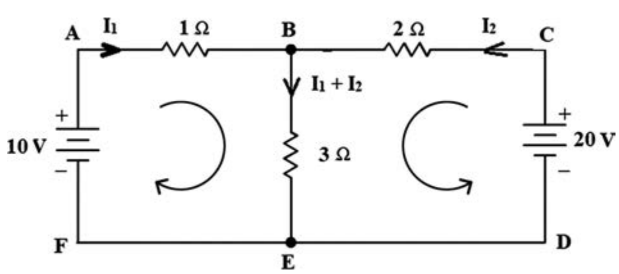
Fig 1.3 represents, loads R_1, R_2, and R_3 connected in series. Potential drop across R_1 is IR_1, potential drop across R_2 is IR_2 and potential drop across R_3 is IR_3.

$$V_1 = IR_1$$
$$V_2 = IR_2$$
$$V_3 = IR_3$$
$$V = V_1 + V_2 + V_3$$
$$IR = IR_1 + IR_2 + IR_3$$

Problems:

Example:

Find the current in the 3Ω resistor in the circuit as shown.



In the closed loop ABEFA

$$I_1 + 3\,(I_1 + I_2) = 10V$$
$$I_1 + 3I_1 + 3I_2 = 10$$
$$4I_1 + 3I_2 = 10 \qquad (1)$$

In the closed loop BCDEB

$$2I_2 + 3\,(I_1 + I_2) = 20V$$
$$2I_2 + 3I_1 + 3I_2 = 20$$
$$3I_1 + 5I_2 = 20 \qquad (2)$$

$$3 \Rightarrow 12I_1 + 9I_2 = 30$$
$$4 \Rightarrow 12I_1 + 20I_2 = 80 \qquad (4)$$
$$\Rightarrow -11I_2 = -30$$
$$= \frac{-50}{-11} = 4.545\,A = 4.55A$$

Substituting the value of I_2 in equation (2) to get

$$3I_1 + 5I_2 = 20$$
$$3I_1 + 5 \times 4.55 = 20$$
$$3I_1 = 20 - 22.75$$
$$= -2.75$$
$$I_1 = -\frac{2.75}{3}$$
$$= -0.916A$$
$$I_1 = -0.916A$$

The value of current I_1 is negative, So the current flow in the circuit, is in opposite direction.

The current in 3Ω resistor is $I_1 + I_2$ $= -0.92 + 4.55 = 3.63A$

1.4 TYPES OF ELECTRIC CIRCUIT

An electric circuit is defined as the current flowing from the supply points through the load to complete the path. In this chapter, we will study about the types of the electrical circuits. There are three types of electrical circuit namely;

i) Closed circuit,
ii) Open circuit and
iii) Short circuit.

i) Closed circuit

When loads are connected in series between two terminals of electric supply, then the current passing through the load is called as closed circuit.

For example, it the switch is OFF, the circuit is open and the lamp will not glow. If the switch is ON, the circuit is closed and the lamp will glow.

ii) Open circuit

In this circuit, if there is no way to the flow of current due to disconnection of wire or the switch is in OFF condition, then the circuit is called open circuit.

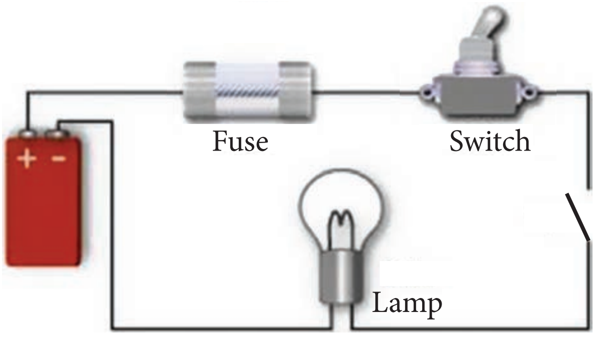


Fig 1.4 *Open circuit*

Ex: In lighting circuit, if the switch is in OFF condition, the circuit is open and the lamp will not glow and it is called an open circuit.

iii) Short circuit

In this circuit, the two terminals of the supply is connected directly without a load and the current flow is infinite because of very low resistance. Then the circuit is called as short circuit. It causes heavy damage to the load.

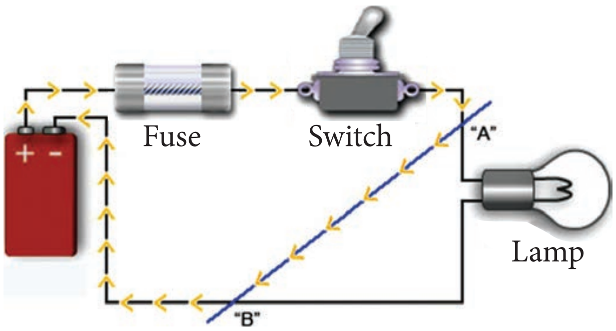


Fig 1.5 Short circuit

1.4.1 Classification of Electric circuits

Here we will study about the classification of the electrical circuits in terms of resistances. They are,

i) Series circuit
ii) Parallel circuit
iii) Series-parallel circuit

i) Series circuit

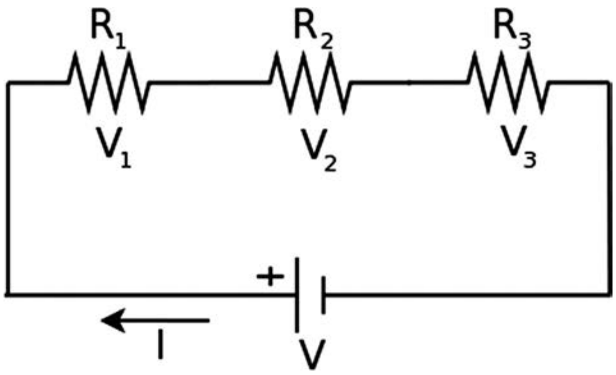


Fig 1.6 Series circuit

When three resistors are connected in series with each other as shown in Figure 1.6, so that the same current passes through all of them is called series circuit.

Here the resistors R_1, R_2 and R_3 are connected in series. The current flowing in all three resistors is same as that of supply current. But across each resistor, it

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has a potential drop depending on their resistance value.

According to Ohm's law

$V_1 = IR_1, V_2 = IR_2, V_3 = IR_3$

The sum of the three potential drops in equal to the supply voltage V

$I = I_1 = I_2 = I_3$

$V = V_1 + V_2 + V_3$

$V = IR_1 + IR_2 + IR_3$

$V = I(R_1 + R_2 + R_3)$

$\frac{V}{I} = R_1 + R_2 + R_3$

Where $R = R_1 + R_2 + R_3$

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

❖ **Important points for series circuit**

1. In series circuit, the current flows through only one path.
2. If one more resistance is to be added, the total value of resistance is increased. Total resistance is equal to the sum of all the resistance connected to this circuit.

i.e $R = R_1 + R_2 + R_3 + \ldots\ldots$

3. The current flows in all resistor is same

i.e, $I = I_1 = I_2 = I_3$

4. The sum of the potential drop across each resistor is equal to the supply voltage i.e $V = V_1 + V_2 + V_3$
5. If there is a fault in any place of the circuit, the total circuit will be inactive.

Example:- In many of the places like temple functions, malls, theatres and marriage halls, serial sets are used to make different decorative items using serial bulbs. In serial circuit, the path of the current flow is only one. So if any fault (brake in wire connection) occurs in any one place of the circuit, then the total circuit (serial set) will be inactive.

ii) Parallel circuit

When resistors are connected across supply so that the same voltage (supply voltage) is applied between the end point of each resistor, then this type of connection is said to be parallel connection as in figure 1.7.

In this circuit, the voltage across each resistor is same as supply voltage but the current in each resistor is different. In this circuit, the sum of the current I_1, I_2 and I_3 is equal to supply current I, i.e $I = I_1 + I_2 + I_3$

According to ohm's law

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

$$I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{V}{R_3}$$

But total current $I = I_1 + I_2 + I_3$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

But $\frac{I}{V} = \frac{1}{R}$

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

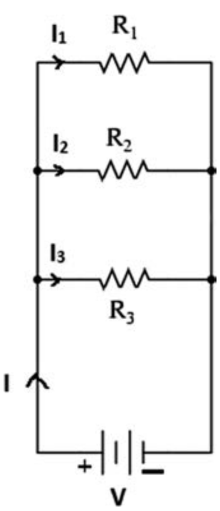


Fig 1.7 Parallel circuit

$$\frac{1}{R} = \frac{R_2R_3 + R_1R_3 + R_1R_2}{R_1R_2R_3}$$

$$R = \frac{R_1R_2R_3}{R_2R_3+R_1R_3+R_1R_2}$$

Important points of a parallel circuit

i) In parallel circuit, the current flows through two or more parallel paths at a junction.

ii) Current varies in different resistances i.e The sum of the current is equal to supply current.

$$I = I_1 + I_2 + I_3 + \ldots$$

$$I = \frac{V}{R}, \quad I_1 = \frac{V}{R_1}, I_2 = \frac{V}{R_2}, I_3 = \frac{V}{R_3}$$

iii) The voltage is same across all resistors as supply voltage.

$$V = V_1 = V_2 = V_3 = \ldots$$

iv) The total value of the resistance is reduced by adding one or more resistor in the circuit. If three resistances are connected in parallel then the total resistance is

$$R = \frac{R_1R_2R_3}{R_2R_3+R_1R_3+R_1R_2}$$

v) If there is a fault in any one resistor, the other two resistors will work, the current will flow through the remaining resistors.

Example: In our house or factories, different types of electrical appliances are used, i.e., fan, bulb, television, motor, heater, etc., Each one has a separate circuit. For example, if there is a fault in fan circuit, the fan circuit alone is inactive. Other circuits like bulb, television etc will work as usual. So, in parallel circuits there are number of current paths available.

Problems – (Series circuit)

1) ***10Ω, 20Ω and 30Ω resistances are connected in series. The circuit voltage is 240V. Calculate i) Total resistance ii) current through the circuit.***

$R_1 = 10\Omega$, $R_2 = 20\Omega$, $R_3 = 30\Omega$
$V = 240V$
$R = ?$
$I = ?$

When the resistors are connected in series
$R = R_1 + R_2 + R_3$
$= 10 + 20 + 30 = 60\Omega$

Total Resistance $R = 60\Omega$
According to Ohm's law

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

$$= \frac{240}{60} = 4A$$

Current I = 4A.

Problem – (Parallel circuit)

1) ***Two resistances 8Ω and 2Ω are connected in parallel. Voltage of this circuit is 240V. Find the value of***
i) Total resistance
ii) Current.

$R_1 = 8\Omega$, $R_2 = \Omega$
$R = ?$

In parallel circuit, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{8 \times 2}{8+2} = \frac{16}{10} = 1.6\Omega$$

According to ohm's law

$$I = \frac{V}{R}, I = \frac{240}{1.6} = 150A$$

2) ***Three resistors 6Ω, 3Ω and 2Ω are connected in parallel. The current flow of this circuit is 2A. Find out the value of***
i) Total resistance
ii) Voltage.

$R_1 = 6\Omega$, $R_2 = 3\Omega$, $R_3 = 2\Omega$, $I = 2A$
$R = ?$ $V = ?$

When they are connected in parallel,

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

Then
$$R = \frac{R_1 R_2 R_3}{R_2 R_3 + R_1 R_3 + R_1 R_2}$$

$$= \frac{6 \times 3 \times 2}{(3 \times 2) + (6 \times 2) + (6 \times 3)}$$

$$R = \frac{36}{6 + 12 + 18} = \frac{36}{36} = 1\Omega$$

According to Ohm's law

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

$$2 = \frac{V}{1}, V = 2V$$

iii) Series - Parallel circuit

In series parallel circuit, one or more resistors are connected in series with more resistors connected in parallel. This is the combination of series parallel circuit.

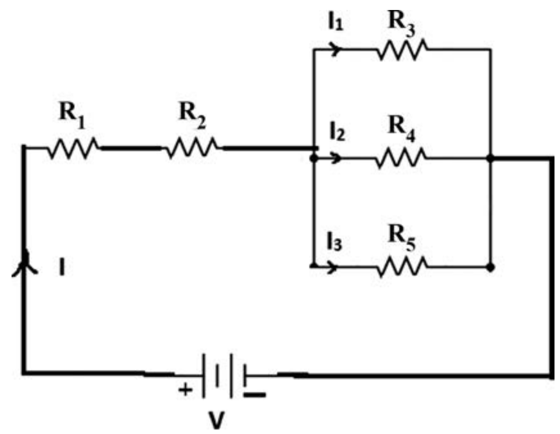


Fig. 1.8 Series-parallel circuit

Fig 1.8 represents, five resistors connected in series parallel circuit. Here R_1, R_2 are connected in series and R_3, R_4, and R_5 are connected in parallel. These parallelly connected resistors are connected in series with R_1 and R_2.

Hence the total resistance of the circuit is

$$R = R_1 + R_2 + \left[\frac{R_3 \times R_4 \times R_5}{R_4 R_5 + R_3 R_5 + R_3 R_4}\right]$$

1.5 POWER GENERATING PLANTS

The electrical power is generated power generating plants. They are genarally.

a) Hydroelectric power plant
b) Thermal power plant
c) Atomic power plant
d) Gas power plant
e) Diesel power plant
f) Solar power plant
g) Wind power plant

a) Hydroelectric power plant

From the water reservoir, the water is taken through the penstock pipes to the water turbine. For the rotation of turbine, the kinetic energy of water is used and mechanical energy of the turbine is converted into electrical energy by generator coupled with the turbine.

This type of plants are located in Mettur, Kunda, Pykara, Suruliyaru and Kadamparai.

b) Thermal power plant

In thermal power plants heat energy is converted into electrical energy by burning coal or lignite in boiler plant. Water in the boiler is converted into high pressure steam by heat energy. This steam is flown through the steam turbine which is coupled to the generator. This energy is converted into mechanical energy by the rotation of turbine. The mechanical energy is again converted into electrical energy by the generator.

This type of plants are located at Ennore, Neyveli, Tuticorin and Mettur in Tamil Nadu.

c) Atomic power plant

By the diffusion of an atom of Uranium or Thorium, more heat is produced. The atomic power plant is working based on this principle. The heat energy produced is used to rotate the steam turbine and this energy is converted into mechanical energy. The generator converts the mechanical energy into electrical energy.

This type of plants are located in Kalpakkam near Chennai, Koodangulam in Tirunelveli District and Tharapur in Rajasthan.

d) Gas power plant

The process of generating electrical energy with the help of gas turbine (which acts as a prime mover) is known as Gas power plant. It is available in Ramanathapuram and Nagapattinam districts.

e) Diesel power plant

Diesel power plant is used in places where continuous supply of electricity is needed i.e., in industries. Electricity is produced by the generator which is connected to a big diesel engine which acts as prime moves.

Depending upon the requirements, different capacities of small or large diesel generators are used in hotels, hospitals, jewellery shops, cinema theatres, shipyards, etc.

f) Solar power plant

Now a days solar panels are used to generate electrical power in many places. Solar panels are made out of photovoltaic cells that convert the sun radiative energy into electrical energy.

g) Wind power plant

A wind turbine is a deivce that converts kinatic energy of wind is conducted into electrical energy. Wind power plant is a group of wind turbines in the same location to produce electricity.

Hydro Power Plant

Thermal Power Plant

Atomic Power Plant

Gas Power Plant

Diesel Power Plant

Solar and Wind Plant

Fig 1.9 *Types of power plants*

1.6 INTRODUCTION OF LT/HT LINE

Generated power from power station is transmitted and distributed through transformers, overhead lines and cables to the end users.

1.6.1 LT Lines

In India, low Tension (LT) supply is 440 volts for three-phase connections and 230 volts for single-phase connection.

Fig 1.10 *LT Line*

Consumer of electricity like individual houses, shops, small offices and smaller manufacturing units get their electricity on LT connection.

1.6.2 HT Line voltage

High tension (HT) supply is applicable for bulk power purchase which needs 11 kV or above. Major industries are operating at High tension supply only.

Fig 1.11 *HT Lines*

Activities

1. Produce electricity by any two materials applying friction method.
2. How the supply leakage electric shock can be eradicated?

GLOSSARY

Hydroelectric power plant	—	**நீர் மின் நிலையம்**
Thermal power plant	—	**அனல் மின் நிலையம்**
Gas power plant	—	**வாயு மின் நிலையம்**
Diesel power plant	—	**டீசல் மின் நிலையம்**
Solar power plant	—	**சூரிய ஒளி மின் நிலையம்**
Wind power plant	—	**காற்றாலை மின் நிலையம்**
LT – Low tension line	—	**குறைவழுத்த மின்சாரம்**
HT – High tension line	—	**உயர்வழுத்த மின்சாரம்**

PART A

Mark 1

Choose the correct answer:

1. The smallest particle of an element is known as
   a) Atom
   b) Molecule
   c) Nucleus
   d) Electron
2. An atom is composed of
   a) Electrons only
   b) Protons only
   c) Neutrons only
   d) Electrons, Protons and Neutrons
3. HT line means
   a) 230V
   b) 440V
   c) Above 11 Kv
   d) Below 11 Kv
4. LT lines means
   a) 230 volts or 440 volts
   b) 440 Kv
   c) Above 11 Kv
   d) Below 11 Kv
5. The number of electrons in an atom are
   a) equal to the neutrons
   b) equal to protons
   c) equal to the atomic structure
   d) equal to molecules
6. The supply voltage used for single phase domestic purpose is
   a) 110–120V
   b) 120–130V
   c) 220–230V
   d) 400–440V
7. Switch should always be connected with
   a) neutral wire
   b) earth wire
   c) phase wire
   d) line wire
8. The charge of an electron is --------
   a) positive
   b) negative
   c) positive and negative
   d) no charge
9. Neutrons are -------------- charged particle.
   a) positive
   b) positive and negative
   c) negative
   d) no charge
10. Electrons revolving around the nucleus in a definite path is called --------------
    a) orbit.
    b) track
    c) route
    d) neutrons
11. Which is a good conductor?
    a) Gold
    b) Silver
    c) Copper
    d) Aluminium
12. The most commonly used semi conducting material is
    a) silicon and germanium

b) rubber
c) copper
d) iron

13. Single-phase AC power supply is commonly used in
a) industries
b) domestic purposes.
c) cinema theatre
d) hotels

14. The material that does not conduct current is
a) conductor
b) insulator
c) semiconductor
d) mercury

15. Good conductor is having the property of
a) low resistance
b) high resistance
c) medium of these two
d) low voltage

16. EMF is measured by
a) volt
b) ohm
c) ampere
d) watt

17. Unit of power is
a) volt
b) ampere
c) watt
d) ohm

18. The instrument used to measure the power is __________
a) wattmeter
b) ammeter
c) voltmeter
d) tacho meter

19. According to ohm's law I is equal to
a) V^2/R
b) I^2R
c) V/I
d) V/R

20. Unit of force is __________
a) newton
b) ampere
c) volt
d) joule

Q A

PART B

Mark 3

Answer the questions in brief

1. Define an atom.
2. What is called electricity?
3. Define LT & HT line.
4. Write about atomic theory of electricity.
5. Define a conductor.
6. Write short note on insulator.
7. Write briefly about semiconductor.
8. Define Ohm's law.

9. Voltage of circuit is 240V and 12 A current is flowing through it. Find the value of resistance.
10. Explain 'open circuit'. and "closed circuit'.
11. Two resistance 3Ω and 6Ω are connected in parallel Voltage of the circuit in 240V. Find the value of total resistance.

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain the properties of conductors.
2. Explain the properties of insulators.
3. What are the important rules for series circuit?
4. What are the important rules for parallel circuit?
5. Three resistors 3Ω, 6Ω and 18Ω are connected in parallel. The current flow of the circuit is 3A. Find the value of i) Total resistance ii) voltage.
6. Explain the laws of resistance.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain the various methods adopted in power generation.
2. Explain the construction and working principle of series and parallel circuit.
3. Explain kirchhoff's laws with neat diagram.

LESSON 2

Electrical Safety and Hazards

U6SL1

LEARNING OBJECTIVES

The objective of this lesson is to learn about hazards of electricity and chemicals to those who work in the electrical industry. Also to study about safety measures, first aid, fire extinguisher and its operations.

Table of Content

2.1 Introduction
2.2 Electric shock and its causes
2.3 First aid for electrical emergency
2.4 Environmental factors
2.5 Electrical and chemical hazard
2.6 Exposure to hazardous substances
2.7 Fire extinguisher
2.8 Protecting devices

2.1 INTRODUCTION

Electrical safety is a general practice of workers followed to be to handling and maintaining electrically powered equipments. It is a guideline used to follow to prevent accidents, electrical safety be followed while working in electricity related works.

2.2 ELECTRIC SHOCK AND ITS CAUSES

Human body has a electrical conducting property. Without sweating the resistance of human body is approximately 80000 Ω (ohm) and during sweating, resistance of the human body is approximately 1000 Ω. If we touch any current carrying conductor, the current is conducted through our body to earth and we get electric shock. The nervous structure, heart, lungs, and brain affected by electric shock. If the current is heavy, even death may occur.

2.2.1 How shock occurs?

There are many ways of getting electric shock. Electrical shock occurs either when a person comes in contact with:

- phase and neutral wires of an electric circuit,
- one phase wire and the ground,
- a metallic part that accidentally becomes contact with an electrical conductor

If a person is within three meters of a HT power line, the energy flow can takes place towards you and take a path to the ground. Never grow trees near to power line.

When assembling the components in a panel board, proper precautions have to be considered to ensure safety.

2.2.2 Preventive measures to avoid electric shock

Some of the methods employed to avoid electric shock are:

1. The operation of electrical equipment must be clearly known.
2. Avoid damaged wires and accessories.
3. Use proper electrical instruments.
4. The hand tools should be properly insulated.
5. Proper earthing should be provided.

2.3 FIRST AID FOR ELECTRICAL EMERGENCY

When a person gets affected by an electrical shock in an unavoidable condition, first aid should be given before taking to the hospital. When a person is affected by current shock, the circuit should be disconnected first. If the main switch is nearer, put off the switch by using any wooden stick and disconnect the person from the circuit. Then immediately take him to a hospital. If the affected person loses consciousness, and breath normally, then loosen his clothes and apply cold water on his face and keep him in open air. If the person does not breathe freely, then immediately artificial method of respiration has to be made.

There are two methods of artificial breathing.

2.3.1 Holger Nelson method

Fig 2.1 *Holger Nelson method*

In this method, the casuality should laid on the bed facing the ground. The helper sitting upon him should massage his back using both hands. This has to be done immediately.

2.3.2 Mouth to mouth method

In this method, the helper pushes air by keeping his mouth on the casuality 's mouth. By closing his nose, the air is filled in lungs.

Fig 2.2 *Mouth to mouth method*

2.4 ENVIRONMENTAL FACTORS

Environmental pollution causes harm to our environment and in turn to the people who exist based on the environment. Environmental pollution occurs when pollutants contaminate the surroundings which brings about changes that affect our normal lifestyles.

2.4.1 Types of environmental pollution

Pollution of environment is of the following types

1. Air pollution
2. Water pollution
3. Soil pollution
4. Noise pollution
5. High humidity

1. Air pollution

The quality of air is one of the environmental factor that play a vital role which affects the overall health of human body. Pollution of air is the major problem for living things.

2. Water pollution

Water pollution is nothing but the contamination of water bodies. Water pollution is caused when water bodies such as rivers, lakes, oceans, groundwater and other water resources get contaminated with industrial and agricultural effluents. The water pollution affects the entire eco system.

Water pollution affects aquatic life severely. Dioxin is a chemical that causes cancer due to water pollution.

3.Soil pollution

Soil pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil. Naturally occurring contaminants in the soil also makes soil pollution.

4. Noise pollution

Noise pollution or sound pollution is defined as the sound that is produced unwantedly, causes disturbance to nearby individuals. It cause distraction, hearing damage, or disrupts normal activities and affects quality of life. Workplaces are required to take those in the surrounding environment into account with regard to noise pollution, such as an industrial plant next to a residential area.

5. High humidity

Humidity is greatly influenced by intensity of solar radiation, temperature, altitude, wind, water status of soil etc. Low temperature causes higher relative humidity by decreasing the capacity of air moisture. Process such as transpiration, absorption of water etc. are influenced by atmospheric humidity.

2.5 ELECTRICAL AND CHEMICAL HAZARDS

2.5.1 Electrical hazards

Hazards from electric power causes damage to the equipment and makes serious injury to the person who operate it. Wearing of protective equipments can preserve the life of men and materials of electrical devices. Safety measures can be adopted by taking appropriate procedure of using electrical commodities.

2.5.2 Precautionary tips to avoid from electrical hazard

1. Physical hazards like loosening of cords and wires can be properly insulated.
2. Wear protective equipments like gloves, safety glass, goggles etc..
3. If it is heat area use proper glass and heat resistive clothes.
4. Be careful while cleaning the electrical devices.
5. Be cautious while testing and replacing the components in the panel.
6. When doing work with electric supply the area should be away from water and moisture.
7. Don't use damaged or broken plugs.
8. Switch off the power supply while doing repair in electrical work.
9. Always use the insulated tools and materials for repairs.

2.6 EXPOSURES TO HAZARDOUS SUBSTANCES

Hazardous substances are defined as any material which causes injury to people or the environment and are responsible for many immediate and long-term health conditions. But with the right control measures in place, workers can be protected from these hazards.

Some hazardous substances produce immediate effects upon exposure such as irritated eyes or skin rashes. Depending on the hazardous substance, the effects can be short-term and treatable with the right medical care, or they can be serious or even causing death.

Electrical equipment is the most typical form of potentially hazardous waste in many offices. Chemicals found in laptops, cell phones, and lighting equipment could all have a role. To avoid environmental damage, it's critical that such garbage is properly disposed off.

Almost in all business work hazardous substances must carefully examine the potential consequences for their employees, the public, animals, and the environment. These impacts can be minimized if safety laws are followed and hazardous material is properly disposed off.

2.6.1. Chemical hazards are caused due to:

1. Improper storage of chemicals causing a chemical leakage
2. Mishandling of chemicals due to inadequate training or negligence.

2.7 FIRE EXTINGUISHER

Fire extinguisher is an equipment used to extinguish or control fire at initial stage.

Fire can be divided into four types depending on the nature of the firing materials.

1. Class 'A' – Fire caused by wood, paper and clothes.
2. Class 'B' – Fire caused by oil and liquid fuels.
3. Class 'C' – Fire caused by Liquified petroleum gas (LPG).
4. Class 'D' – Fire caused by metals and electrical appliances.

2.7.1 Types of fire extinguishers

It is essential to know the various types of fire extinguisher. Commonly three type of fire extinguishers are used.

1. Water filled extinguisher

It's classified in two types

a. Gas cartridge type

b. Stored pressure type

These types of fire extinguishers are used to extinguish the fire caused by trees, paper and clothes.

2. Foam extinguisher

These types are compressed by air and gas. These types are used to extinguish fire caused by oil and inflammable liquid fuels.

3. Dry powder extinguisher

Gas-filled or pressure type of fire extinguishers are commonly used for dry powder. These fire extinguishers are used to extinguish fire caused by metals and electrical equipments.

The steps to operate a fire extinguisher in case of an emergency has been shown in fig 2.3

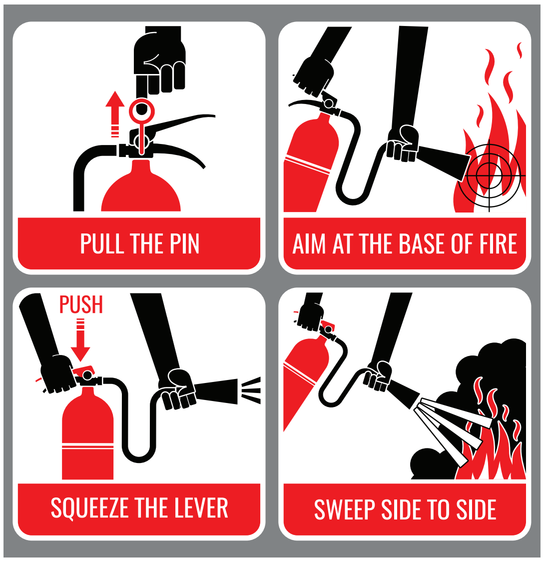


Fig 2.3 *Operation of fire extinguisher*

Step 1: Identify the safety pin of the fire extinguisher which is generally present in its handle

Step 2: Break the seal and pull the safety pin from the handle

Step 3: Use the fire extinguisher by squeezing the lever

Step 4: Sweep it to the flame in the proper direction.

2.7.2 Precautions

Usage of fire extinguisher should be known to the person who is going to operate. Some of the precautions to be followed are:

1. Observe if there is a risk of fire in or near the work area.
2. Keep the work area free from untidy things.
3. All the gates should be easily accessible in emergency situation.
4. Proper maintenance of fire extinguisher should be done regulaly.
5. Ensure all safety equipments are maintained properly.

2.8 PROTECTING DEVICES

2.8.1 Relay

Fig 2.4 *Relay*

The relay shown in Fig 2.4 is an electrically controlled switch used to isolate or to connect the equipment in the circuit. It has a coil that can be enegized and de-energized by voltage and contacts that change logic state (on/off) based on its coil (logic input) state.

2.8.2 Types of relay

1. Electromagnetic relay
2. Solid state relay
3. Hybrid relay
4. Thermal relay

1. Electromagnetic relay

When different mechanical parts are connected on the basis of the electromagnet, contact connection is established. AC or DC power supplies can be used for electromagnetic relays.

2. Solid state relay

This relay is used in semiconductor devices to make a connection to ensure the effectiveness, efficiency, and easiness of the switching speed. This is commonly used for faster-switching process and durability. This relay utilize solid state components in order to execute a switching function without moving parts.

3. Hybrid relay

Hybrid relay contain electronic components and electromagnetic relays. The electronic circuits are in the input section of the device. These circuits have several control functions available within them.

4. Thermal relay

This bending allows the users to make contact connections. Thermal relays are commonly used for the purpose to protect motor. Its temperature sensors and other bimetallic elements assist in giving protection to the motor.

2.8.3 Electrical circuit breaker

1. Description

A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused due to overload of electricity or short circuit. A circuit breaker function is to detect a fault and immediately disconnect the current flow.

2. Working of a circuit breakers

A circuit breaker consists of fixed and moving contacts called electrodes. Under normal operating conditions, these contacts remain closed and do not open automatically until and unless the system becomes faulty. The contacts can be opened manually or by remote control whenever desired. When a fault occurs on any part of the system, the trip coils of the breaker gets energised and the moving contacts are pulled apart by a certain mechanism, thus opening the circuit.

When the contacts of a circuit breaker are separated under faulty conditions, an arc is struck between them. The main problem in a circuit breaker is to extinguish the arc within the shortest possible time so that heat generated by it does not reach a dangerous value.

3. Methods of arc quenching

There are two methods of quenching the arc in circuit breakers.

1. High resistance method.
2. Low resistance method.

4. Classification of circuit breakers

Circuit breakers are classified depending upon the medium use for arc extinction.

Sl. No.	Type	Medium used for arc extinction	Voltage range
1	Air break circuit breaker.	Air	Up to 1000 V
2	Tank type oil circuit breaker.	Transformer oil	Up to 33 KV
3.	Minimum oil circuit breaker.	Transformer oil	Up to 132 KV
4.	Air blast circuit breaker.	Compressed air	Up to 132 KV
5	Sf_6 circuit breaker.	Sf_6 gas	400 KV to 760KV
6	Vacuum circuit breaker.	Vacuum	11 KV to 33 KV
7	High voltage direct current circuit breaker.	sf_6 gas or vacuum	+ 500 KV DC

5. Miniature circuit breaker (MCB)

MCB is an electromechanical device which guards an electrical circuit from an over current that may effect from short circuit or overload. The structure of miniature circuit breaker is shown in fig 2.5.

Fig 2.5 *Circuit breaker*

- Normally work with currents below 100 amperes.
- Low voltage circuit breaker is typically found along with fuse box in a residential or commercial building.

6. Types of miniature circuit breaker

a. Single pole miniature circuit breaker

i. Single–pole circuit breakers are typically used for electric circuits with low power requirements used in live conductor, providing power for lamps or general purpose electric outlets.

ii. A single–pole low voltage circuit breaker occupies only less space in a fuse box.

b. Double pole miniature circuit breaker

i. It is used for devices that operate with two live conductors, such as domestic air conditioner models.

ii. When a double–pole circuit breaker is tripped, both lines are disconnected even if only less of them was involved in the electrical fault.

iii. A double–pole low voltage circuit breaker occupies two spaces in a fuse box.

c. Triple –pole miniature circuit breaker

i. It is used to protect electric equipment that works with three-phase power.

ii. It is used to protect and safeguard the appliances which runs in 3 phase supply like escalators and big cooling towers.

7. Moulded Case Circuit Breaker (MCCB)

This circuit breaker is an electro mechanical device which guards a circuit from short circuit and over current. They offer short circuit and over current protection for circuits ranging from 63 amps – 3000 amps. The primary functions of MCCB are to give a means to manually open a circuit, automatically open a circuit under short circuit or overload conditions.

i. Higher current ratings when compared to miniature circuit breakers.

ii. The breaking current ratings of a molded circuit breaker can be modified.

8. Earth Leakage Circuit Breaker (ELCB)

The ELCB is used to protect the circuit from the electrical leakage. When someone gets an electric shock, then this circuit breaker cuts off the power at the time of 0.1 second for protecting the personal safety and avoiding the gear from the circuit against short circuit and overload.

ELCB is a security device used in electrical system with high earth impedance to avoid shock. The main principle of earth leakage protectors is to stop injury to humans and nature due to electric shock.

In fig 2.6, the ELCB is connected between the conductor and earth. The ELCB notices fault currents from live to the ground wire inside the installation it guards. If enough voltage emerges across the sense coil in the circuit breaker, it will turn off the supply, and stay off until reset by hand.

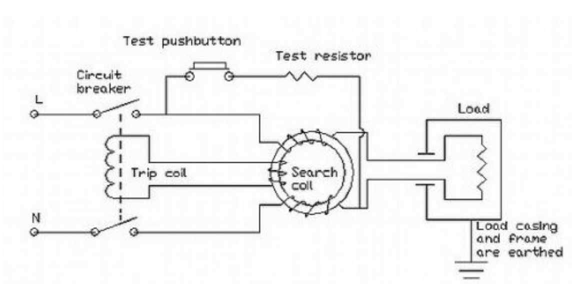


Fig 2.6 *Earth Leakage Circuit Breaker*

9. Types of Earth Leakage Circuit Breaker

1. Voltage operated Earth Leakage Circuit Breaker (Voltage – ELCB)
2. Current operated Earth Leakage Circuit Breaker (Current – ELCB)

10. Voltage operated Earth Leakage Circuit Breaker

One terminal of the relay coil is connected to the metal body of the equipment to be protected against earth leakage and other is connected to the earth directly. If any insulation failure occurs or live phase wire touches the metal body of the equipment, there must be a voltage difference of 50V and it produces a current to flow in the relay coil and disconnect the power supply to the equipment. In this way, the circuit is protected from earth leakage fault.

11. Current operated Earth Leakage Circuit Breaker

This breaker operates due to the current flow in the earth wire caused by the short circuit in electrical equipment. It also protects from earth leakage fault. When short circuit occurs, different values of current flow in three phases, which make circuit breaker to operate and protect from the fault.

2.8.4 Fuse

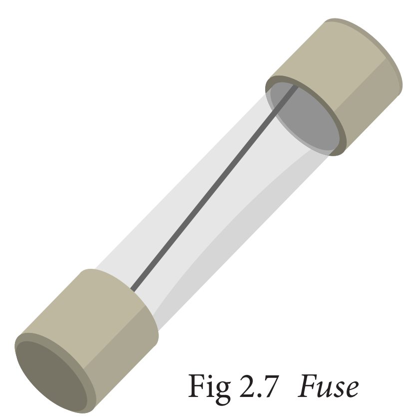


Fig 2.7 *Fuse*

A fuse is a short length of wire. It is designed to melt and isolate the circuit when fault occurs. Fuses are always connected in series with component(s). When a fuse blows (opens), it opens the entire circuit and stops the current through the component(s).

GLOSSARY

respiration	—	சுவாசம்
contamination	—	மாசடைதல்
hazards	—	ஆபத்துகள்
humidity	—	ஈரப்பதம்
effluents	—	கழிவுகள்

Q A

PART A

XP8CK

Mark 1

Choose the correct answer:

1. Without sweating of human body, the resistance is approximately
   a) 80 KΩ
   b) 40 KΩ
   c) 10 KΩ
   d) 20 KΩ

2. With sweating of human body, the resistance is approximately
   a) 80 KΩ
   b) 40 KΩ
   c) 1 KΩ
   d) 10 KΩ

3. ECO system is connected with which type of pollution?
   a) High humidity
   b) Water pollution
   c) Earth
   d) Noise

4. Loose cords and wires can cause --------- hazard.
   a) Chemical hazard
   b) Mechanical hazard
   c) Electrical hazard
   d) Thermo hazard

5. Repairing of electrical equipment with wet hand causes-----------
   a) Heat is produced
   b) Conduction of electric current
   c) Nothing will happens
   d) High current will produce

6. What hazard will happen when we stored chemicals improperly?
   a) Thermal hazard
   b) Electrical hazard
   c) Chemical hazard
   d) Physical hazard

Q A

PART A

Mark 1

7. What is the use of control relay?
   a) To maintain static voltage
   b) To avoid voltage drops
   c) To turn ON/OFF
   d) to control the supply

8. Electrical circuit breaker is like a ----------
   a) resistance
   b) capacitance
   c) switch
   d) inductance

9. The ---------- circuit breaker is used to protect circuit from the leakage current.
   a) Miniature circuit breaker
   b) Earth leakage circuit breaker
   c) Moulded case circuit breaker
   d) Open circuit breaker

10. The earth leakage circuit breaker breaks the circuit in ----- seconds.
    a) 1
    b) 0.1
    c) 0.5
    d) 0.7

11. The earth leakage circuit breaker connects which two parts?
    a) Conductor – conductor
    b) Conductor – body
    c) Conductor – earth
    d) Earth – earth

12. The operating voltage of voltage operated earth leakage circuit breaker is
    a) 100 volt
    b) 50 volt
    c) 5 volt
    d) 10 volt

13. Which type of device is a circuit breaker?
    a) Mechanical switching device
    b) Electrical device
    c) Voltage regulating device
    d) Current regulating device

14. Which type of circuit breaker is used for over current and short circuit?
    a) Miniature circuit breaker
    b) Oil circuit breaker
    c) Air circuit breaker
    d) Vacuum circuit breaker

15. Which type of circuit breaker is used for current leakage?
    a) Miniature circuit breaker
    b) Moulded circuit breaker
    c) Earth leakage circuit breaker
    d) Air circuit breaker

16. Due to --------------- shock in ELCB is avoided.
    a) High current value
    b) High voltage value
    c) High earth impedance
    d) High power supply

17. Fuse is connected with ---------- supply
    a) Phase
    b) Neutral
    c) Resistance
    d) capacitance
18. How many types of fire extinguisher is commonly used?
    a) 4
    b) 1
    c) 2
    d) 3
19. Which type of fire can be put out by using water filled extinguisher?
    a) Fire caused by oil and liquid fuels.
    b) Fire caused by wood, and clothes.
    c) Fire caused by Liquified petroleum gas (LPG).
    d) Fire caused by metals and electrical appliances.
20. Which type of fire extinguisher is used for fire caused by metal and electric equipment?
    a) Water filled extinguisher
    b) Gas filled extinguisher
    c) Foam extinguisher
    d) Dry powder extinguisher
21. Which type of fire extinguisher is used to control flammable liquid gas?
    a) Water filled extinguisher
    b) Gas filled extinguisher
    c) Foam extinguisher
    d) Dry powder extinguisher

Q A

PART B

Mark 3

Answer the questions in briefly

1. List out the types of environmental pollution.
2. What are causes of chemical hazards?
3. What is called relay?
4. What is called circuit breaker.
5. What are the types of fire extinguisher?
6. Define fuse.
7. How electrical shock occurs?

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain the method of preventing an electric shock
2. Explain miniature circuit breaker.
3. Explain Earth leakage circuit breaker.
4. Explain moulded case circuit breaker.

Q A

PART D

Mark 10

Answer the questions not exceeding one page

1. Explain the type of fire extinguisher operating method and precautions.
2. Explain the types of first aid given to electric shock.
3. Write down the precautionary tips for electrical hazard.

LESSON 3

Electro Magnetism

ALG89

LEARNING OBJECTIVES

To know the classification and properties of magnetic materials, concepts of magnet, types of electromagnetic induction, Hysteresis and its laws related to magnetism.

Table of Content

3.1 Magnetism – Introduction
3.2 Properties of magnets
3.3 Magnetic materials
3.4 Electro magnetism
3.5 Electro magnetic induction
3.6 Hysteresis loop
3.7 Rules/Laws related to magnetism

3.1 MAGNETISM - INTRODUCTION

Magnetism is a force field that acts on some materials. A physical device which possess this force is called a magnet.

The force to attract iron particle is known as magnetism. The properties which possess magnetism are called magnet. The materials attracted by magnets are known as magnetic materials.

Magnetism plays an important role in electricity. Without the aid of magnet, it is impossible to operate devices like generator, electric motors, transformers, electrical instruments, etc. Magnets are also used in the functioning of radio, television, phones and ignition system of auto mobiles.

3.2 PROPERTIES OF MAGNET

- Magnet attracts magnetic substances such as iron, nickel, cobalt and its alloy.
- If a magnet is freely suspended, the pole will always tend to set themselves in the direction of north and south.
- Like poles repels and unlike poles attracts each other.

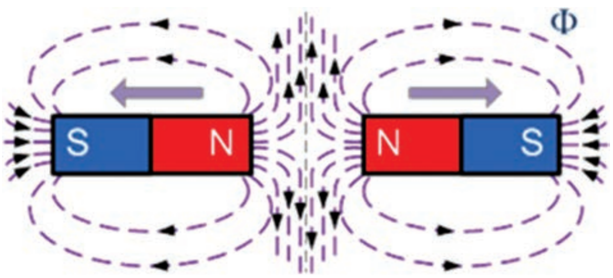


Fig 3.1 *Like poles*

- If a magnet is broken into number of pieces, each piece becomes an independent magnet which has North and South.

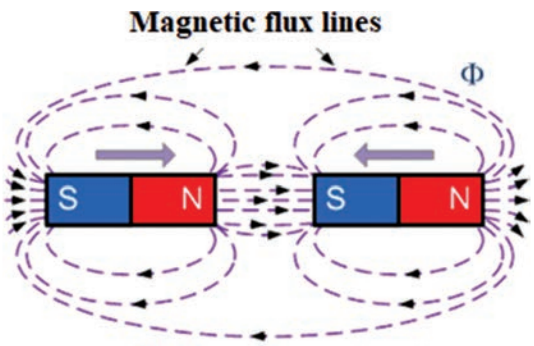


Fig 3.2 *Unlike poles*

- A magnet loses its properties when it is heated, hammered or dropped from height.

3.2.1 Classification of magnets

1. Natural magnet

The magnet found in nature is known as lodestone. The natural magnet is one of the iron ore magnetite with chemical composition Fe_3O_4

2. Artificial magnet

The magnets prepared by artificial method are called artificial magnets. It can be made in different shape, size and strength only in certain metals. There are two types of artificial magnet.

a) Permanent magnet

In a permanent magnet, the magnetic materials can retain magnetic property permanently for a long time. Bar magnet, Horse shoe magnet, Ring magnet, Cylindrical magnet are some types based on shapes.

Fig 3.3 *Permanent magnets*

ALNICO (Aluminium-Nickel-Cobalt) is an alloy metal specifically used as permanent magnet because it can be lifted up to 50 times weight load compared to its own weight. Permanent magnets can be formed by touch method, electric current method and induction method.

b) Temporary magnet (or) Electro magnet

When an electric current is passed through a coil of wire wound around a soft laminated silicon steel core, a very strong magnetic field is produced. This is called as electro magnet. If the current is cut off, the core will be demagnetized, and hence itis also known as temporary magnet.

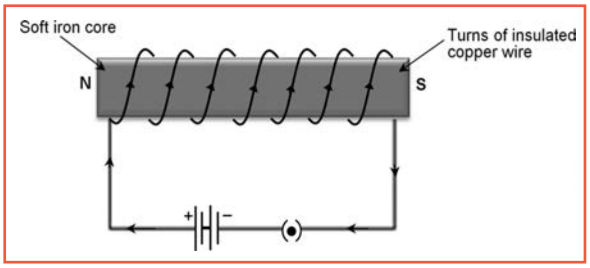


Fig 3.4 *Electro magnet*

3.2.2 Comparison of Electro magnet & Permanent magnet

Electro magnet	Permanent magnet
1. Polarity can be changed easily.	Polarity cannot be changed easily.
2. Strength can be varied.	strength cannot be varied.
3. More cost.	Less cost
4. Suitable for large size motorand and generator.	Not suitable for large size.
5. Used in electric bells, signals, escalators, cranes.	Not used in any of these.
6. Cannot be used for navigation	Mostly used for navigation as magnetic needle
7. Cannot be used in cycle and motor cycle dynamo.	Used in cycle and motor cycle dynamo.

3.3 MAGNETIC MATRIALS

Magnetic materials are classified based on permeability property by three types.

a) Dia–magnetic materials

- The materials which are repelled by a magnet are known as diamagnetic materials. Ex: zinc, mercury, lead, sulphur, copper, silver, bismuth, wood, etc.
- The permeability value of these materials is less than one.

b) Para magnetic materials

- The materials which are not strongly attracted by a magnet are known as paramagnetic materials. Ex: (aluminium, tin, platinum, magnesium etc.).
- The permeability value of these materials is just greater than one.

c) Ferro -magnetic materials

- The materials which are strongly attracted by a magnet are known as ferromagnetic materials. Ex: (iron, nickel, cobalt, etc.)
- The permeability value of these materials is very high (varies from several hundreds to thousands).
- Materials which are easily magnetized with a high relative permeability, low coercive force (small hysteresis) are called soft ferromagnetic materials.
- Materials which are difficult to magnetize, but retain magnetism with great tenacity, with low relative permeability, high coercive force are called hard ferromagnetic materials.

3.3.1 Magnetic terms and properties

a) Magnetic field:

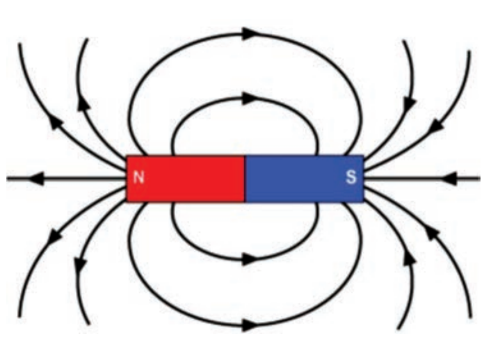


Fig 3.5 *Magnetic field lines*

- The magnetic field around a magnet is represented by imaginary lines called magnetic line of force.
- The magnetic line of force emerges from north pole to south pole and it continues through the body of magnet to form a closed loop.
- Two magnetic lines of force will not intersect each other.
- If magnetic lines of force are rows together, the field is strong. If they are spaced out the magnetic field is weak.

b) Magnetic flux

- The amount of magnetic field produced by a magnetic source is called magnetic flux.
- It is denoted by Greek Letter ϕ and its unit is weber.

c) Magnetic flux density

- The magnetic flux density is the flux per unit area at right angles to the flux.

Magnetic flux density, $B = \phi/A$ wb/m^2

d) Permeability

- Permeability of a material means, the conductivity for magnetic flux. The greater the permeability of material, the greater is its conductivity of magnetic flux and vice-versa. Air or Vacuum is the poorest conductor of magnetic flux. The absolute (actual) permeability μ_0 (Greek Letter 'mu') of air is $4\pi \times 10^{-7}$ Henry/metre. The absolute (actual) permeability of magnetic material(μ) is much greater than μ_0.

The ratio between permeability of material and permeability of air (μ_0) is called relative permeability(μ_r)

$$\mu_r = \mu/\mu_0$$

The relative permeability for air is 1 ($\mu_r = \mu_0/\mu_0$)

The value of μ_r for all non- magnetic material is also 1.

The relative permeability of magnetic materials is very high. For example, soft iron (i.e pure iron) has a relative permeability of 8000, whereas its value for perm alloy (22% Iron, +78% nickel) is as high as 50,000.

e) Magneto Motive Force (MMF)

It is a magnetic pressure which tends to set up magnetic flux in a Magnetic circuit.

The work done in moving a unit magnetic pole once round the magnetic circuit is called MMF. It is equal to the product of current and number of turns of the coil.

MMF = Number of turns × current.
Its unit is Ampere-turns (AT)

f) Reluctance

The opposition that the magnetic circuit offers to magnetic flux is called reluctance. Magnetic materials (eg iron, steel) have low reluctance, on the other hand non-magnetic materials have a high reluctance.

$$\text{Reluctance } S = l/\mu_0 \mu_r A$$

g) Magnetic Neutral Axis (MNA)

The imaginary line which is perpendicular to the magnetic axis and passes through the centre of the magnet is called magnetic neutral axis. There is no magnetic influence along this line.

Magnetic Axis (MA) is the imaginary straight line joining North to South pole. There is maximum magnetic influence along this line.

i) Magnetic saturation

The limit beyond which the strength of magnet cannot be increased is called magnetic saturation.

ii) Residual magnetism

It is the magnetism which remains in a material when the effective magnetizing force has been reduced to zero.

iii) Magnetic retentivity

The property of retaining magnetism by a magnetic material is called magnetic retentivity.

iv) Hysteresis

The energy required to demagnetize the residual magnetism of material is known as hysteresis.

v) Leakage flux

Leakage flux is defined as the magnetic flux which does not follow the particularly intended path in a magnetic circuit.

vi) Coercivity

Coercivity is a measure of the ability of a ferro magnetic materials to withstand an external magnetic field without becoming demagnetized.

3.4 ELECTRO MAGNETISM

When current is passed through a coil of wire, a magnetic field is set up around the coil. If soft iron bar is placed inside the coil of wire carrying current, the iron bar becomes magnetized. This process is known as electro magnetism.

The iron remains as a magnet as long as the current is flowing in the circuit. It looses its magnetism when current is switched off.

The polarity of an electromagnet depends upon the direction of the current flowing through it.

If the direction of current is altered, the polarity of the magnetic field will also be changed.

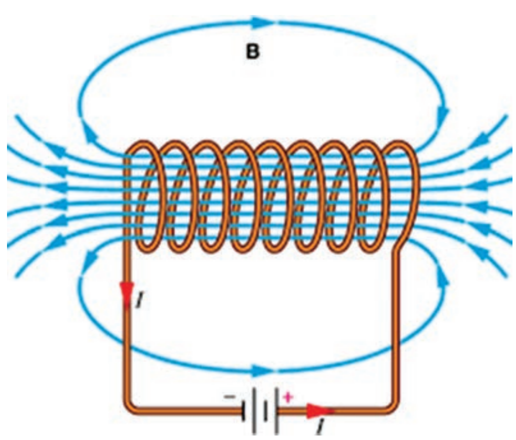


Fig 3.6 *Magnetic field lines*

3.4.1 Lenz law

A change in current produces an emf, whose direction is in such a way that it opposes the change of current.

3.4.2 Lorent'z law

Lorentz law states that the Lorentz force (or electromagnetic force) is the combination of electric and magnetic force on a point charge due to electromagnetic fields as shown in the figure

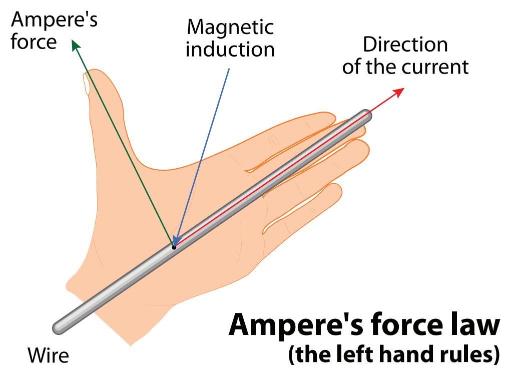


Fig 3.7 *Indication of Lorent'z law*

3.4.3 Electric field

It is a medium around a charge (or) region in which the electric force act is called electric field.

Electric field is the physical field that surrounds electrically charged particles and exerts force on all other charged particles in the field.

Electric field strength is measured in SI unit volt per meter (V/M) The direction of this field is taken as the direction of the force which is exerted on the positive charges.

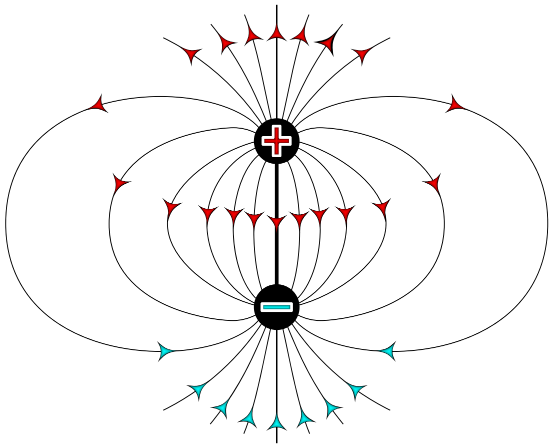


Fig 3.8 *Electric field*

E = F/Q

E – Electric field

F – Force

Q – Charge

The electric field is radially outwards from positive charge and radially in towards negative point charge.

3.4.4 Electro magnetism in a current carrying conductor

A magnetic field is formed around a conductor carrying current. The direction of the magnetic field depends on the direction of the current flow.

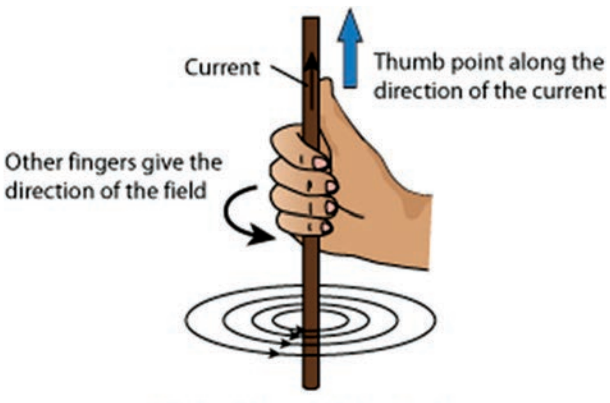


Fig 3.9 *Right hand grip rule*

Right hand grip rule

- It is used to determine the direction of the magnetic field in a current carrying conductor.
- If you wrap your fingers around the wire with your thumb pointing direction of current flow, your index finger will point the direction of magnetic field.

Maxwell's cork screw rule

- Assume a right handed cork screw to be along the wire to advance in the direction of current.
- The motion of handle gives the direction of magnetic lines around the conductor.

Force between parallel conductors

When two current carrying conductors are parallel to each other, a mechanical force act on each conductor. This force is due to magnetic field produced in the two conductors. If the currents are in the same direction, the forces are attractive. If the currents are in the opposite direction, the forces are repulsive.

i) Current in the same direction

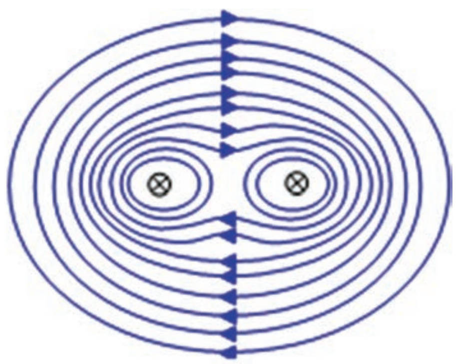


Fig 3.10 *Current in same direction*

- If two wires (A & B) carrying current in same direction are brought together, their magnetic fields will aid one another and attracts.
- Since the flux lines around two conductors are going in the same direction, the flux lines join and the field brings the wire together.

ii) Current in the opposite direction

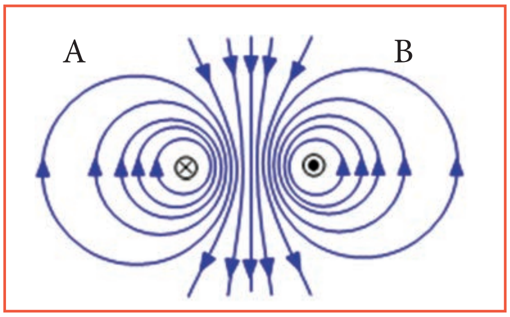


Fig 3.11 *Currents in opposite direction*

- If two wires (A & B) carrying current in opposite directions are brought together their magnetic field will oppose one another.
- Since the flux lines around two conductors are going in the opposite direction, the flux lines cannot cross and the field moves the wires apart.

3.4.5 Solenoid

A current carrying wire is made to form a loop and a number of loops are wound in the same direction to form a coil. More magnetic fields will add to make the flux lines through the coil stronger and dense.

A helically wound coil that is made to produce a strong magnetic field is called a solenoid.

The flux lines in a solenoid act in the same way as in a magnet. They leave the north pole and go around to the south pole.

The directions of the magnetic field in a solenoid is known by the following rules.

End rule

Look at the end of the solenoid of the electromagnet. If the current in the coil is clock wise the end is south pole . If the current in the coil is counter-clockwise the end is north pole.

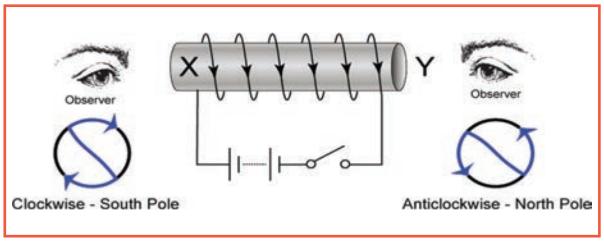


Fig 3.12 *End rule*

Helix rule

Hold the right hand palm over the solenoid in such a way the fingers point in the direction of current in the solenoid conductors. Then the thumb indicates the direction of magnetic field (North) of the solenoid.

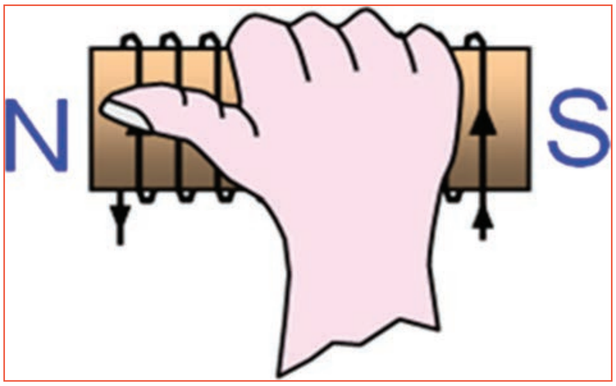


Fig 3.13 *Helix rule*

Uses of solenoid

- Used for circuit breaking.
- Voltage regulating device.
- Automatic motor starter.
- Contactor, elevator, crane.

Toroid

A helix bent into a circular form is known as Toroid (i.e coiled coil)

Fig 3.14 *Toroid*

3.4.6 Comparision between magnetic and electric circuits

S.No	Properties	Magnetic circuit	Electric circuit
1	Definition	The closed path followed by magnetic flux is called magnetic circuit.	The closed circuit followed by electric current is called electric circuit.
2	Driving Force	MMF is the pressure required to set up the magnetic flux in magnetic circuit (Ampere-Turn)	EMF is the pressure required to set up the current in an electric circuit (Volt).
3	Response	Flux $(\varnothing) = \frac{MMF}{Reluctance}(weber)$	$\text{Current}(\text{I}) = \frac{EMF}{Resistance}(Ampere)$
4	Impendance	Reluctance(S)=$l/(\mu_0\mu_r A)$ [AT/Weber]	Resistance (R)=ρl/A(ohms)
5	Admittance	$\text{Permeance} = \frac{1}{Reluctance}[wb/AT]$	$\text{Conductance} = \frac{1}{Resistance}(Siemens)$
6	Proportionality	$\text{Reluctivity} = \frac{1}{Permeability}(M/H)$	$\text{Resistivity} = \frac{1}{Conductivity}(ohm\text{-}meter)$
7	Density	Flux density B = μ H(wb/m^2)	Current density J=I/A(Amp/ m^{2})
8	Field Intensity	Magnetic field intensity(H)=NI/l(AT/m)	Electric field intensity=E/l(volt/m)

3.5 ELECTRO MAGNETIC INDUCTION

Electricity induced by the magnetic field is known as electro magnetic induction.

Whenever a conductor or coil is moved or rotated in a magnetic field and cut the magnetic line of force (flux), an EMF will be induced in that conductor or coil.

3.5.1 Faraday's law of electromagnetic induction

First law: Whenever a conductor cuts magnetic flux, an EMF is induced in that conductor.

Second law: The magnitude of the induced EMF is directly proportional to the rate of change of flux linked with the conductor.

Types of EMF induced are:

i) Dynamically induced EMF.

ii) Statically induced EMF.

3.5.2 Dynamically induced EMF

Moving a coil/conductor in a uniform magnetic field will induce an EMF which is known as dynamically induced EMF. DC Generator works on this principle.

Consider a conductor of length l (meters) placed in a uniform magnetic field of density B(wb/m^2), moved with a velocity V(m/s) perpendicular to the direction of the magnetic field. Then the flux is cut by the conductor and an EMF is induced.

The magnitude of EMF induced is $e = BlV \sin\theta$

3.5.3 Statically induced emf

By keeping a conductor or coil in statically and varying the magnetic field will induce an electro motive force in the conductor or coil which is statically induced electro motive force.

Statically induced electro motive force can be classified as self inductance and mutual inductance.

(a) Self induction

- This is the EMF induced in a coil due to the change of its own flux linked with it.
- If current through the coil is changed, then the flux linked with its own turns will also change, which will produce self induced EMF.
- The induced EMF is always opposite in direction to the applied EMF.

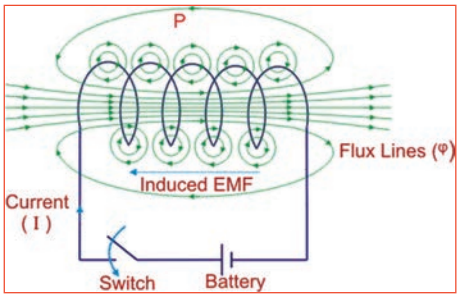


Fig 3.15 *Self induction*

(b) Mutual induction

It is the ability of one coil to produce an EMF by induction. When the current in the second coil changes, both coils are placed nearer.

- When two coils are placed nearer and current is passed through one of the coil, magnetic flux will be produced which is common to both coils.
- When current through first coil is varied, the magnetic flux will vary, which will induce an emf in second coil.

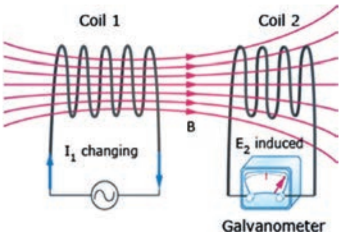


Fig3.16 *Mutual induction*

Fleming's right hand rule

The direction of induced EMF in generators and alternators (Dynamically induced emf) is given by Fleming's Right hand rule.

Stretch the thumb, forefinger and middle finger Right hand mutually at right angles [90°] to each other.

If the thumb indicates the direction of motion of the conductor, the forefinger indicates direction of the magnetic flux, then the middle finger indicates the direction of the induced EMF.

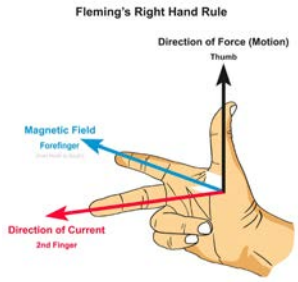


Fig 3.17 *Right hand rule*

Fleming's left hand rule

Stretch thumb, forefinger and middle finger of the left hand mutually at right angles (90°) to each other .

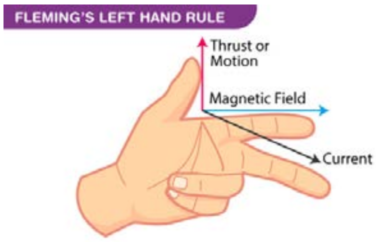


Fig 3.18(a) *Left hand rule*

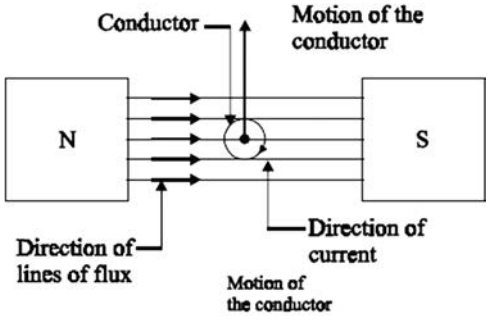


Fig 3.18(b)

If the forefinger indicates the direction of the magnetic field (B), the middle finger indicates the direction of current (I) in the conductor and the thumb point to the direction of motion (F) of the conductor.

3.6 HYSTERESIS LOOP

Take a piece of iron bar AB and magnetise the same by placing it within the field of solenoid. The field H produced by the solenoid is called the magnetising field. The field (H) can be increased (or) decreased by increasing (or) decreasing the current through it. Let 'H' be increased slowly from zero to a maximum value and the corresponding value of flux density (B) be noted. If we plot the relation between H and B, OA is obtained. The material becomes magnetically saturated at point A and has the maximum flux density induced in it.

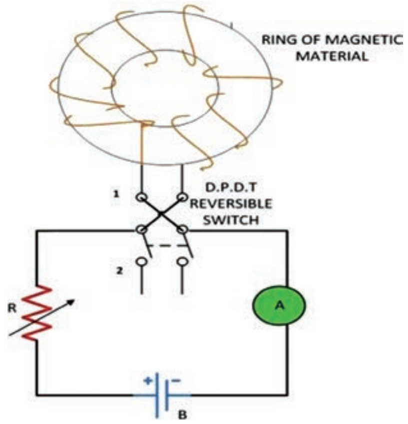


Fig 3.19 *Hysteresis loop circuit*

If 'H' is decreased slowly by decreasing the current in the solenoid, the flux density(B) will not decrease along AO but will decrease less rapidly along AR_1. When H is made to be zero, at that time, B will not be zero but will have the value OR_1. It means that on removing the magnetising force, H the iron bar is not completely demagnetized. This value ($B = OR_1$) is the retentivity of the material (Residual magnetism).

To demagnetise the bar, we have to supply the force H in the opposite direction.

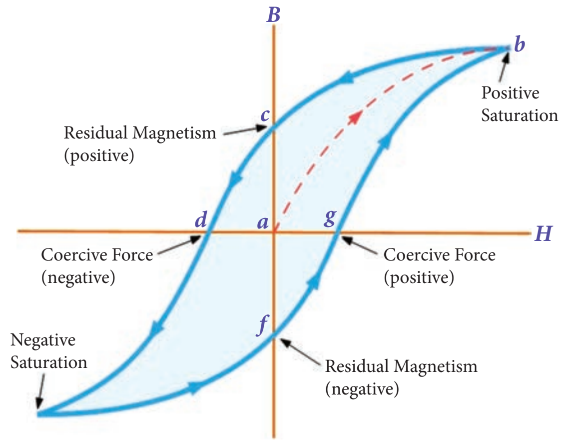


Fig 3.20 *Hysteresis loop*

When H is reversed by reversing the current through the solenoid, then B is reduced to zero at point C. This value is required to clear off the residual magnetism. This is known as the coercive force and is a measure of the coercivity of the material.

After reducing the magnetism to zero, if the value of H is further increased in the negative direction (i.e reversed direction), the iron bar reaches a state of magnetic saturation at point A_1, which is negative saturation. By taking H back from its value corresponding to negative saturation to its value for positive saturation, the closed loop which is obtained when iron bar is taken through one complete cycle of magnetism. This loop is called hysteresis loop .

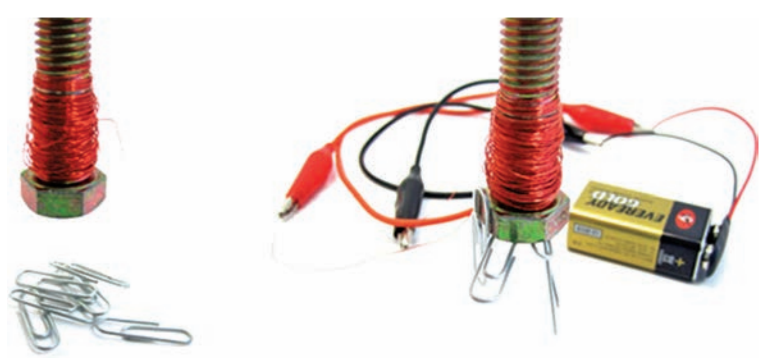
In this BH curve, it is seen that B always lag behind H. The two never attain zero value simultaneously. Hysteresis literally means to lag behind. The closed loop which is obtained when iron bar is taken through one complete cycle of reversal of magnetisation is known as hysteresis loop.

3.7 RULES/LAWS RELATED TO MAGNETISM

Rule or Law	Uses
Maxwell cork screw rule	To find out the direction of line of force (magnetic field) around a straight current carrying conductor.
Right and grip rule	Wrap your fingers around the wire with your thumb pointing direction of current flow, your index finger will point the direction of magnetic field.
Helix rule	To find out polarity of the poles of an electromagnet (solenoid)
End rule	To find out polarity of the poles of an electromagnet (solenoid)
Fleming's right hand rule	To find out the direction of current in the conductor of a generator.
Fleming's left hand rule	To find out the direction of rotation of the armature of DC motor.
Lenz's law	To find out the direction of the counter current produced in the armature.
Lorentz law	To find out the direction of line of the electrification at a point.

Activities

1. Apply the magnetic rule by using two magnets.
2. How can the induced current be known by mutual induction method.
3. Do the practice observed from the diagram.



GLOSSARY

Permanent magnet	—	நிலைக் காந்தம்
Artificial magnet	—	செயற்கைக் காந்தம்
Electro magnet	—	மின்காந்தம்
MMF (Magneto Motive Force)	—	காந்த இயக்கு விசை
Magnetic flux	—	காந்தப் புலம்
Magnetic saturation	—	காந்தப் பூரிதம்
Residual magnetism	—	தங்கிக் கொண்ட காந்த சக்தி
Hysteresis loop	—	காந்தத் தயக்க வளையம்

Q A

PART

Mark 1

Choose the correct answer:

IF8K2

1. Magnetic field lines
   a) intersect each other
   b) cannot intersect.
   c) are crowded near poles
   d) are crowded near north poles

2. In an electro magnet, when current is switched off, the iron bar
   a) holds its magnetism
   b) gains voltage
   c) losses its magnetism
   d) gains current

3. The direction of magnetic lines of force is
   a) from south pole to north pole
   b) from north pole to south pole
   c) from one end of the magnet to other
   d) direction of current

4. Fleming's left hand rule is applicable for ___________
   a) Motor
   b) Generator
   c) Inverter
   d) Computer

5. In Fleming's left hand rule, middle finger represents ___________
   a) direction of generated current
   b) direction of magnetic field
   c) direction of motion of the conductor
   d) direction of generated voltage

6. In Fleming's left hand rule, thumb represents ________
   a) direction of motion of the conductor
   b) direction of magnetic field
   c) direction of generated current
   d) direction of generated voltage

7. The permanent magnet is used in
   a) Dynamo
   b) Energy meters
   c) Transformers
   d) Loud Speaker

8. Magnetic properties in a magnet can be destroyed by
   a) heating
   b) hammering
   c) by inductive action of another magnet
   d) by all above methods.

9. A material which is slightly repelled by magnetic field is known as
   a) Ferro magnetic material
   b) Para magnetic material
   c) Dia magnetic material
   d) Conducting material.

10. Total number of magnetic field lines passing through an area is called
    a) Magnetic flux density
    b) EMF
    c) Magnetic flux
    d) Voltage.

11. The unit of magnetic flux density is
    a) weber/m^2
    b) lumens
    c) tesla
    d) weber

12. Which of the following circuit element stores energy in an electromagnetic field?
    a) Capacitor
    b) Inductance
    c) Resistance
    d) Variable resistance

13. EMF induced by motion of conductor across magnetic field is called
    a) emf
    b) dynamic emf
    c) static emf
    d) rotational emf

14. The magnitude of the induced emf in a conductor depends on the
    a) flux density of the magnetic field
    b) amount of flux cut
    c) amount of flux linkages
    d) rate of change of flux linklages

Q A

PART B

Mark 3

Answer the questions in briefly

1. What is called an electro magnet?
2. Why ALNICO is used in permanent magnet?
3. State any three uses of permanent magnets.
4. State Maxwell cork's screw rule.
5. What is Solenoid and Toroid?
6. What are the uses of solenoid?
7. Define End rule.
8. Define Faraday's laws of electromagnetic induction.
9. State Flemings right hand rule.
10. Explain Fleming's left hand rule.
11. Define Lenz's law.
12. Define Lorentz's law.
13. Define Electric field.

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Compare electro magnet and permanent magnet.
2. Explain magnetic materials?
3. Define Flux, MMF and Reluctance.
4. Define Magnetic saturation, Retentivity and Residual magnetism.
5. How to do you increase the magnitude of induced emf.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain the types of electro magnetic induction with neat diagram.
2. Explain hysteresis loop with a neat diagram.

Reference book

1. 'A text book of Electrical Technology' B.L. Theraja and A.K. Theraja, S. Chand & Company Ltd.

Internet resource

1. www.sciencebuddies.org

LESSON 4

Batteries

LEARNING OBJECTIVES

The main objective of a battery is to know the classifications of the various types of cells, also to know about the chemical reactions during charging and discharging, maintenance, and tips for care of battery.

Table of Content

4.1 Introduction

4.2 Dry cell

4.3 Secondary cell

4.4 Lithium ion battery

4.5 Seven features about disparity between Lead acid battery and Lithium ion battery

4.6 UPS battery

4.7 Maintenance of batteries

4.8 Do's and don'ts of storage battery

4.9 Nine tips for proper battery care

4.1 INTRODUCTION

Battery is a device that transforms chemical energy into electrical energy. Batteries consist of electro chemical cells that are electrically connected.

Every battery has two terminals. The positive one is called 'Anode' and negative one is called 'Cathode' as shown in and Fig 4.1.

Battery is a storage device used for the storage of chemical energy and for the transformation of chemical energy into electrical energy.

Battery consists of a group of two or more electric cells connected together electrically in series. Battery acts as a portable source of electrical energy.

Battery or cell is an electrochemical device consisting of two electrodes made up of different material and an electrolyte. The chemical reactions between the electrodes and the electrolyte produce voltage.

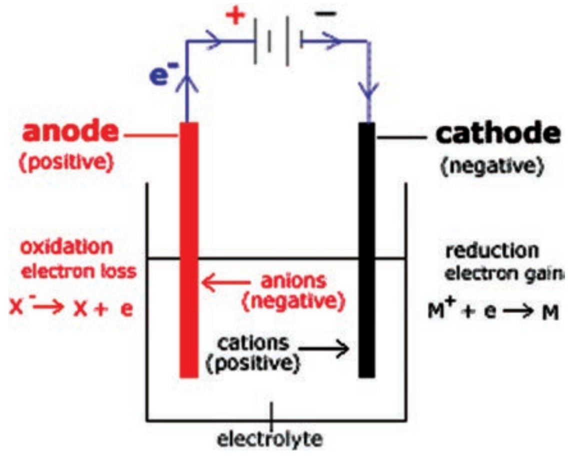


Fig 4.1 *Simple battery structure*

Cells are classified as 1. Dry and 2. Wet cells.

4.1.1 Dry cell

Dry cell is one that has a paste (or) gel electrolyte. It is semi sealed and can be used in any position. Nowadays the term 'Dry cell' refers to a cell that can be operated in any position without leakage.

4.1.2 Wet cell

Wet cells are cells that must be operated in an upright position. These cells have vents to allow the gases generated during charging or discharging to escape. The most common wet cell is the Lead-Acid cell.

4.1.3 Primary cells

Primary cells are those cells that are not rechargeable. That is, the chemical reaction that occurs during discharges is not easily reversed. When the chemicals used in the reactions are all converted, the cell is fully discharged. It must then be replaced by a new cell.

Example:-

Voltaic cell, Leclanche cell, Alkaline cell, Mercury cell, Lithium cell.

4.2 DRY CELL

The most common and the least expensive type of a dry cell battery in the Zinc-carbon type as shown in figure 4.2.

Fig 4.2 *Dry cell.*

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Zinc-Carbon dry cell

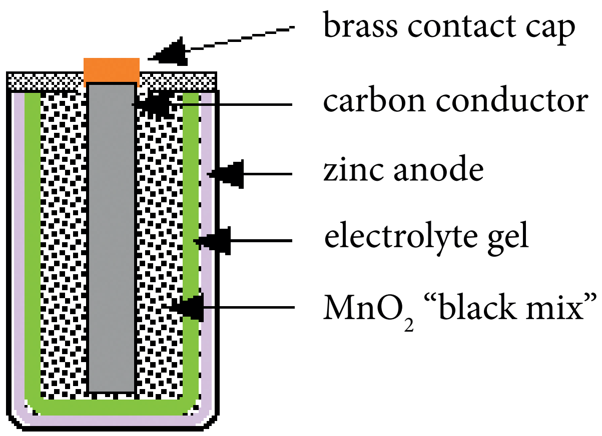


Fig 4.3 *Zinc-Carbon dry cell*

The Zinc-carbon consists of a zinc container which acts the negative electrode. In the center, a carbon rod is there which is electrode. The electrolyte in the form of a moist paste, made up of a solution containing ammonium chloride. As with all primary cells, one of the electrode becomes decomposed as part of chemical reaction. As a result, cells left in equipment for long periods of time can rupture, spilling the electrolyte and causing damage to the other parts.

Zinc-carbon cells are produced in common standard sizes. These include 1.5v AA, C, D cells.

(AA-pen type cell, C-minimum size, D-large/Economy size.)

4.2.1 Uses of primary cell

Primary cells are used in electronic products ranging from watches, smoke alarms, cardiac pacemaker torches, hearing aids, transister radios, etc.

4.2.2 Series cell connection

Cells are connected in series by connecting the positive terminal of one cell to the negative terminal of the next cell. (See the connection diagram in fig. 4.4)

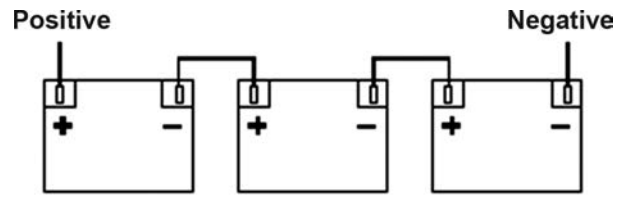


Fig 4.4 *Batteries in series connection*

Identical cells are connected in series to obtain a higher voltage is available as a single cell. With this connection of cells, the output voltage is equal to the sum of the voltages in the cells.However, the ampere hour rating remains equal to that of a single cell.

4.2.3 Parallel connection

Cells are connected in parallel by connecting all the positive terminals together and all the negative terminals together as shown in the fig 4.5.

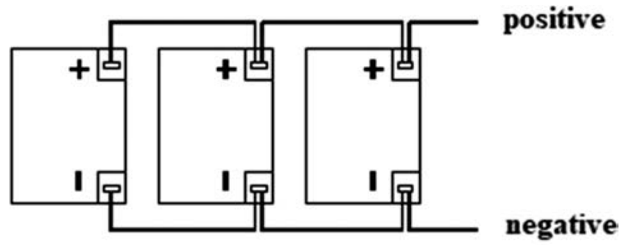


Fig 4.5 *Batteries in parallel connection*

Identical cells are connected in parallel to obtain a higher output current or ampere-hour rating. With this connection of cells, the output ampere-hour rating is equal to the sum of the ampere-hour rating of all the cells. However, the output voltage remains the same as that of a single cell.

When connecting groups of cells or batteries in parallel, each group must be in the same voltage level paralleling two batteries of unequal voltage levels set up a difference of potential energy between the two. As a result, the higher voltage battery will discharge its current into the other battery until both are at equal voltage value.

4.3 SECONDARY CELL

In a secondary cell, the charging and discharging processes are taking place according to Faraday's law of electrolysis.

A cell that can be recharged by sending electric current in the reverse direction to that of a discharge mode is known as a secondary cell. Secondary cells are Storage batteries since, after it is charged, it stores the energy until it is used or discharged.

4.3.1 Secondary cell classification

Secondary cells may be classified as

(i) Lead acid cell
(ii) Alkaline cell

Example: Nickel iron cell, Nickel cadmium cell

Secondary cell is a type of electrical battery, which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discharged after use. It is composed of one or more electro chemical cells. The term 'accumulator' is used, as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to mega watt systems connected to stabilize an electrical distribution network.

Several different combinations of electrode materials and electrolytes are used, including Lead-acid, Nickel-cadmium, Nickel-metal hydride, and Lithium ion.

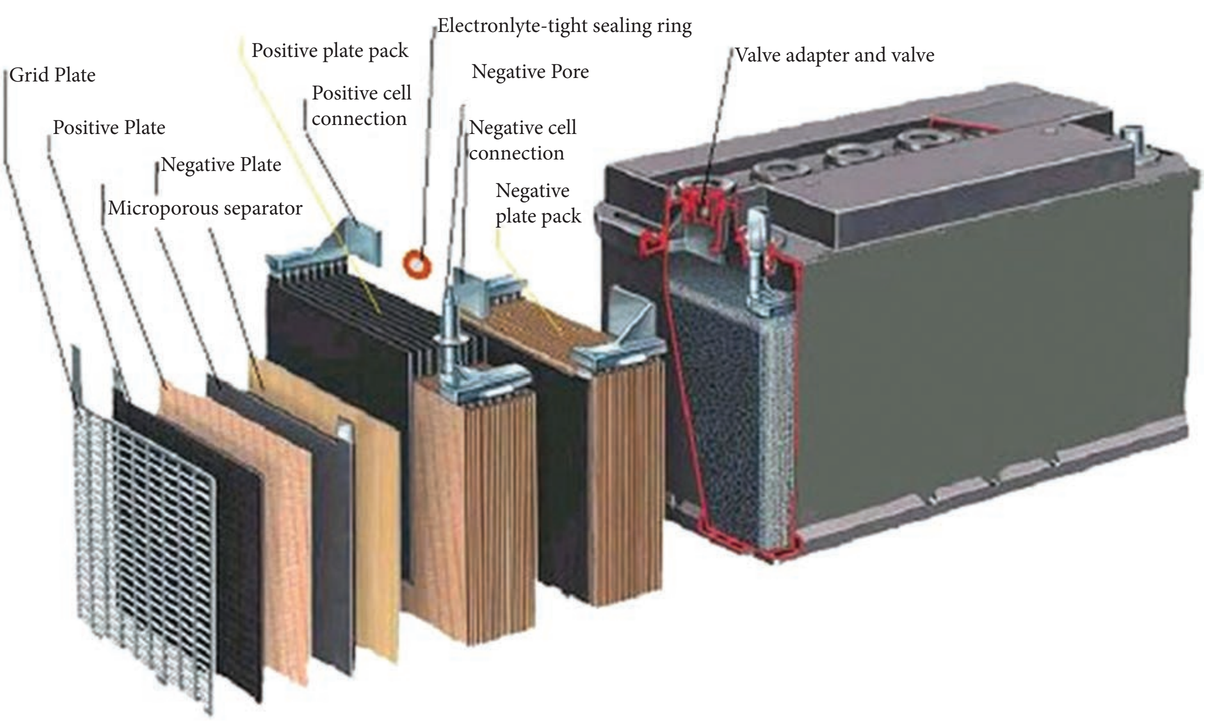


Fig 4.6 *Lead acid battery*

Initial cost of rechargeable batteries will be more than the disposable batteries, but have a much lower total cost of ownership.

Storage battery is a cell or a connected group of cells which converts chemical energy into electrical energy by reversible chemical reaction and may be recharged by passing a current through in the direction opposite to that of its discharge.

4.3.2 Lead acid battery

The battery which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical energy is called lead acid cell battery. This type of battery is most commonly used in the power stations and substations, because it has higher cell voltage and lower cost.

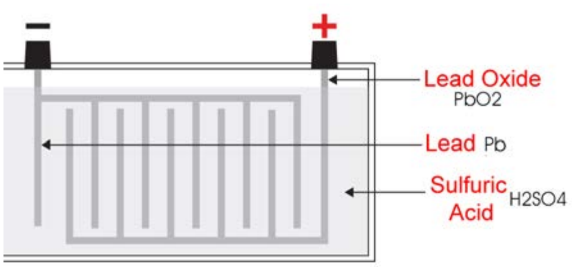


Fig 4.7 *Main parts of lead as acid battery*

Construction

First of all, we shall see the various parts of the lead acid cell battery with the help of fig 4.6. The container and the plates are the main parts of the lead acid cell battery.

1. Container

The container stores chemical energy which is converted into electrical energy with the help of plates. The container is made of glass, lead lined wood, ebonite, hard rubber of bituminous components, ceramic materials or moulded plastic and are seated at the top to avoid the discharge of electrolyte. At the bottom of the container, there are four ribs, on two of them rest on the positive plate and the others support the negative plate.

The prism serves as the support for the plates, and at the same time protects them from short-circuit. The material which the battery containers are made should be resistant to sulphuric acid.

2. Plate

The plates of the lead acid cell is of diverse designs and they all consist some form of a grid which is made up of lead and the active material. The grid is essential for conducting the electric current and for distributing the current equally on the active material. If the current is not uniformly distributed, then the active material will loosen and fall out.

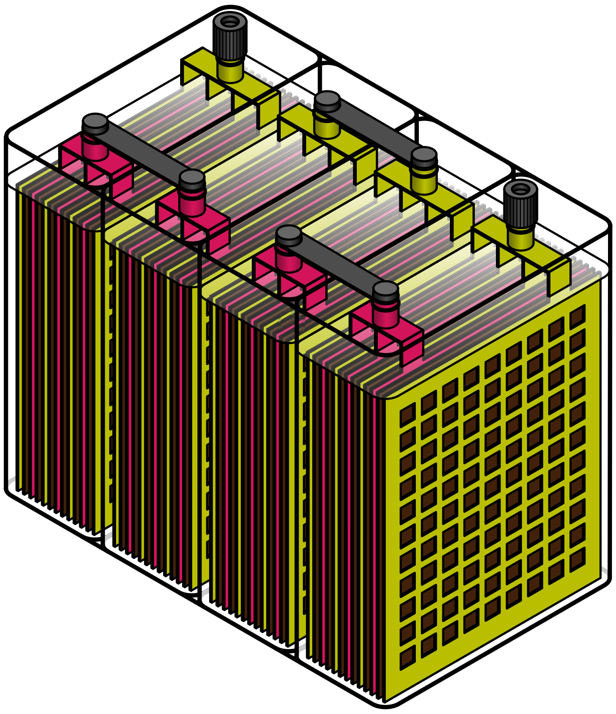


Fig 4.8 *Plate arrangements of lead-acid battery*

The grids are made up of an alloy of lead and antimony. The grid for the positive and negative plates are of the same design, (as shown in fig. 4.8) but the grids from the negative plates are made lighter because they are not as essential for the uniform conduction of the current.

The number of negative plates in a cell is always more than one number of positive plates in a cell, so that end plates at both the sides of the group remain negative.

3. Active material

The material in a cell which takes active participation in a chemical reaction during charging or discharging is called the active material of the cell. The active element of the lead acid cells are

a) Lead peroxide (PbO_2)

It forms the positive active material. The PbO_2 is dark chocolate brown in colour.

b) Sponge lead (Pb)

It forms the negative active material. It is grey in colour.

c) Dilute sulphuric acid (H_2SO_4)

It is used as an electrolyte. It contains 31% of sulphuric acid.

4.Separators

The separators are thin sheets of non-conducting material made up of chemically treated leadwood, porous rubbers or mats of glass fibre and are placed between the positive and negative to insulate from each other. Separators are grooved vertically on one side and are smooth on the other side.

5. Battery terminals

A battery has two terminals:–

Positive and Negative

a) Working principle

In a lead acid cell, sulphuric acid is used as an electrolyte. In this H_2So_4, electrolyte is poured after pouring water in it. Then, sulphuric acid dissolves and the molecules of hydrogen and sulphate are formed. In this, hydrogen ions are positive and sulphate ions are negative.

Two electrodes of battery are dipped in an electrolyte and DC supply is given as an input. Hydrogen positive ions go towards negative plate of electrode. Sulphate negative ions go towards positive plate of the electrode. In this way lead acid battery functions.

The sign(+) indicates positive terminal and sign(–) indicates negative terminal

Positive terminal-17.5mm dia

Negative terminal-16mm dia

b) Chemical reactions during discharging

When the cell is discharging, current flow in the external circuit is from positive to negative. (See fig. 4.9) The flow of current through the electrolyte (H_2SO_4) splits into positive hydrogen ion (H_2^+) and two negative sulphate ions (SO_4^{-2}).

Each sulphate ions move towards the cathode and on reaching there, give up two electrons to become radical SO_4, attack the metallic lead cathode and form lead sulphate, whitish in colour according to the chemical equation.

At Anode, H_2 combines with oxygen of PbO_2 and H_2SO_4 attacks lead to form $PbSO_4$.

At Anode:

$$PbO_2 + H_2 + H_2SO_4 \rightarrow PbSO_4 + 2H_2O$$

At cathode: $Pb + SO_4 \rightarrow PbSO_4$

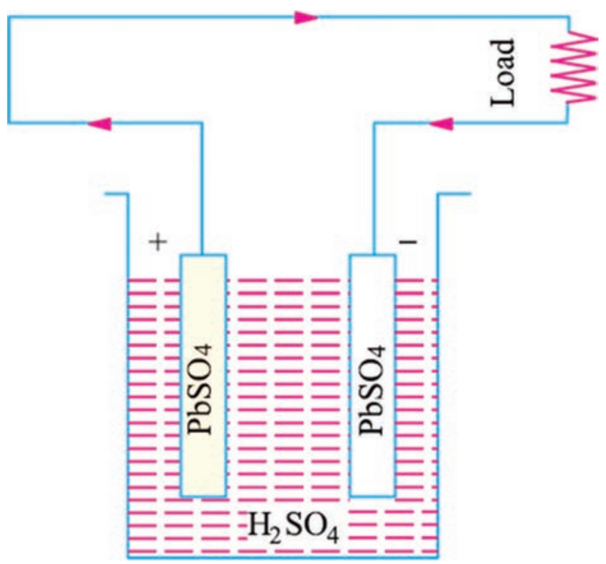


Fig 4.9 *Discharging process*

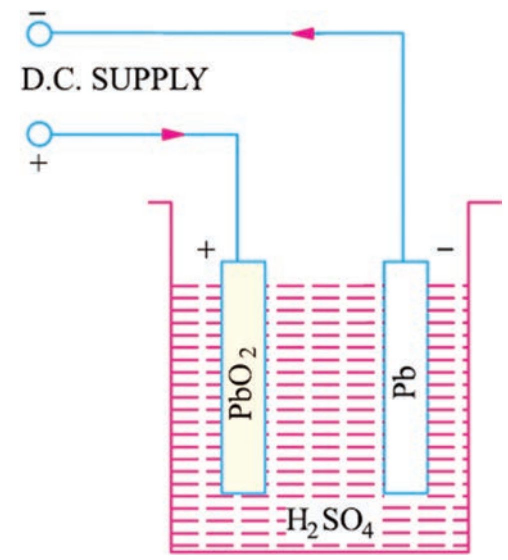


Fig 4.10 *Charging process*

Physical changes while discharging

1. Both the positive and negative plates are slowly converted into lead sulphate $PbSO_4$ (white in colour)
2. Water is formed during discharge. So the acid becomes more and more dilute. Specific gravity of sulphuric acid solution decreases.
3. Decrease in emf

c) Chemical reaction during charging

For recharging, the anode and cathode are connected to the positive and the negative terminal of the DC main supply. The hydrogen ions are positively charged move towards the cathode. (as in fig 4.10)

Sulphate ions move to the anode, and the following chemical reaction occurs.

At Anode: $PbSO_4 + H_2 \rightarrow Pb + H_2SO_4$

At Cathode:

$PbSO_4 + SO_4 + 2H_2O \rightarrow PbO_2 + 2H_2SO_4$

Physical changes while charging

1. Anode and cathode return back to their original colour (i.e positive plate dark brown and negative plate grey).
2. Specific gravity of an electrolyte is increased due to absorption of water.
3. Increase in emf values.

d) Difference between primary and secondary cells

Primary cell	Secondary cell
1. Primary cell cannot be recharged.	Secondary cell can be recharged.
2. Chemical energy is converted into electrical energy.	In this, electrical energy is converted into chemical energy.
3. Internal resistance is high.	Internal resistance is low.
4. It is light in weight.	It is heavy in weight.
5. It is less expensive.	More expensive.
6. Short life.	Long life.
7. Low efficiency.	High efficiency.
8. Less maintenance.	High maintenance.

4.4 LITHIUM ION BATTERY

A Lithium-ion battery is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and lithium ions move from positive electrode to the negative electrode when charging.

The three primary functional components of a lithium ion battery are the positive electrode, negative electrode and electrolyte. The negative electrode is made from carbon. The positive electrode is a metal oxide and electrolyte is a lithium salt in an organic solvent.

Nominal cell voltage is 3.6/3.85 Volt

Fig 4.11 *Lithium ion battery*

Lithium ion battery is a primary cell type battery. (see fig 4.11) It is available in variety of sizes and configurations. Depending on the chemicals used with lithium, the cell voltage is between 2.5 to 3.6volt.

4.4.1 Advantages of lithium battery

The are many advantages of using lithium-ion battery.

i) High energy density

The main advantage of lithium ion battery is high energy density. In mobile phones, it needs to operate for a long time between charges while still charging more power, there is always a need to batteries, with a much higher energy density. It is a distinct advantage.

ii) Self discharge

One issue with battery is that they loose their charges overtime. The main advantage is that the rate of self-discharge is very low than the other batteries.

iii) No requirement for priming

In this, lithium ion battery does not need to be primed, but the other batteries require priming.

iv) Low maintenance

Lithium ion battery does not require any maintenance to ensure the performance.

4.4.2 Disadvantages

The disadvantages of lithium ion battery are as follows:

i) Protection required

Lithium ion cells require protection from being overcharged and discharged too much. In addition, they need to have the current maintained within safe limits. Accordingly, lithium ion battery disadvantage is that they require protection to ensure that is it kept within the safe operating limits.

ii) Ageing

Another disadvantage of this battery is ageing. The battery is dependent upon the number of charge and discharge cycles that the battery has undergone. Lithium ion battery should be kept in a cool storage area, that will increase the life of battery.

iii) Transportation

Lithium ion battery applications are restricted on their transportation, especially by air. These batteries require care and protection while on transportation.

iv) Cost

The cost of lithium ion battery is high compared with other types of batteries.

4.5 SEVEN FEATURES ABOUT THE DISPARITY BETWEEN LEAD ACID AND LITHIUM ION BATTERIES

1. Weight

Lithium ion batteries are one third the weight of lead acid batteries

2. Efficiency

Lithium-ion batteries are of nearly 100% efficiency both charge and discharge, allowing the same ampere hours both in and out. But lead acid cell battery is 85% efficiency.

3. Discharge

Lithium-ion batteries are discharged 100%, but lead acid batteries discharge less than 80%.

4. Life cycle

Life cycle of the lithium-ion battery is 400–1200 cycles, whereas lead acid battery life cycle is 400 to 500 cycles

5. Voltage

Lithium-ion batteries maintain their voltage throughout the entire discharge cycle. This allows greater and longer lasting efficiency of electrical components. Lead acid cell battery voltage drops consistently throughout the discharge cycle.

6. Cost

Despite the higher upfront cost of lithium ion batteries, the true cost of ownership is less than lead acid battery when considering the life span and performance.

7. Environmental impact

Lithium ion batteries are updated technology and are safer for the environment.

Applications

Lithium-ion batteries are one of the most popular types of rechargeable battery for portable electronics with a high energy density, tiny memory effect and low self-discharge. Also used in electric vehicle and aerospace application.

4.6 UPS BATTERY

Fig 4.12 *UPS Battery*

An uninterruptible power supply is called UPS. It is a device that permits supply to keep on running for a short period of time, when the primary power is off.

UPS contains a battery that “kicks in” when the device senses a loss of power from the primary source (as in fig. 4.12).

If you are using computer, when the UPS notifies you of the power loss, you have time to save and data you are working on and exit, before the secondary power source runs out. When all power runs out, any

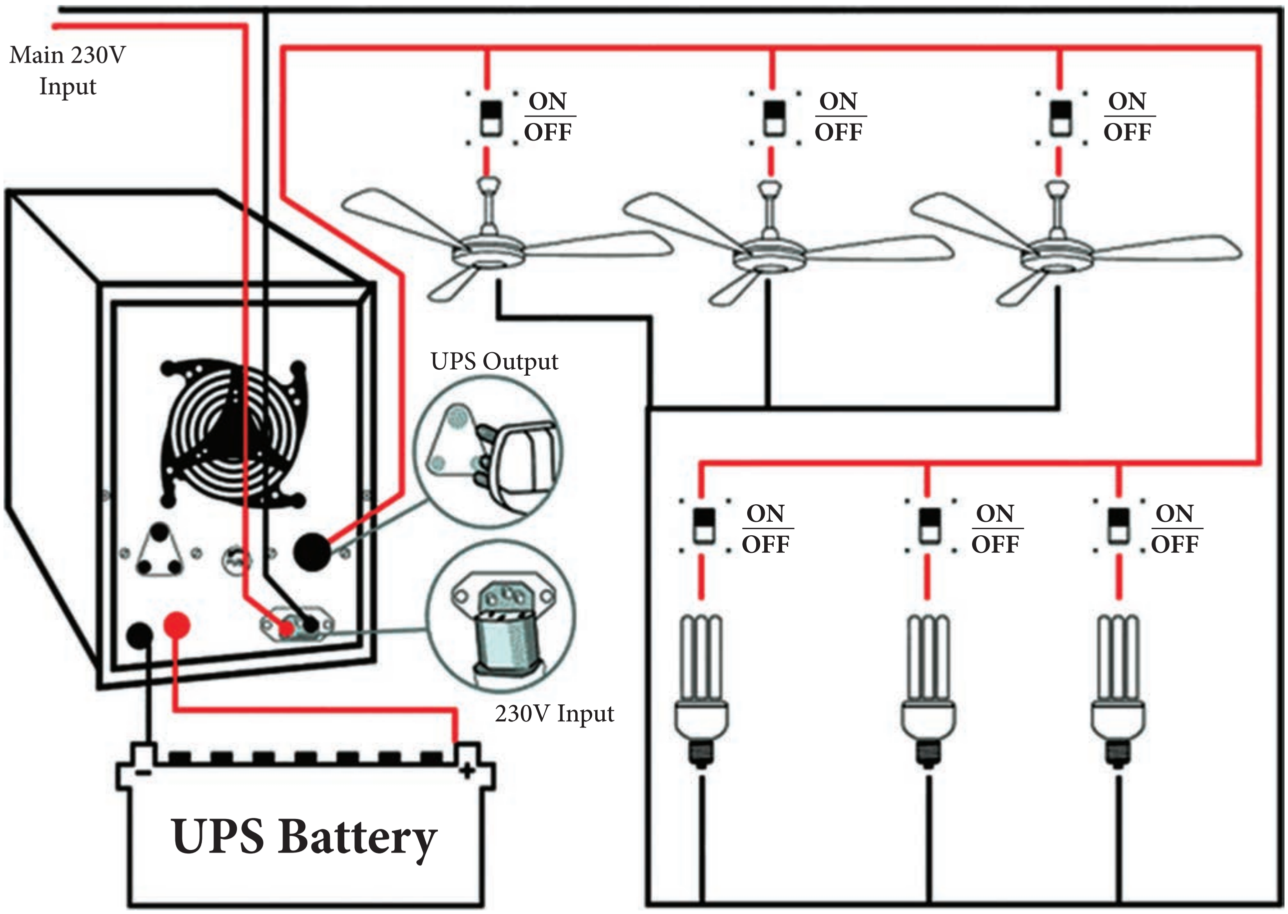


Fig 4.13 *Components of UPS System*

data in computers Random Access Memory (RAM) is erased when power surges occur, a UPS intercepts the surge, so that it doesn't damage the computer.

How does UPS work?

In a continuous UPS, the computer is always running short of battery power and the battery is continuously being recharged. The battery charger continuously produces DC power, which the inverter continuously turns back into 120 volt AC power. If the power fails, the battery provides power to the inverter.

Components of UPS (Ref. fig. 4.13)

1. The Static Bypass
2. The Rectifier
3. The Battery
4. The Inverter

Types of UPS

Range		Types
0.5 to 3 KVA	-	Line interactive
0.5 to 5 KVA	-	Stand by online hybrid
3.0 to 15 KVA	-	Stand by ferro double
5.0 to 5000KVA	-	Conversion online

4.7 MAINTENANCE OF BATTERIES

1. Battery should be cleaned properly
2. Cable connection of the battery should be clean and tightened, Many battery problems are caused by dirty and loose connection.
3. The fluid level of the battery will always be higher at a full charge.

4. Distilled water alone is the best for filling because other types of water are loaded with chemicals and minerals that are harmful to the battery. Don't over fill the battery especially in warm weather.
5. Use silicon seals in the cable leads. Coat the cable washer end with grease or petroleum jelly (vaseline).

4.8 DO'S AND DONT'S OF STORAGE BATTERY

Do's

1. Store batteries in a clean, ventilated and dry area.
2. Store batteries in a fully charged state.
3. Ensure the correct polarity connection when recharging.
4. Follow proper recharging schedules to prevent overcharging.
5. Keep the battery away from spark, heat and sources of fire.
6. Use proper size of cables along with correct plugs.
7. Charge the batteries immediately after it is discharged.
8. Terminal bolts are to be tightened with spring washers and apply torque. The tightness is to be checked.

Don'ts

1. Do not add any acid or distilled water in battery, during supply.
2. Do not tamper the vent plug.
3. Do not over tight or make loose the terminal bolts which may cause terminal breakage or fire due to loose contact.
4. Do not keep any metal object to rest on battery. It may cause short circuit.
5. Do not keep the battery in direct sunlight, dust or moist area.
6. Do not allow discharged battery for more than 12 hours in idle condition.

Precautions

1. Always handle a battery and its parts by wearing hand gloves, as the acid is corrosive.
2. Always pour the acid into water and not the water into the acid. Heat is produced when the acid is mixed with water.
3. Since the electrolyte is highly corrosive, the storage of electrolyte is used only glass or lead lined container If the batteries are handled with the above precautionary measures, the life of the battery will be prolonged. Follow the correct procedures and be safe while handling the battery.

4.9 NINE TIPS FOR PROPER BATTERY CARE

1. Size your battery correctly.
2. Periodically check the voltage of your batteries.
3. Don't try to charge alkaline batteries.
4. Prevent alkaline batteries from leaking.
5. Take care with parallel connections.
6. Give VRLA (Valve-Regulated Lead-Acid) battering breathing space.
7. Don't leave lead acid batteries in a discharged state.
8. Take off golden ornaments when connecting a battery.
9. Protect from cold temperatures and snowy climates.

Activities

1. Test the supply voltage from lemon?
2. Test the voltage produced in carrot?
3. How to produce electricity from orange?

GLOSSARY

Battery	—	மின்கலம்
Dry cell	—	உலர் மின்கலம்
Wet cell	—	பசை மின்கலம்
Separator	—	பிரிப்பான்
Charging	—	மின்னேற்றம்
Discharging	—	மின்னிறக்கம்
UPS-Battery (Un-interrupted Power Supply)	—	தடையில்லா மின்சாரம் தரும் சாதனம்

Q A

PART A

Mark 1

Choose the correct answer:

1. Battery is a storage of _______
   a) heat energy
   b) electrical energy
   c) chemical energy
   d) solar energy

2. In battery, chemical energy is transformed into _________ energy.
   a) electrical energy
   b) light energy
   c) sound energy
   d) heat energy.

3. Primary cells are _______
   a) not rechargeable
   b) chargeable
   c) partly chargeable
   d) not available

4. In dry cell, carbon rod is _________ electrode
   a) positive electrode
   b) negative electrode
   c) phase
   d) neutral

5. Charging and discharging process in secondary cell fulfills in which law?
   a) Ohm's law
   b) Faraday's laws of electrolysis
   c) Lenz's laws
   d) current law
6. Lead acid battery is commonly used in _______
   a) railway station
   b) radio station
   c) TV station
   d) power station and substation
7. Separators in a battery is of ________ material
   a) conductive
   b) non –conductive
   c) partly conductive
   d) heavy conductive
8. The voltage range of lithium-ion battery is ______
   a) 2 to 2.5V
   b) 2.5 to 3.6V
   c) 3.6 to 5V
   d) 5 to 6.6V
9. Advantage of using lithium ion battery is ____
   a) high energy density
   b) low energy density
   c) medium energy density
   d) poor energy density
10. The battery used in electric vehicles and Aerospace applications is________
    a) lead acid cell battery
    b) lithium-Ion battery
    c) UPS battery
    d) charger battery

Q A

PART B

Mark 3

Answer the questions in briefly

1. What is called a battery?
2. State the different types of battery.
3. Write about the primary cell.
4. State the uses of a primary cell.
5. What is called a secondary cell?
6. What is called a Lead acid cell battery?
7. What is a the use of separators?
8. What is called a Lithium-ion battery?
9. Write a short note on UPS Battery.
10. Write down the types and range of UPS.
11. What are the precautions to be followed in a battery?

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. State the differences between primary and secondary cell.
2. State the advantages of lithium-ion battery.
3. Write seven features about the disparity between a Lead acid and a lithium ion battery.
4. State the Do's and Don'ts of a storage battery.
5. What are the maintenance produces to be observed in a battery?

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain dry cell with a neat sketch.
2. Explain the construction working principle of lead acid battery.
3. Explain the chemical reactions and physical changes during discharging in lead-acid battery.
4. Explain the chemical reactions and physical changes during charging in lead-acid battery.
5. Explain in detail about Lithium ion battery with diagram.
6. Draw and explain about an UPS battery with a circuit diagram.

Reference book

1. A text book of Electrical Technology' Volume I and Volume III by B.L. Theraja and A.K. Theraja, S. Chand & Company Ltd.

Internet resource

www.sciencebuddies.org

LESSON 5

AC Circuits

LEARNING OBJECTIVES

The learning objective of AC circuit is preferably to know about RLC circuits, its advantages and disadvantages, three phase star / delta connection, interconnection of three phases and digital energy meter. According to the trend of applications, it is necessary to know the various types of connections in AC circuits.

Table of Content

5.1 AC circuit - Introduction

5.2 AC wave form and it's characteristics

5.3 Advantages and disadvantages of AC supply

5.4 Types of electrical elements

5.5 Inductor and Inductance

5.6 RLC series circuit

5.7 Three phase star/delta connection

5.8 Single phase and three phase supply

5.1 AC CIRCUIT- INTRODUCTION

An alternating current supply may be generated in two methods:

(i) By rotating a coil at constant angular velocity in a uniform magnetic field

(ii) By rotating a magnetic field, constant angular velocity within a stationary coil

In both the cases, the generated voltage will be sinusoidal. The magnitude of generated voltage depends upon:

(i) Number of turns of the coil
(ii) The strength of magnetic field
(iii) The speed of rotation

The first method is used for small A.C generators and the second method is used for large type of A.C generators.

In fig. 5.1, an Alternating current shows the change in the direction of current and magnitude at regular intervals of power system. Alternating current plays a vital role in today's electrical energy generation.

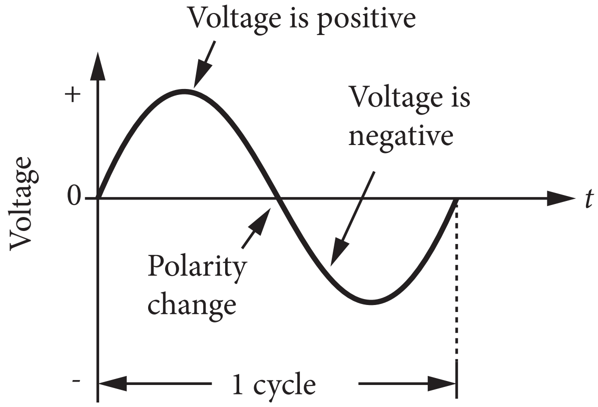


Fig 5.1 *Voltage vs Time*

5.2 AC WAVE FORM AND IT'S CHARACTERISTICS

A wave form is a representation of low alternating current (AC) that varies with time. The most familiar AC waveform is the sine wave, which derives its name from the fact that the current (or) voltage varies with the sine of the elapsed time.

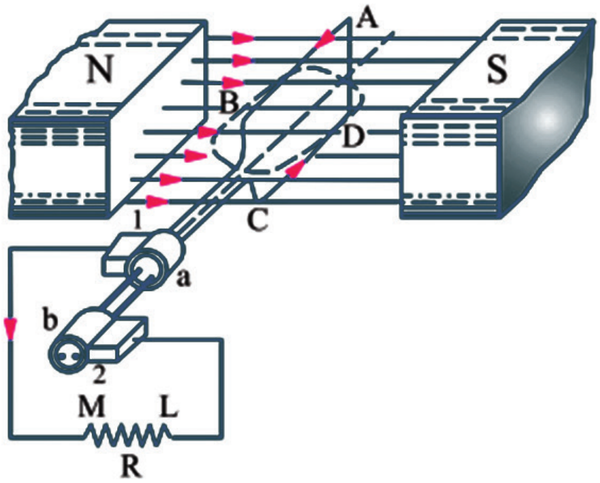


Fig 5.2(a) Schematic of an AC generator

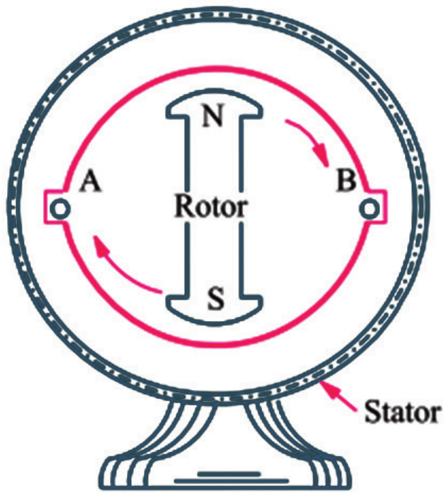


Fig 5.2(b) Sectional view of an AC generator

In fig 5.2 (a) A stationary magnetic field and rotating coil

In fig 5.2 (b) A stationary coil and magnetic field rotating

If a coil rotates in the magnetic field or rotates inside the coil, there is an alternating emf induced in the coil. The generated alternating emf depends upon the number of turns of coils, magnetic field and the angle between the coil and magnetic field.

Induced emf e = Blv Sinθ

Where

B = Flux density in weber/m^2

l = Length of the conductor in meter

v = Velocity of the conductor in meter/second

Ø = Angle between magnetic field and conductor

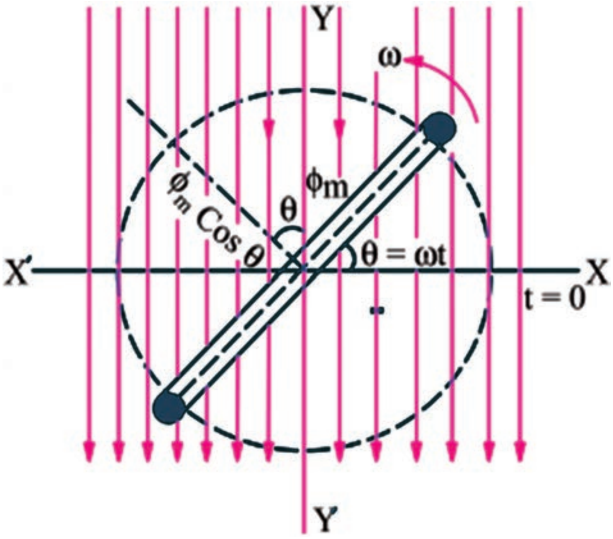


Fig 5.3 *Rotating coil in a magnetic field*

In fig. 5.3, a rectangular coil having 'N' turns and rotating in counter clock wise direction in a uniform magnetic field with an angular velocity of 'ω' radians/sec is shown.

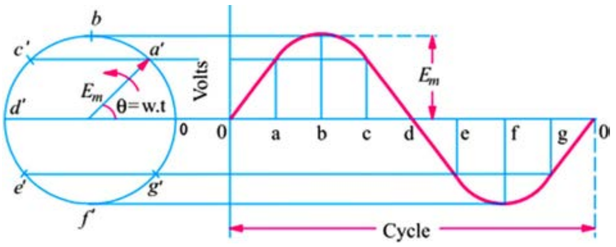


Fig 5.4 *Generation AC waveform*

So, the generated AC emf value is also depending upon the value of the angle between the magnetic field and the coil.

The sine wave may be drawn in graph by taking the electro motive force in 'Y' axis and time in 'X' axis.

In fig. 5.4, a coil is rotating in a magnetic field in anti-clock wise direction. Let us assume that the coil is in the position 'O'. Now the angle between the magnetic field and coil is zero. Then, the e.m.f in the coil is also zero (ie, sin θ = 0)

Now the coil moves to the position 'a' and the angle between the magnetic field and coil is θ. Then, emf is equal to Blv Sinθ.

Now the coil moves to the position 'b' and the angle between the magnetic field and coil is 90°. Then sin 90 = 1. The emf is maximum. This emf is called positive maximum.

Now the coil moves to the position 'd' and the angle between the magnetic field and coil is zero. In this position emf value is zero.

Now the coil moves to the position 'f' the angle between magnetic field and coil is 90°, sin 90° = 1 and the e.m.f is maximum in magnetic side, so it is called as negative maximum.

Now the conductor moves to the position '0', the emf is zero.

Similarly, the conductor rotates one revolution in the magnetic field. This rotation produces the sine wave form.

a) Cycle

One complete set of positive and negative values of alternating quantity is known as cycle. One complete cycle is said to spread over 360° or 2π radians.

b) Time period

Time period is denoted by 'T'. The time taken for any wave to complete one full cycle is called the time period.

c) Frequency

The frequency of a wave is defined as the number of cycles that a wave completes in one second. It is denoted by the letter 'F' and its unit is cycles / second or Hertz(Hz). In India, the supply frequency is 50Hz. Frequency is calculated by

$$f = \frac{PN}{120} \text{Hz}$$

Whereas

f = Frequency in Hertz

P = Number of poles

N = Revolution in r.p.m

d) Instantaneous value

At any given time, it has some instantaneous value. This value is different at different points along the waveform. During the positive and negative cycle, these values are positive and negative respectively.

e) Peak value

The peak value of the sine wave is the maximum value of the wave during positive half cycle or negative half cycle.

f) Peak factor

The ratio of maximum value to the r.m.s. value of an alternating quantity is known is peak factor

$$\text{Peak factor} = \frac{\text{Max. value}}{\text{RMS value}} = 1.414$$

g) Average value

The average value of the sine wave is the ratio of total area under the half-cycle curve to the distance of the curve

$$\text{Average value} = \frac{\text{Area under the curve}}{\text{Base length}}$$

$$\text{Average value} = \frac{2Im}{\neq} \text{ or } \frac{2Vm}{\neq}$$

h) Effective value or RMS value

The value of an Alternating Current (or) Voltage is equal to the square root of the arithmatic mean of the squares of the instantaneous values taken through one complete cycle.

$$\text{RMS value} = \frac{Im}{\sqrt{2}} \text{ or } \frac{Em}{\sqrt{2}}$$

AC ammeters and voltmeters are calibrated to record RMS values.

i) Form factor

The ratio of RMS value to the average value of an alternating quantity is known as form factor

$$\text{Form factor} = \frac{(\text{RMS value})}{(\text{Average value})} = 1.11$$

The form factor is useful in rectifier service because it enables to find the rms value from average value and vice versa.

j) Power factor

Cosine value of angle between voltage and current is called as power factor. Power factor is also defined as the ratio of true power to apparent power

Power factor = cos θ (θ is angle between voltage and current)

$$\text{Power factor} = \frac{VI\cos\theta}{VI} = \frac{\text{True power}}{\text{Apparent power}}$$

The power factor can never be greater than the value 1. If the powerfactor is 1, it is called as unity power factor. The word lagging or leading with the numerical value of power factor should be noted to signify whether the current lag or leads the voltage.

5.2.1 Phase

A particular value of an alternating quantity is the fractional part of the time period or cycle through which the quantity has advanced from the selected zero position of reference is known as phase.

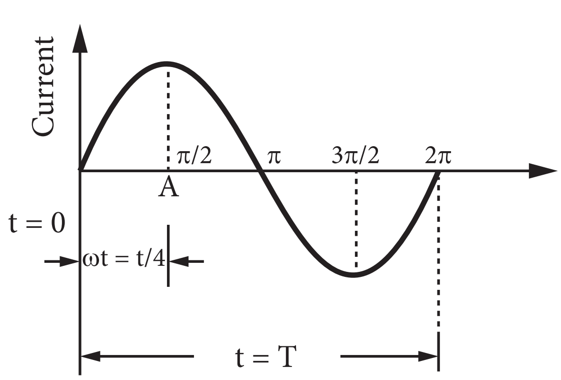


Fig 5.5 *Phase*

5.2.2 Phase difference

When two alternating quantities of the same frequency have different zero points, they are said to have a phase difference.

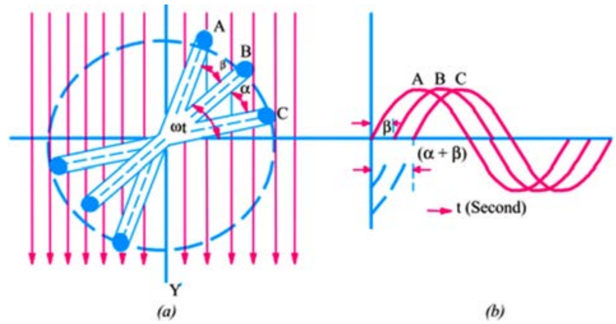


Fig 5.6 *Phase difference*

The angle in between the difference in the phase angle of the two wave is θ. It is generally measured in degrees or radians. The quantity which crosses through its zero point earlier is said to be leading while the other is said to be lagging.

5.3 ADVANTAGES AND DISADVANTAGES OF AC SUPPLY

Advantages

1) It is easy to transmit alternating current from one place to another place.
2) High voltage can be generated easily.
3) The cost of AC equipment is low.
4) It is possible to convert into DC.
5) Step down, step up voltage can be easily done by transformer.
6) AC motors are cheap.

Disadvantages

1) AC supply cannot be stored in batteries.

2) Ac supply produce high output. So it needs good insulation to avoid electric shock.
3) The voltage drop is occurred due to high starting current in AC.
4) The speed of the AC motor depends upon the frequency.
5) In Inductive load, power factor will be low.

5.4 TYPES OF ELECTRICAL ELEMENTS

There are two types of electrical elements.

1. Active elements
2. Passive elements

5.4.1 Active elements

Active elements produce energy in the form of voltage sources and current.

5.4.2 Passive elements

Passive elements consume energy. Some of the common examples of passive element are resistor, capacitor, inductor, etc.

5.4.3 Resistor – Types

Resistor is of two types. They are,

1. Fixed resistor and

2. Variable resistor.

(i) Fixed resistor

Resistors that have a defined value of the resistance are called fixed resistors.

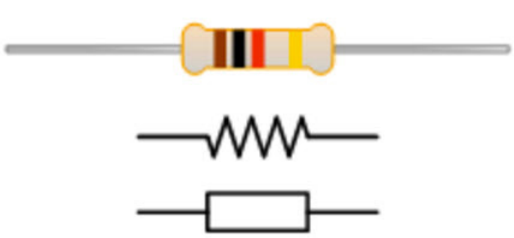


Fig 5.7 Resistor

(ii) Variable resistors

A variable resistor is a resistor, in which the value can be adjustable. A variable resistor is used with a potential divider having 3 terminals are known as a potentiometer.

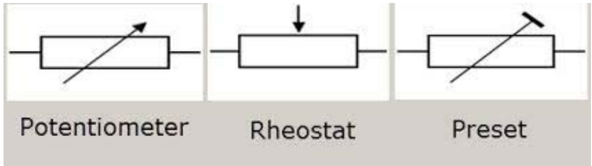


Fig 5.8 *Variable resistor*

5.4.4 Colour coding of resistors

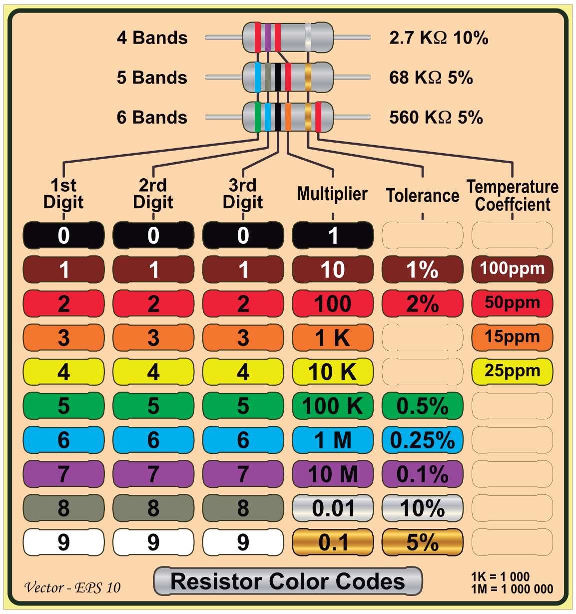


Fig 5.9 Colour coding of resistors

To calculate the resistance value, you have to group the values with the significant digits bands — i.e., the values of the first two or three bands from the left, depending on the total number of bands. Then multiply that value by the multiplier to get the resistance value.

Let's take for example a four-band resistor with the following band colors: Violet, Green, Yellow and Gold

Since it is a four-band resistor, the first two bands (violet and green) will indicate the significant digits, according to the table above is 75.

Then multiply that number by multiplier indicated with the 3rd band (yellow) which has the value of 104 = 10000.

The result of the multiplication will be: 75 x 10000 = 750000Ω = 750kΩ.

5.5 INDUCTOR AND INDUCTANCE

Inductance (L) is the tendency of an electrical conductor to oppose a change in the electric current flowing through it. A component which possesses the inductance property is called inductor.

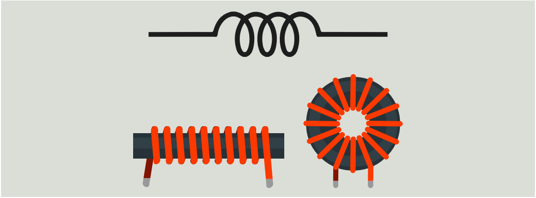


Fig 5.10 Inductor

5.5.1 Inductor in series circuit

Inductors in series are simply "added together" because the number of coil turns is effectively increased, with the total circuit inductance LT being equal to the sum of all the individual inductances added together as shown in fig.

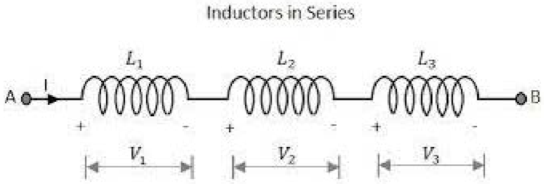


Fig 5.11 Inductors in series

The current (I) that flows through the first inductor L1 and pass through the second and third inductor.

$$V = L\left(\frac{di}{dt}\right)$$

$$L\ total = L_1 + L_2 + L_3 + \ldots.. + L_n\ ..$$

Inductors in parallel

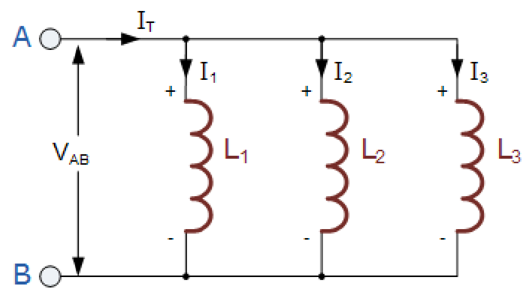


Fig 5.12 Inductors in parallel

When inductors are connected together in parallel so that the magnetic field of one links with the other, the effect of mutual inductance either increases or decreases the total inductance depending upon the amount of magnetic coupling that exists between the coils. The voltage drop across all of the inductors in parallel will be the same.

The voltage across the inductors is given as $V = L\left(\frac{di}{dt}\right)$

We can reduce it to give a final expression for calculating the total inductance of a circuit when connecting inductors in parallel and this is given as:

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots.. \frac{1}{L_N}$$

5.5.2 Capacitor in series circuit

When capacitors are connected in series, the total capacitance is less than any one of the series capacitors' individual capacitances. If two or more capacitors are connected in series, the overall effect is that of a single (equivalent) capacitor having the sum total of the plate spacing's of the individual capacitors.

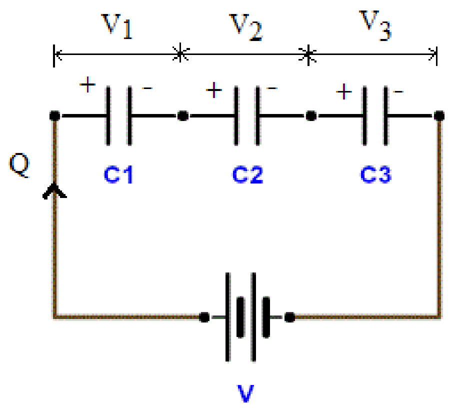


Fig 5.13 Capacitor in series circuit

We can find an expression for the total capacitance by considering the voltage across the individual capacitor as shown in above

The total capacitance in series cs to be

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$$

5.5.3 Capacitor in parallel circuit

Capacitors are connected together in parallel when both of its terminals are connected to each terminal of another capacitor. The sum of voltage connected across all the capacitors that are connected in parallel is same, as that of inductor in parallel.

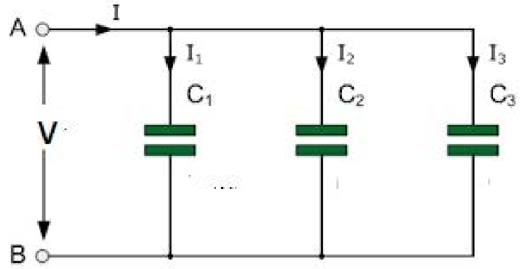


Fig 5.14 Capacitor in parallel circuit

5.5.4 Conditions for parallel

- Voltage rating of capacitors should be higher than the supply voltage Vs.
- Polarity should be maintained in the case of polarized capacitors (electrolytic capacitors).

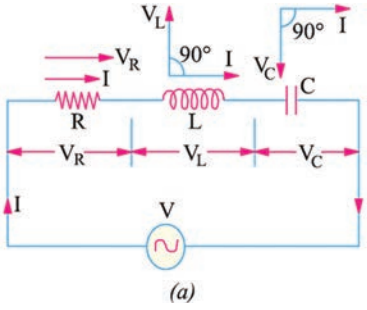
Therefore,

$$C_T = C_1 + C_2 + C_3$$

5.6 RLC SERIES CIRCUITS

In this circuit, the three (RLC) components are all in series with the voltage source.

5.6.1 RLC series circuit



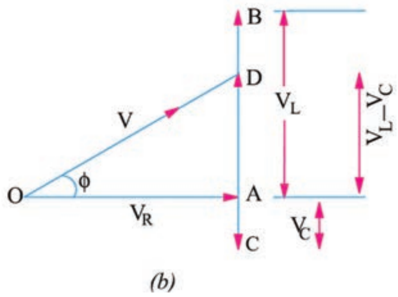


Fig 5.15 *RLC series circuit*

In this RLC circuit resistance, inductance and capacitance are connected in series. In this the current is same. The voltage is differed by circuit elements, Total supply voltage is 'V'

$I = I_R = I_L = Ic$

And

$V = V_R + V_L + V_C$

V_R = Voltage across the resistance

V_L = Voltage across the inductance

V_C = Voltage across the capacitance

And also

V_R is in phase with current

V_L leads current by 90°

V_C lags current by 90°

(i) If inductive reactance is greater than capacitive reactance ($X_L > X_C$)

$$V^2=V^2_R+(V_L-V_C)^2$$

$$V=\sqrt{V^2_R+(V_L-V_C)^2}$$

$$V=\sqrt{(IR)^2+(IX_L-IX_C)^2}$$

$$V=\sqrt{I^2R^2+I^2(X_L-X_C)^2}$$

$$V=I\sqrt{R^2+(X_L-X_C)^2}$$

$$\frac{V}{I}=\sqrt{R^2+(X_L-X_C)^2}$$

$$\text{Impedance } Z=\sqrt{R^2+\left(X_L>X_c\right)}\,2\,\text{ohms}$$

$$\left(\frac{V}{I}=Z\right)$$

$$\text{Power factor } \cos\theta=\frac{R}{Z}$$

$$\text{and power } P=VI\ \cos\theta\ \text{watts}$$

(ii) If capacitive reactance is greater than inductive reactance ($X_C > X_L$)

$$\text{Impedance } Z=\sqrt{R^2+(X_C>X_L)^2}\ \text{ohms}$$

$$\text{Power factor } \cos\theta=\frac{R}{Z}$$

$$\text{And power } P=VI\ \cos\theta\ \text{watts}$$

5.6.2. AC circuits with pure resistance

A circuit having only resistance and without inductance and capacitance is called pure resistance circuit

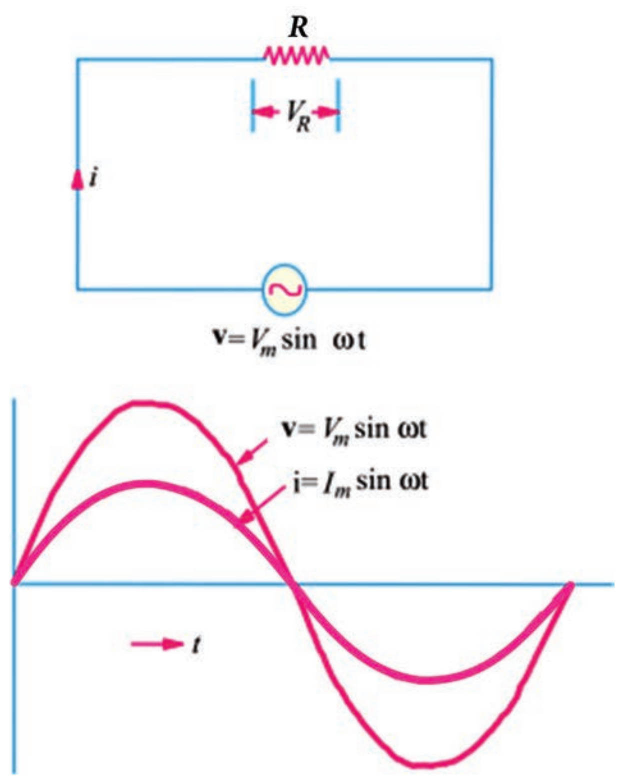


Fig 5.16 *AC through resistance*

Let

The value of resistance is R

The value of current is I

The value of electro motive force is E

Then

$$\text{Current}(I)=\frac{\text{Electromotive Force}(E)}{\text{Resistance}(R)}$$

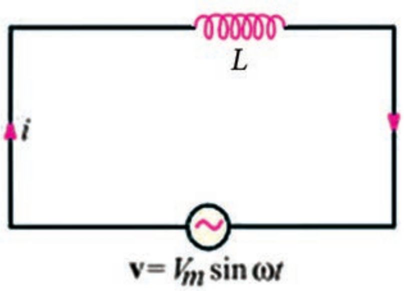
$$I=\frac{E}{R}$$

$$\text{Power} = \text{Current} \times \text{EMF}$$

In this circuit power factor is unity, because the angle between current and voltage is zero (cosθ = 1).

5.6.3. AC circuits with pure Inductance

A circuit having only inductance and without resistance and capacitance is called pure inductance circuit.



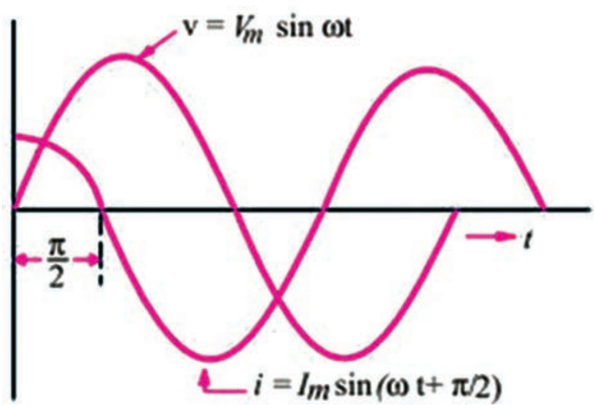


Fig 5.17 *AC through inductance*

If AC current flows through a coil, Back emf is induced due to inductance of the coil. This back emf opposes supplied voltage in a pure inductance coil. Back emf is equal to supply voltage. In inductive circuit only, the frequency is same for voltage and current, but they are out of phase and current is lagging by 90° to the voltage.Therefore power factor (cos 90=0)is zero.

5.6.4. Inductive reactance

Inductive reactance means the opposition due to self inductance to the AC current through a coil. It's unit is ohm and it is denoted by the letter "X_L"

$$X_L = 2\pi fL$$

Where

X_L-Inductive reactance in ohm
f-Frequency in Hertz
L-Inductance in Henry

5.6.5. AC Circuits with pure capacitance

A circuit having only capacitance and without resistance and inductance is called as pure capacitive circuit.

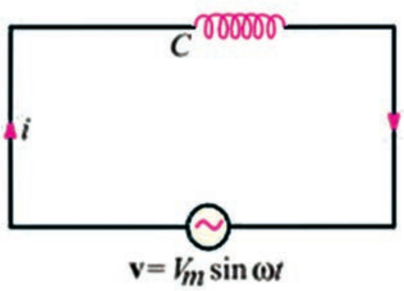


Fig 5.18 *AC through capacitance*

In the first half cycle (up to 90°) capacitor is charged and from 90° to 180° the capacitor is discharged. Similarly in the second half cycle, capacitor is charged first and discharged next, in opposite direction. So, in one cycle, capacitor is charged and discharged two times, in capacitor only. In AC circuit, the current is leading by the voltage at 90°. There fore power facter (Cos 90 = 0) is zero. So, power is zero.

5.6.6 Capacitive reactance

The resistance offered by a capacitor is called as capacitive reactance. The unit of capacitive reactance is ohm(Ω) and it is denoted by letters Xc.

$$Xc = \frac{1}{2\pi fc}$$

Where

Xc = Capacitive reactance in ohm
C = Capacitance in farad
F = Frequency in Hertz

5.6.7 Impedance

Impedance is the total opposition offered by the circuit elements [ie, Resistance, Inductance and Capacitance] simply, impedance is defined as the ratio of the voltage to current

$$\text{Impedance } (Z) = \frac{\text{Voltage}(V)}{\text{Current}(I)}$$

5.6.8 Diode

A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction. When a diode is reverse-biased, it acts as an insulator and does not permit current to flow.

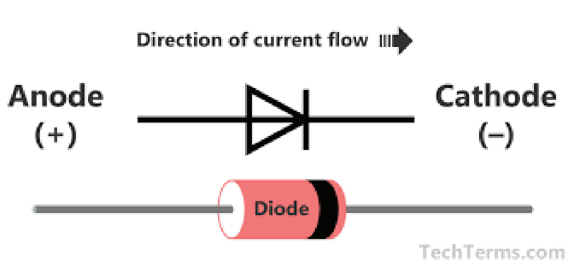


Fig 5.19 Diode

5.6.9 Transistor

"When a third doped element is added to a crystal diode in such a way that two pn junction formed, the resulting device is known as a transistor

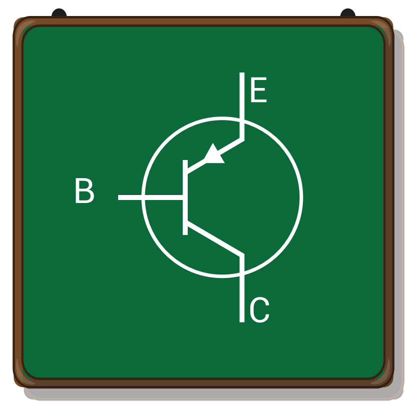


Fig 5.20 Transistor

5.6.10 Integrated circuit (IC)

Integrated circuit (IC) also called micro electronic circuit, micro chip, or chip. It is having an assembly of electronic components, fabricated as single unit, in which miniaturized active devices.

Fig 5.21 Integrated circuit

All IC's chips have a two-part serial number. The first part of the serial number indicates the manufacturer's information. The second part of the serial number indicates the IC's technical specifications. Many IC manufacturers produce identical chips with the same technical specifications

Acronym	Name	Year	Transistor count	Logic gate number
SSI	Small-scale integration	1964	1 to 10	1 to 12
MSI	Medium scale integration	1968	10 to 500	13 to 99
LSI	Large scale integration	1971	500 to 20000	100 to 9999
VLSI	Very Large scale integration	1980	20000 to 1000000	10000 to 99999
ULSI	Ultra large scale integration	1984	1000000 and more	100000 and more

5.6.11 Advantages of ICs

1. The integrated circuit can be easily replace but it can hardly repair, in case of failure.
2. The reduction in power consumption is achieved due to extremely small size of IC.
3. The weight and price of IC is very less.
4. The IC is more reliable.
5. The temperature difference between components of a circuit is less.
6. It is suitable for small signal operation.

5.6.12 Disadvantages of ICs

- The integrated circuit can handle only limited amount of power.
- The high grade PNP assembly is not possible.
- It is difficult to achieve low temperature coefficient.
- The power dissipation is limited to 10 watts.
- The inductors cannot be fabricated directly.

5.6.13 Application

Many integrated circuits can be found in almost every electronic devices such as Timers, Amplifiers, Logic units, Calculators, Temperature sensors, Computers and Radio receivers.

5.7 THREE PHASE STAR/ DELTA CONNECTION

3 phase AC generator is shown in Fig 5.13. Three identical windings A,B and C are placed 120^0 electrical degree apart. It generates 3 phase supply. Three phases are indicated in Red (R), Yellow (Y) and Blue (B) colors.

5.7.1 Poly phase system

If the armature of an alternator generating AC apply is having only one winding, it generates single phase supply. Instead of one winding, the alternator is having two or three windings, with two or three phases generated respectively. So a system produces more than one phase is called poly-phase system.

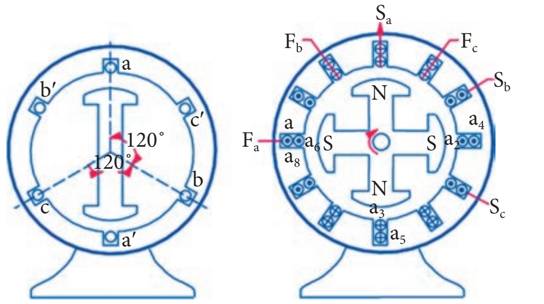


Fig 5.22 *Poly phase system generation*

5.7.2. Reasons for the use of three-phase system

Three phase system is preferred over single phase system for the following reasons.

Three phase power has a constant magnitude whereas single phase power pulsates from zero to peak value at twice the supply frequency.

A three phase system can set up a rotating magnetic field in stationary windings. This cannot be done with a single phase current.

For the same rating, Three phase machines (generators, motors, transformers) are smaller, simpler in construction and have better operation than single phase machines.

To transmit the same amount of power to a fixed distance at a given voltage. The three phase system requires only three-fourth weight of copper that is required by the single phase system.

The voltage regulation of a three phase transmission line is better than that of a single phase line.

5.7.3. Phase sequence

It is the term which is used to represent in what sequence the three phase voltage or current attains maximum value. If the phase sequence is said to be R, Y, B then first red phase attains maximum value with a phase difference of 120° each, the yellow phase and blue phase attains their peak value.

In a three phase alternator, there are three windings or phases. Each phase has two terminals. If a separate load is connected across each winding six conductors are required to transmit power. This will make the system complicated and expensive. In practice, three windings are interconnected to give two methods of connection.

Star (Y) connection

Mesh (Δ) connection.

5.7.4 Star ´Y´ Connection

In this method, similar ends of the three phases are joined together to form a common junction (N) supply is taken from other three ends. The common junction (N) is called the star point or netural point. The voltage between any one line and netural is called phase voltage. The current flows through that phase is called phase current. Voltage between any two line is called line voltage and current through that line is called line current.

In this connection,

Phase current = Line current

$I_{ph} = I_L$

$$\text{Phase voltage} = \frac{\text{Line voltage}}{\sqrt{3}} = \frac{V_L}{\sqrt{3}}$$

If the neutral wire is taken for external connection, then the system is called a three-phase four wire star connected system. If the neutral wire is not taken for external connection, then the system is called a three phase three wire star connected system.

Total power p = 3 × power in each phase
Power in each phase P = $V_{ph}\, I_{ph} \cos\theta$

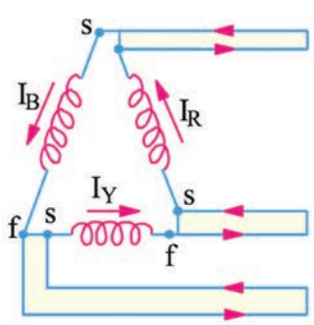
$$P = 3 \times \frac{V_L}{\sqrt{3}} \times I_L \cos\theta$$

$$(\text{where as } I_{ph} = I_L, V_{ph} = \frac{V_L}{\sqrt{3}})$$

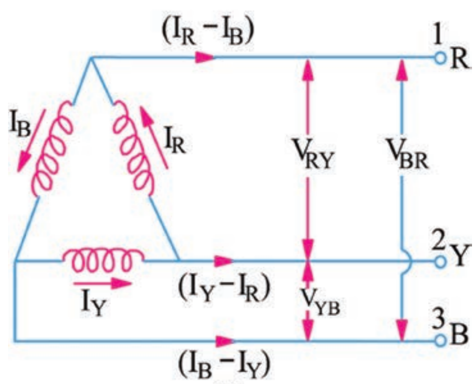
$$\therefore P = \sqrt{3} V_L I_L \cos\theta$$

5.7.5. Delta or Mesh Connection(Δ)

In this method of interconnection, the dissimilar ends of the three phase windings are joined together. The finishing end of one phase is connected to the starting end of the other phase so as to obtain Mesh or Delta connection. The three line conductors are taken from the three junctions of the Mesh or Delta and they designated as R, Y and B. This is called three phase three wire delta connected system. Since no neutral exists in Delta connection, only three phase, three wire system can be formed.



(a)



(b)

Fig 5.23 *Delta connection*

In this connection, the line voltage is equal to the phase voltage.

Phase volltage = Line voltage

$$V_{ph} = V_L$$

Phase current = Line current

$$I_{ph} = \frac{I_L}{\sqrt{3}}$$

Power

Total power P = 3 × power per phase

$$P = 3\, V_{ph}\, I_{ph} \cos\theta$$

$$P = 3 \times V_L \times \frac{I_L}{\sqrt{3}} \times \cos\theta$$

$$V_{ph} = I_L,\ I_{ph} = \frac{I_L}{\sqrt{3}}$$

$$\text{i.e., Power} = \sqrt{3}\, V_L I_L \cos\theta$$

Where cosθ is power factor.

5.7.6 Advantages of star connection over delta connected system

1. A star connected alternator will require less number of turns than a delta connected alternator for the same line voltage.
2. A star connected alternator requires less insulation over a Delta connected alternator for the same line voltage.
3. In star connection, Three-phase, Four-wire system permits to use two voltage ie, Phase voltage as well as line voltage.
4. In star connection, single phase load can be connected between any one line and the neutral. Such a flexibility is not available in Delta connections.
5. In star connection, the neutral point is earthed. Moreover, earthing of neutral permits to use protective devices to protect the system in case of any ground fault occurs.

5.8 SINGLE PHASE AND THREE PHASE SUPPLY

5.8.1. Single phase supply

In a single phase system, it consists of phase and neutral. The current will flow between them. The cyclical changes in magnitude and direction usually changes flow of current and voltage about 50 cycles per second.

The single-phase AC supply is utilized commonly for domestic purposes. Single phase supply = 230V, 5A and 50 Hz.

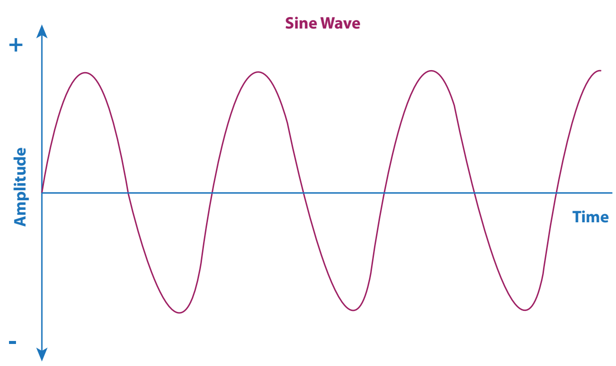


Fig 5.24 Single phase supply

Application of single phase power supply

Single-phase supplies are most commonly used in domestic loads such as lighting, fans, television, refrigerator and heating.

5.8.2. Three phase supply

The three-phase power supply includes four wires which consist of one neutral wire along with three conducting phase wires. The three conductors are away from phases and they have a phase angle of 120° from each other. The voltage of the three phase supply is 415V to 440V

Application of Three phase power supply:

Three phase power supply is used industries for heavy loads.

Points to Remember:

- ✶ Induced EMF e = Blv sinθ
- ✶ Frequency $f = \frac{PN}{120}$ Hz
- ✶ Average value = $\frac{2I_m}{\neq}$ or $\frac{2V_m}{\neq}$
- ✶ R.M.S. value = $\frac{I_m}{\sqrt{2}}$ or $\frac{V_m}{\sqrt{2}}$
- ✶ Form factor = $\frac{\text{RMS value}}{\text{Averagevalue}} = 1.11$
- ✶ Peak factor = $\frac{\text{Max. Value}}{\text{RMS Value}} = 1.414$
- ✶ Power factor= $\frac{V_I \cos\theta}{V_I}$
- ✶ In pure resistance circuit, power factor is one (unity)
- ✶ In pure inductive or capacitive circuit, power factor is zero
- ✶ Inductive reactance $X_L = 2\pi fL$
- ✶ Capacitive reactance $X_C = 1/2\pi f_C$
- ✶ Impedance $Z = \frac{V}{I}$

In RLC series circuit power factor $\cos\theta = \frac{R}{Z}$

Both in RLC series and parallel circuit

- ✶ Power P = VI cosθ watts

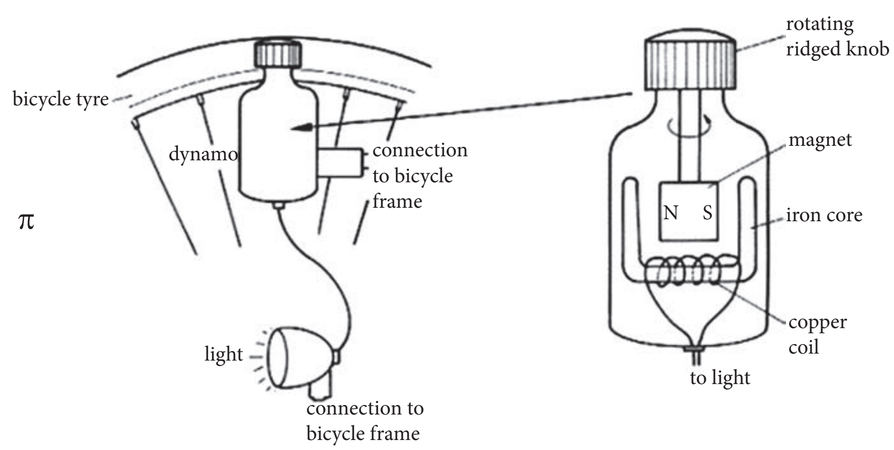
In Star onnection

Phase current = Line current

Activities

1. Practice the following (dynamo) type of voltage generation.

π π



GLOSSARY

AC supply	—	மாறுதிசை மின்சாரம்
Frequency	—	அலைவு வேகம்
Average value	—	சராசரி மதிப்பு
Peak value	—	உச்சமதிப்பு
Time period	—	கால அளவு
Instantaneous value	—	கன மதிப்பு
Effective value	—	பயன் மதிப்பு
Form factor	—	வடிவுக்காரணி
Peak factor	—	உச்சக்காரணி
Power factor	—	திறன்காரணி
Voltage sensor	—	மின்னழுத்த உணர்வி
Current sensor	—	மின்னோட்ட உணர்வி

Q A

PART A

Mark 1

Choose the correct answer:

1. The unit of the frequency is
   a) Henry
   b) Hertz
   c) Cycles
   d) Ampere

2. The value of form factor is
   a) $2/\pi$ b) $\pi/2$
   c) 1.414 d) 1.11

3. In connected with the value of power factor, which is incorrect?
   a) Unity
   b) 0.8 leading
   c) 0.8 lagging
   d) 1.5

4. Power factor of pure resistive circuit is
   a) unity
   b) leading
   c) lagging
   d) less than one

5. The power factor of pure Inductive circuit, with respect to current is
   a) unity
   b) leading
   c) lagging
   d) Too much

6. Power factor of pure capacitive circuit, with respect to current is
   a) unity
   b) leading
   c) lagging
   d) Too much

7. The unity of Inductance is
   a) Henry
   b) Hertz
   c) Farad
   d) Ohm

8. The unit of capacitance is
   a) Henry
   b) Hertz
   c) Farad
   d) Ohm

9. What is the letter represents resistance?
   a) R b) C
   c) W d) V

10. The unit of the resistance is ____________
    a) volt b) ampere
    c) watts d) ohm

11. The resistance value is measured by ________
    a) ohm meter
    b) volt meter
    c) watt meter
    d) frequency meter

12. A variable resistor value is
    a) adjustable
    b) not adjustable
    c) fixed
    d) constant

13. How many types the electrical element consists of?
    a) Two
    b) Three
    c) Four
    d) one

14. When a diode is reverse-biased, it acts as
    a) conductor
    b) insulator
    c) biasing
    d) semi conductor

15. The unit of the flux density is
    a) Ampere
    b) Volt
    c) Weber
    d) Weber/m^2

16. In the value of power factor, which one is incorrect?
    a) Unity
    b) 0.8 leading
    c) 0.8 lagging
    d) 1.512

17. Power factor of pure resistive circuit is
    a) Unity
    b) Leading
    c) lagging
    d) greter than one

18. The unity of Inductance is
    a) Henry
    b) Hertz
    c) Farad
    d) Ohm

19. The unit of Impedance
    a) Henry
    b) Hertz
    c) Farad
    d) Ohm

Q A

PART B

Mark 3

Answer the questions in brief

1. State active components.
2. What is called electrical inductance?
3. Define the term transistor.
4. Write down the advantages of IC.
5. What are the applications of IC?
6. Define 'cycle' in an alternating current.
7. Define the form factor.
8. Define the peak factor
9. What are the uses of capacitor?
10. What is called phase sequence?

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Draw a diagram of a series and parallel inductor circuit.
2. Explain AC circuit with resistance only.
3. Explain AC circuit with Inductance only.
4. What are the advantages of Star connection system?
5. Tabulate the advantages and disadvantages of IC.
6. What are the advantages of a three-phase power system?

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain RLC series electrical circuits with a diagram.
2. Explain the three phase star connection with a neat diagram.
3. Explain the three phase delta connection with a neat diagram.

Reference book

1. 'A text book of Electrical Technology' Volume I, by B.L. Theraja and A.K. Theraja, S. Chand & Company Ltd.

Internet resource

www.allaboutcircuits.com

LESSON 6

Transformer

P98FV

LEARNING OBJECTIVES

The main objective of learning this lesson is to know in detail about Transformer, its construction, types, operation, emf equation, losses, testing method, protective devices of transformer, which are existing under new technique.

Table of Content

6.1 Transformer - Introduction
6.2 Construction and types of transformer core
6.3 Working principle of a transformer
6.4 EMF equation of a transformer
6.5 Types of instrument transformer
6.6 Losses in a transformer
6.7 Testing methods of a transformer
6.8 Protective devices of transformer

6.1 TRANSFORMER-INTRODUCTION

A Transformer is a static device which transfers electrical energy from one circuit to another circuit without changing voltage and frequency. It works on the principle of mutual induction. The transformer works only on AC supply.

Generating stations generate electricity at a voltage of 11KV. The electric power from the generating station is to be brought to the consumers end from 33KV, 66KV etc through various transmission stages.The transformer is used to step down (or) step up the voltage required according to the requirement.

6.2 CONSTRUCTION AND TYPES OF TRANSFORMER CORE

Based on the construction, it is classified into 3 types. They are:

i) Core type

ii) Shell type and

iii) Berry type

6.2.1 Core type

The winding surrounds the core is called core type transformer. The fig. 6.1 represents the core type.

The magnetic circuit is made up of laminated iron core. Silicon steels are used to reduce the hysteresis loss in the iron core. Laminated sheets are insulated from by a layer of varnish for insulation.

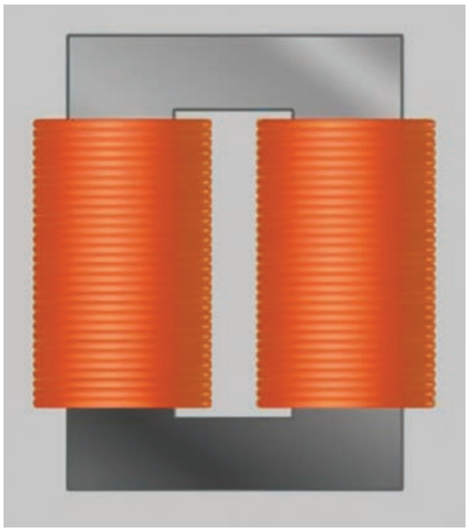


Fig 6.1 *Core type construction*

Advantages

i) Easily handled and maintained.

ii) The coils are in the outside, so it gets cooled easily.

Disadvantages

i) High magnetic loss.

ii) High leakage flux.

6.2.2 Shell type

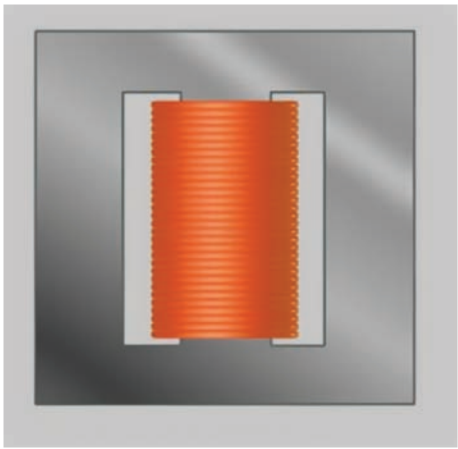


Fig 6.2 *Shell type transformer*

The core surrounds the winding is known as shell type transformer. The fig. 6.2 represents the shell type.

The primary and secondary windings are placed on the central limb one above the other. This gives a better magnetic coupling.

Advantages

i) More economical for low voltage.

ii) Low current at the time of no load.

Disadvantages

i) Little complicated to make winding.

ii) Less cooling.

6.2.3 Berry type

Berry type is similar to shell type. In berry type magnetic path is placed around the coil. Normally this type is not used.

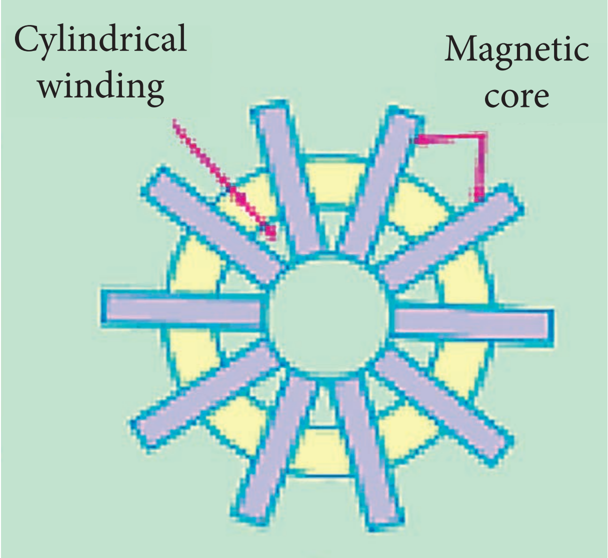


Fig 6.3 *Berry type transformer*

6.2.4 Comparison of core and shell type transformer

Core type transformer	Shell type transformer
1. The winding encircles the core.	The core encircles most part of the winding.
2. It has single magnetic circuit.	It has double magnetic circuit.
3. The cylindrical coils are used.	The multilayer disc (or) sandwichs type of coils are used.
4. The coils can be easily removed for maintenance.	The coils cannot be removed easily.

6.3 WORKING PRINCIPLE OF A TRANSFORMER

Transformer consists of two inductive coils which are electrically separated but magnetically coupled to a core as shown in fig. 6.4. It operates on the principle of mutual induction between two (or) more inductively coupled coils. If the coil is connected to a AC source, an alternating flux is setup. Most of the flux is linked with the other coil. This flux is called mutual flux.

As per Faraday's laws of electromagnetic induction, an emf is induced in the second coil. The first coil which is connected to AC supply is called as primary winding. The second coil is connected to the load is called as secondary winding.

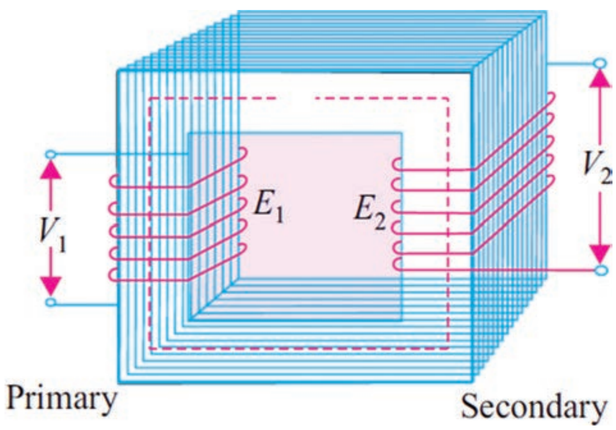


Fig 6.4 *Construction of an ideal transformer*

6.3.1 Step up/ step down transformer

step up transformer – If the output voltage in secondary winding is higher than the input voltage, it is called step up transformer as in fig. 6.5.

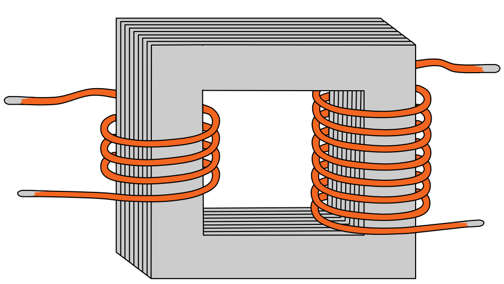


Fig 6.5 *Step-up transformer*

Step down transformer – If the output voltage in the secondary winding is lesser than the input voltage, it is called step down transformer as in fig. 6.6.

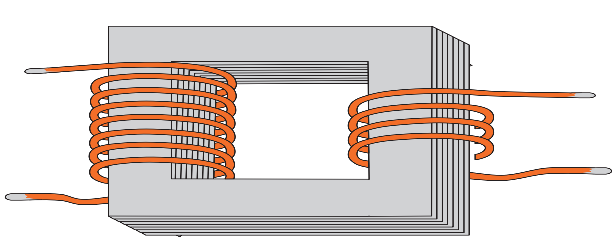


Fig 6.6 *Step-down transformer*

6.3.2 Advantages of transformers

i. The transformer is a static machinery. Hence there is no wear and tear and no friction losses in it.

ii. Maintenance cost is low.

iii. As there is no rotating part in it, extra high voltage can be transferred easily by providing a good insulation to its winding.

6.4 E.M.F EQUATION OF A TRANSFORMER

a) Construction

b) Wave form

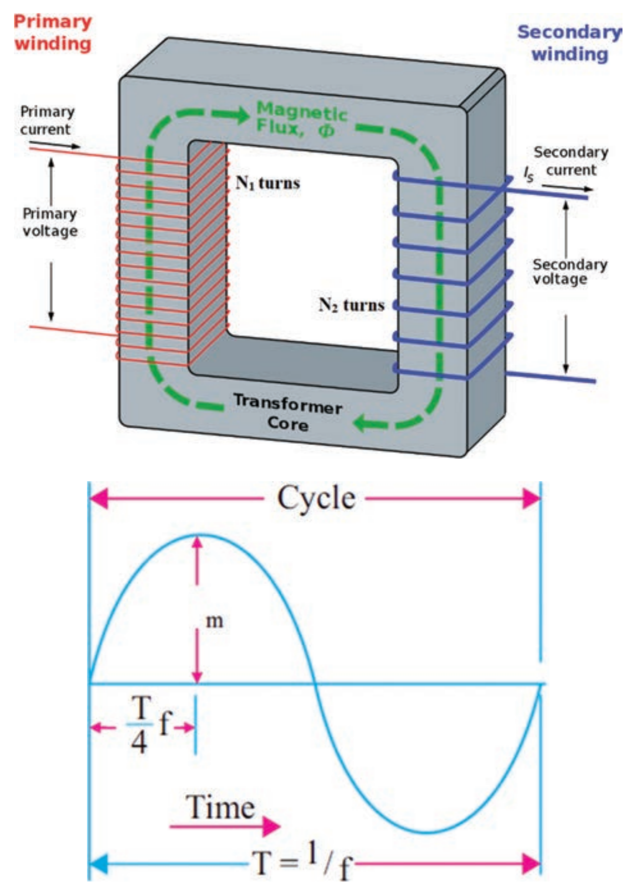


Fig 6.7 *Single phase transformer and wave form*

No. of turns in primary winding = N_1

No. of turns in secondary winding = N_2

Maximum value of flux = ϕ_m webers

Frequency of AC input = f in Hz

The flux in the core will vary sinusoidally as shown in the above fig 6.8.

The flux in the core increases from zero to a maximum value in one quarter cycle (1/4f second)

i.e, Average rate of change of flux $= \frac{Øm}{\frac{1}{4f}} = 4fØm$

i.e average EMF induced per turn = 4f ϕ_m volts.

The flux varies sinusoidally. Hence the, RMS value of induced voltage is obtained by multiplying the average value by form factor which is equal to 1.11 for a sine wave.

i.e, RMS value of induced EMF per turn= 1.11 × 4f ϕm volts.

= 4.44 f Φm volts.

The primary/secondary windings have N_1/N_2 turns respectively,

RMS value of induced emf in primary E_1=4.44 f ϕm N_1 volts
RMS value of induced emf in secondary E_2= 4.44 f ϕm N_2 volts

6.4.1 Voltage transformation ratio (k)

The ratio of secondary voltage to primary voltage is called voltage transformation ratio. It is represented by 'k'.

$$\frac{E_2}{E_1} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = k$$

6.4.2 Current ratio

By neglecting the losses

Input volt × ampere = output volt × ampere

$$V_1 I_1 = V_2 I_2 \quad \text{or} \quad \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$$\frac{I_2}{I_1} = \frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{1}{K}$$

6.4.3 Application of a transformer

- It is used to step up or step down the voltages and currents in an electrical circuit.
- Used in modern electrical transmission and distribution systems.
- It boost voltage levels so as to decrease line losses during transmission.

6.5 TYPES OF INSTRUMENT TRANSFORMER

6.5.1 Potential transformer

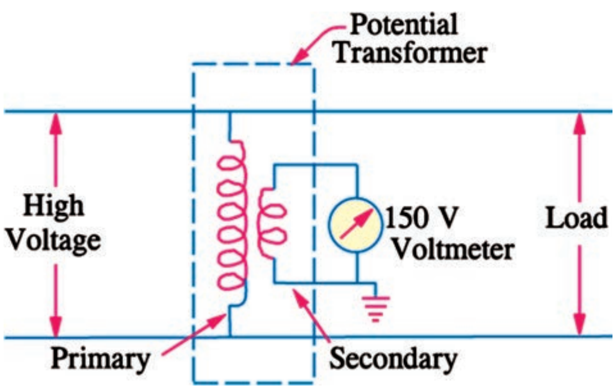


Fig 6.8 *Potential transformers*

Potential transformer do not differ much from the ordinary two winding transformer as shown in fig. 6.8. Hence it is called step down transformers. The primary winding is connected directly across the power circuit. The secondary is usually rated for 110 (or) 220 volts. Voltage ratio is depenting upon primary voltage .

6.5.2 Current transformer

The current transformer has a primary coil of only few turns of thick wire connected in series with the line whose current is to be measured. The secondary coil consisting large number of turns is connected to the terminals of a low range ammeter as in fig. 6.9. Mostly the secondaries of all CT are made wound for 5 amperes.

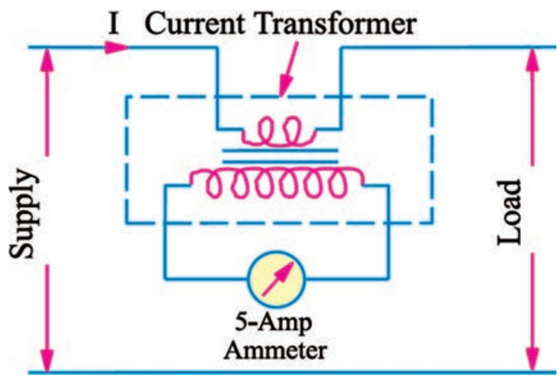


Fig 6.9 *Current transformers*

6.5.3 Auto transformer (VARIAC)

An auto transformer is a single winding transformer which is used to get varying AC voltage. Consider a single winding BA of N_1 turns wound on an iron core as shown in fig. 6.10. The core loss, copper loss, magnetizing current and leakage reactance are negligible. If this winding is connected to an AC voltage V1, a flux will set up in the core and emf E1 will be induced in the winding. Such induced e.m.f is taken by tapping at point C. There are N2 turns between B and C, an e.m.f E2 is induced B and C.

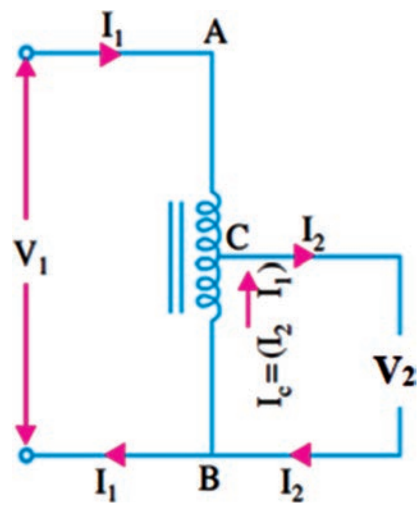


Fig 6.10 *Auto transformer*

When load is connected across the terminals B and C a current I2 flows. The m.m.f due to I2 will be balanced by m.m.f due to I1. This arrangement is referred as an Auto transformer. If point C is sliding contact, a continuously variable output voltage can be made available.

So,

$$\frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1} = K$$

Advantages

1. Copper required is very less.
2. The efficiency is higher.
3. Required less conducting material and hence cost is less.
4. More smooth and continuous variation of voltage.

Disadvantages

1. Direct link between high voltage and low voltage sides there is no isolation as in the case of a two winding transformer.
2. The short circuit current is greater than that of a two winding transformer.

6.5.4 Applications of Auto transformer

1. As a booster of supply voltage to a small extent.
2. Auto transformers are used to start an induction motor.
3. It can be used to vary the voltage to the load, smoothly from zero to the rated voltage.

6.6 LOSSES IN A TRANSFORMER

The losses in a transformer consists of I^2R loss (or) copper loss and iron loss (or) core loss.

I^2R loss (or) Copper loss

These losses occur in primary and secondary windings. Copper loss in a transformer is a variable loss. It varies as the square of the load current (From short circuit test this can be determined).

Iron loss (or) Core loss

Iron loss consists of hysteresis and eddy current losses. They occur in the transformer core due to the alternating flux (from open circuit test, this can be determined.)

Hysteresis loss

When the iron core is subjected to an alternating flux hysteresis loss takes place.

Eddy current loss

Eddy current is induced in the cores. This loss is due to the flow of eddy current. Thin laminations are used to reduce the eddy current loss.

6.6.1 Efficiency of a transformer

The efficiency of a transformer is the ratio of output power to input power.

Input = output + losses

$$\% \text{ Efficiency } (\eta) = \frac{\text{output power}}{\text{input power}} \times 100$$

$$= \frac{\text{output power}}{\text{output power + losses}} \times 100$$

(iron loss + copper loss)

$$= \frac{\text{input power} - \text{losses}}{\text{input power}} \times 100$$

6.6.2 Why transformer rating in KVA?

Already know that copper loss of a transformer depends on current and iron loss equal to voltage. Hence total transformer losses depends on volt ampere (VA) and not on phase angle between voltage and current i.e, it is independent of load power factor. Therefore the rating of transformer is in KVA.

6.6.3 Why transformer does not work on DC supply?

The transformer works on the principle of mutual induction, for which current in one coil change uniformly. If DC supply is given, the current will not change due to constant supply and transformer will not work. This makes the coil burns due to extra heat generated and may cause permanent damage to the transformer. Thus DC supply should not be connected to the transformer.

6.7 TESTING METHODS OF A TRANSFORMER

There are two tests performed on a transformer to determine the power. They are:

1. Open circuit test
2. Short circuit test

These two tests are used for finding out the power loss occurring in the transformer.

6.7.1 Open circuit test on transformer

The open circuit test on transformer is used to determine core losses in transformer.

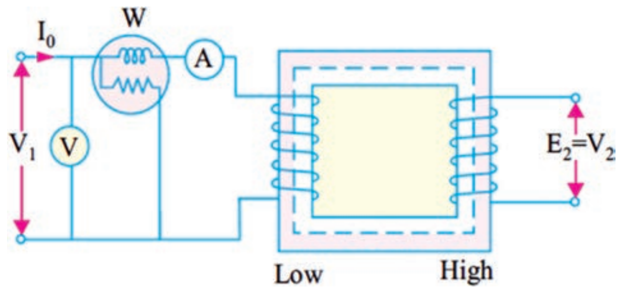


Fig 6.11 *Open circuit test*

The connection diagram for open circuit test on transformer is shown in fig. 6.11. A voltmeter, wattmeter, and an ammeter are connected in primary side of the transformer. The voltage at rated frequency is applied to the primary side with the help of a variac (or) variable ratio auto transformer.

The secondary side of the transformer is kept open. Now with the help of variac, applied voltage gets slowly increased until the voltmeter gives reading equal to the rated voltage of the primary side. After reaching at rated primary side voltage, all three instrument readings (voltmeter, ammeter and wattmeter readings) are recorded.

The ammeter reading gives no load current (I_o) being secondary is open the transformer draws very less current. Hence copper loss are negligible. As no load current (I_o) is quite small compared to rated current of the transformer, the voltage drop due to this current that can be taken as negligible. As the transformer is open circuited, there is no output. Hence the input power consist of core losses and copper loss in transformer during no load condition.

6.7.2 Short circuit test on transformer

The short circuit test on transformer is used to determine copper loss in a transformer.

The connection diagram for short circuit test on transformer is shown in fig. 6.12. A voltmeter, wattmeter, and an ammeter are connected in primary side of the transformer as shown below. A reduced voltage at rated frequency is applied to the primary side with the help of a variac of variable ratio of auto transformer.

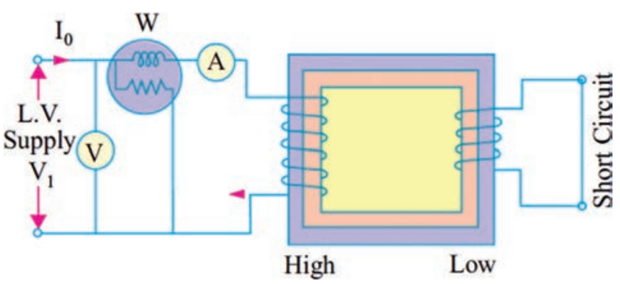


Fig 6.12 *Short circuit test*

The secondary side of the transformer is short circuited. Now with the help of variac applied voltage is slowly increased until the ammeter gives reading equal to the rated current in the primary side. Then three instruments reading (voltmeter, ammeter and watt-meter) are recorded. The voltmeter reading is very small compared to the rated primary voltage of the transformer. Here the core losses in transformer can be taken as negligible.

Let the, voltmeter reading is V1. The input power during test is indicated in wattmeter. As the transformer is short circuited, there is no output, hence the input power consist of copper loss in the transformer.

6.8 PROTECTIVE DEVICES OF TRANSFORMER

The following are the protective devices in transformer and are explained below:

a) Conservator
b) Breather
c) Explosion vent
d) Buchholz relay
e) Transformer oil

Fig 6.13 *Protective devices of transformer*

a) Conservator

Transformer oil losses its insulating properties and is oxidised when it is in contact with the atmosphere. For this reason, the oil must not come in direct contact with the air outside. Conservators or oil expansion chambers are provided to prevent this absorption.

The conservator is cylindrical vessel. It is fitted on the top of the tank. The tank is entirely filled up with oil. The conservator is filled with oil partially (about 50%). The transformer oil gets heated due to the losses in a transformer. The volume increases due to heat and the level of oil in conservator increases. Air is expelled from the conservator through the breather. When the coil cools down, the volume decreases and the level of the oil in the conservator comes down.

This is referred to a "breathing". The oil surface in the conservator is only exposed to oxidation. The sludge is thus confined to the oil surface in the conservator. If there is no conservator the sludge will stick to the cooling tubes. This will spoil the cooling effort.

b) Breather

The breather is a small vessel. It is connected between conservator and air outlet. It contains silica-gel. It is a dehydrating agent. The moisture in the incoming air is removed. The colour of the silica-gel is **blue** when wet and **pink** when damp.

c) Explosion vent

In the event of an accidental internal short circuit in the transformer, an arc is formed between the turns of the winding. Heat is produced by the arc. Due to this, a large volume of gas is produced. Provision must be made for rapid release of gas. Otherwise high pressure will be built up inside leading to the lip of the tank blown off. For this reason an

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explosion vent is provided on the tap of the tank. Under normal conditions air is not allowed to come in contact with the oil. Under short circuit conditions, it is ruptured due to high pressure. The gas is expelled to atmosphere. If the high pressure gas releasing a portion of the hot oil may get splashed and cause injury to the workers in the transformer yard.

The explosion vent's mouth is covered by a glass or aluminium.

d) Buchholz relay

This is a device which is attached to an oil immersed transformer. It is fitted in the pipe connecting the transformer tank with the conservator.

It consists of two floats as shown in Fig. 6.14.

Two pairs of electrical contacts are provided. These contacts may get short circuited under certain situations.

When an insulation breaks down in a transformer, gas is generated in the oil. Quick generation of this gas leads to a serious fault. The gas rushes through the pipe and pushes the lower float to the right. The two lower contacts bridge together and closes to trip the circuit of circuit breaker. Now the transformer is disconnected from the supply. If the fault develops slowly, gas will also generated slow. This may not be sufficient to move the lower float. This gas gets collected gradually in the top of the relay chamber. The oil level gets lowered. This causes the upper float to sink. It finally closes the second pair of contacts. This trips the circuit breaker or it makes ring an alarm bell for caution. A fault can thus be detected and the transformer is disconnected from the circuit.

e) Transformer oil

Transformer oil is a mineral oil. It is obtained by refining crude petroleum. It is a good insulator. Its tendency to form, a sludge is very much less. The dielectric strength of oil is affected to a great extent by the presence of moisture. So it should be kept dry. Transformer oil serves two functions,

1. Cooling
2. Insulation

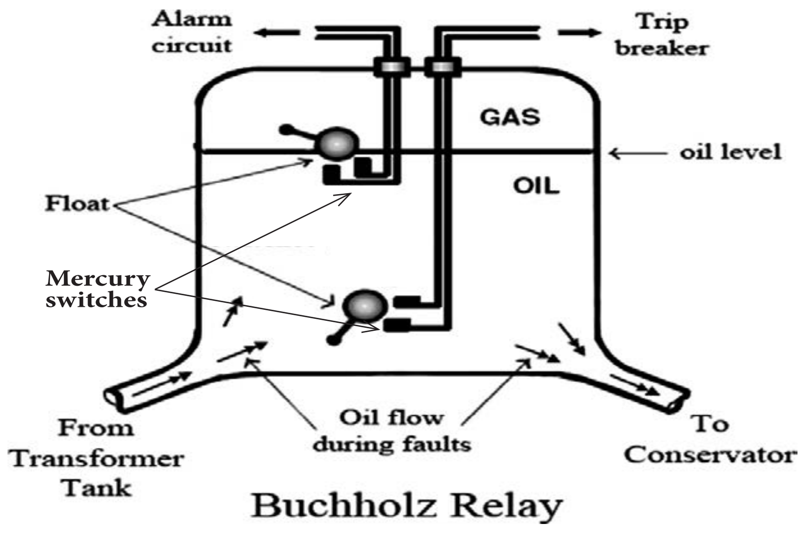


Fig 6.14 *Buchholz relay*

Points to remember:

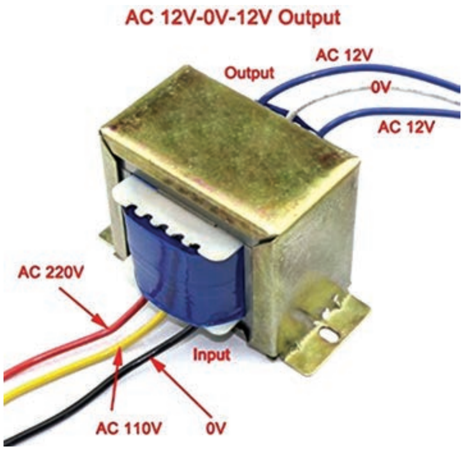
1. Transfer electrical energy from one circuit to another circuit.
2. It works without changing the frequency.
3. Transformer works on the principle of mutual induction.
4. Transformer works on AC supply only, not in DC.
5. E. M. F induced in primary winding = $(E_1) = 4.44\ N_1\ f\varnothing_m$ Volts.
6. E. M. F induced in secondary winding = $(E_2) = 4.44\ N_2\ f\varnothing_m$ Volts.
7. $$\%\ \text{Efficiency}\ (\eta) = \frac{\text{output power}}{\text{input power}} \times 100$$
8. Voltage transformation ratio (K)
$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = k = \frac{V_2}{V_1} = \frac{I_1}{I_2}$$

GLOSSARY

Transformer	–	மின்மாற்றி
Step-up transformer	–	உயர்வழுத்த மின்மாற்றி
Step-down transformer	–	குறைவழுத்த மின்மாற்றி

Activities

1. Measure the output voltage of given transformer below.
2. Construct 6V transformer with centre tapping connection.
3. Calculate the losses occuring in the transformers by OC and SC tests.



QA

PART A

Mark 1

3QFAH

Choose the correct answer:

1. The transformer may represent as
   a) rotating device
   b) electronic device
   c) static device
   d) computing device
2. Transformer operates on the principle of
   a) self induction
   b) mutual induction
   c) ohm's law
   d) len's law
3. To find the RMS value of transformer, EMF is to be multiply with
   a) 2.22 b) 1.12
   c) 1.11 d) 1.14
4. Transformer core is laminated to reduce the
   a) copper loss
   b) eddy current loss
   c) wintage loss
   d) hysteresis loss
5. Transformer oil serves the function of
   a) lubrication
   b) insulation and cooling
   c) only insulation
   d) only cooling
6. Silicon steel sheets are used to reduce the
   a) Frictional loss
   b) Mechanical loss
   c) Hysteresis loss
   d) Eddy current loss
7. The transformer will work on
   a)AC only c) Both AC & DC
   b) DC only d) UPS
8. The iron core is used to …… of the transformer,
   a) increase the weight
   b) provide tight magnetic coupling
   c) reduce core losses
   d) increase copper loss
9. The primary and secondary of a transformer are ….. coupled
   a) electrically
   b) magnetically
   c) electrically and magnetically
   d) thermo
10. Conservator is a
    a) main tank of transformer
    b) protective device of transformer
    c) earthing system of transformer
    d) cooling device
11. The purpose of conducting open circuit test (OC) is to determine
    a) eddy current loss
    b) core loss
    c) hysteresis loss
    d) copper loss

PART B

Mark 3

Answer the following questions in briefly:

1. What is called a transformer?
2. What is meant by step up transformer?
3. What is meant by step down transformer?
4. What are the advantages of a transformer?
5. What is the voltage transformation ratio of a transformer?
6. Mention the advantages of core type transformer.
7. Write down the types of instrument transformer.
8. Write down the applications of auto transformer.
9. What are the protective devices of transformer?
10. Why transformer is rating in KVA?
11. Define efficiency of a transformer.
12. What are the type of transformer according to cooling method?

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain the construction of shell type transformer.
2. Explain why transformer does not works on DC supply.
3. Compare core and shell type transformer.
4. Explain about auto transformer.
5. Explain the losses occuring in a transformer.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Draw and explain the construction and working principle of a transformer.
2. Derive the EMF equation of a transformer.
3. Draw and explain the working principle of potential and current transformer.
4. Draw and explain the various tests conducted in a transformer

Reference book

1. 'A text book of Electrical Technology' Volume II and Volume III by B.L. Theraja and A.K. Theraja, S. Chand & Company Ltd.

Internet resource

https://en.wikipedia.org/wiki/Transformer

LESSON 7

Electric Heating Appliances

9HPLM

LEARNING OBJECTIVES

Electric heating is a process in which electrical energy is converted into heat energy. It is essential for the students to know, how the electrical energy is being utilized in heating appliances. The main objective of this chapter is to make students, to understand the working of various heating appliances through the types of conductive methods.

Furthermore, this lesson also aims to aid the students, to gain practical experience about defects, their reasons and its corrective measures of the heating appliances.

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7.1 Introduction
7.2 Electric iron box
7.3 Induction stove
7.4 Bread toaster
7.5 Microwave oven
7.6 Coffee percolator
7.7 Geyser
7.8 Energy consumption of appliances

7.1 INTRODUCTION

Electricity plays major role in our everyday life. One of the main application of electricity is to produce heat from heating elements. In this chapter, we shall learn about the types of heaters and its working procedure such as Electric iron box, Induction stove, Bread toaster, Coffee percolator and Electric geyser.

7.2 ELECTRIC IRON BOX

An Electric iron box is an appliance used to remove the wrinkles in the clothes when heated. It is of three types.

i) Non-Automatic or Ordinary type iron box
ii) Automatic iron box
iii) Steam automatic iron box

a) Clothes and its temperature

The operating temperature of the iron box for different type of cloth is tabulated below

Nylon - 70°C -90° C

Rayon - 100°C - 120°C

Silk - 130°C - 150°C

Wool - 160°C - 180°C

Cotton - 200°C - 220°C

Linen -230°C - 260°C

According to the range of heat required to clothes, the thermostat can be fixed and the wrinkles were removed from the washed clothes.

b) Power cord

The electric conductor that permits electric supply to an electric appliance will contain three terminals such as Phase (Red color), Neutral (Black color) and Earth (Green). The electrical conductors coiled with cotton threads are the most commonly used power cords.

7.2.1 Non-automatic or ordinary type iron box

As shown in fig. 7.1 the non-automatic or ordinary type iron box is an appliance, where we control the heat of the appliance by simply putting the switch 'ON' and 'OFF' only according to the types of cloth used.

Fig 7.1 *Non-automatic iron box*

The main parts of the iron box are listed below

a) Handle

Handle is made up of Bakelite a hard type of plastic in the iron box. Bakelite is having resistive power of heat and non-conductor of electricity. A rubber tube is provided at the top of the handle, to avoid the damage of power cord while in use.

b) Top cover

Top cover is at the top of the appliance and it covers all the inner parts of the appliance. It is made of metal which is chromium plated to look attractive.

c) Stand

Stand is made up of strong iron to make the appliance to keep stand when not in use.

d) Pressure plate

Pressure plate is made up of hard cast iron and it gives weight to the appliance. Due to this, the wrinkles in the clothes are removed.

e) Mica sheet

Mica is an insulator of electricity. It is kept top and bottom of the heating element for safety purpose. Mica is also good to resist the heat.

f) Heating element

The heating element of the iron box is made from mixed alloy of Nichrome. Usually, in all the heating appliances, it is used as heating element. The heating element here used is of ribbon type.

Heating element is of two types.
1. Coiled type and
2. Ribbon type.

g) Sole plate

Sole plate is plated with chromium and made up of cast iron. The bottom of the sole plate is surface grained for smoothness.

Working principle

The power cord of the iron box is connected to the main supply. The electric energy is converted into heat with this heating element. The heating element is having the property of high resistivity. According to the law of conservation of energy the heat energy produced is proportional to the square of current without any loss. This heat energy makes the sole plate to get hot and with that the wrinkles in the clothes are removed.

In this type of iron box, according to the type of clothes, the heat can be controlled manually, by connecting or disconnecting the supply through switch.

7.2.2 Automatic iron box

In an automatic iron box, the temperature of the clothes can be selected to the required quantity of heat. The temperature is controlled by the thermostat in the appliance automatically. Hence this appliance is called as Automatic iron box.

Fig 7.2 *Electric Automatic iron box*

a) Construction

As shown in fig. 7.2, the construction and operation of automatic iron box is similar to that of an ordinary iron box. In an automatic iron box, the temperature is controlled with the help of thermostat. The Thermostat is a bi-metallic strip. In addition to this, an indicating lamp is connected in series with the heating element. This shows the availability of supply in the appliance.

b) Indicating lamp

In the iron box LED lamp is used as an indicating lamp. Indicating lamp is provided to know whether the supply is in the appliance or not. During the time of supply only, the indicating lamp will glow. After attaining the fixed level in the regulating knob (or) selector knob the indicating lamp turns off automatically.

c) Thermostat

Thermostat is a bi-metallic strip made up two different metals. Generally, during heat, the metals get expanded. After setting the required value in the regulating knob, the heat increases gradually and gets saturated. Then the bi-metallic strip will bend automatically and stop the supply to the heating element. This can be viewed in the fig 7.3.

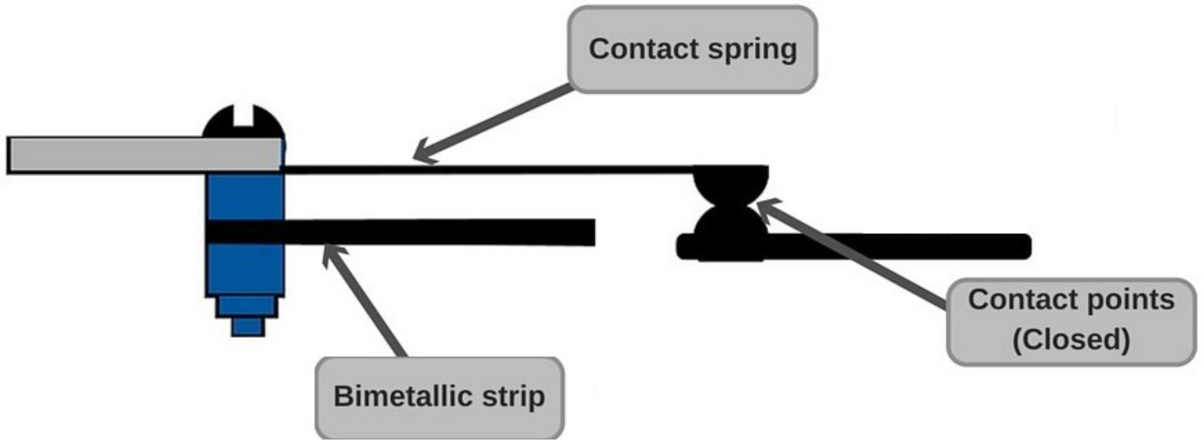

Fig 7.3 *Thermostat in closed position*

After the heat gets reduced in the sole plate, the bi-metallic strip, again contacts with electric supply and makes the appliance to get heated as shown in fig. 7.4. The expansion of the strip will vary, according to the strip which the bi-metal was made.

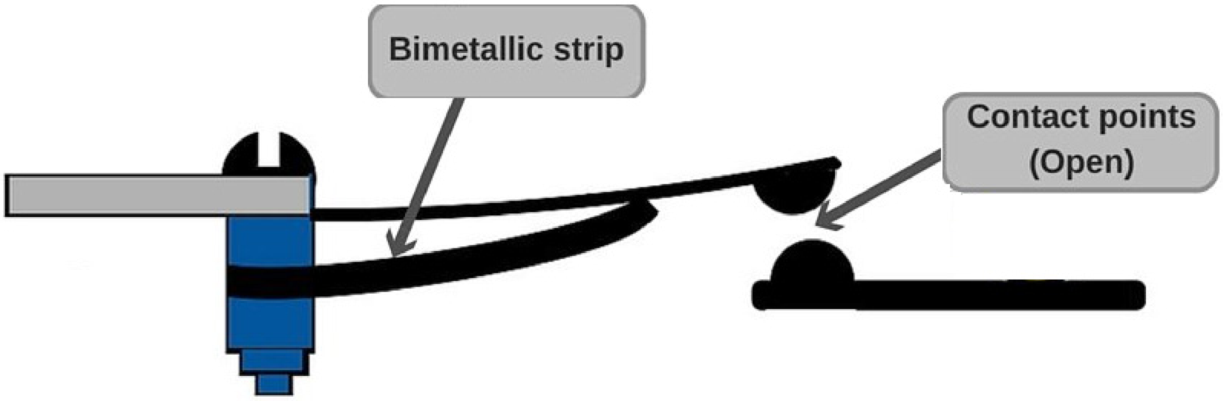

Fig 7.4 *Thermostat in open position*

d) Working principle

The electric input is given to the iron box by putting the switch in ON position. The current goes to the heating element of the iron box through power cord. The heating element gets heated up due to its heat production property. The heat was absorbed by the sole plate and gets heated gradually. This heat removes the wrinkles in the clothes.

7.2.3 Steam iron box

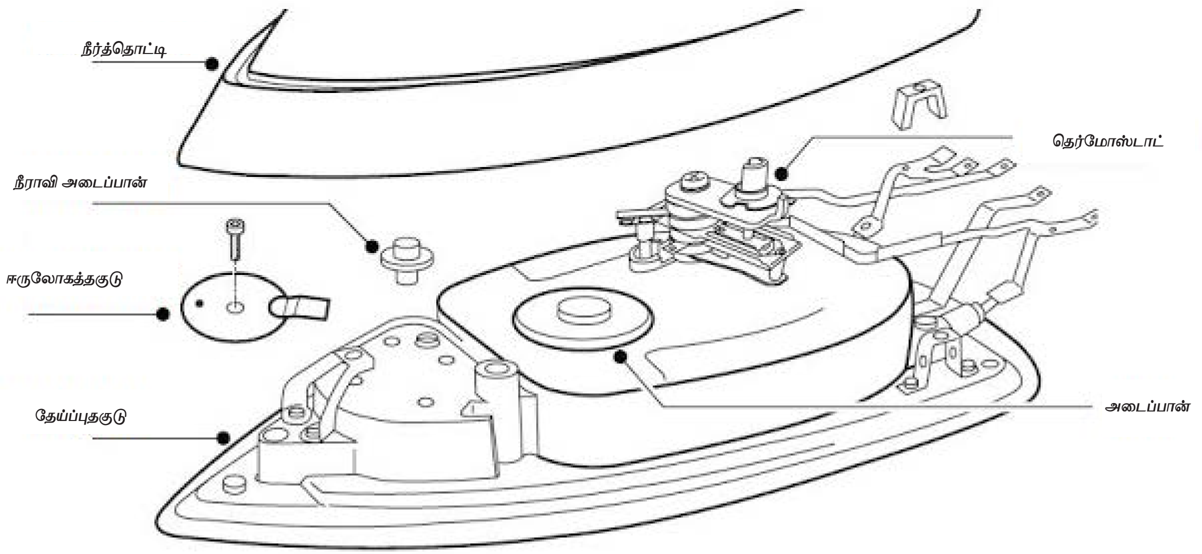

Fig 7.5 *Steam iron box*

The construction and working principle of a steam iron box is similar to that of Automatic iron box. The internal construction is shown in fig. 7.5.

A steam iron is an electric iron A steam iron is an electric iron that produces steam from water. The steam removes the wrinkles in the clothes. It is fitted with thermostat with wattage of around 1000 to 1600 watts. Steam ironing is one of the easiest method to iron the clothes. For the removal of the wrinkles from the clothes and ironing this type is the best. The steam iron requires more duration to get heated when compared with other types.

In this, a small water container is kept above heating element and it supplies water to sole plate through the holes provided in it. The water steam flow is controlled by a press valve kept near the handle. The valve control is provided in handle in order to control the water flow easily. The valve will not allow the water or steam to back side. The water in the tank comes through holes in sole plate in the form of steam. Once the valve gets opened, the steam reaches the cloth and the wrinkles in the cloth will be cleared. The flow of steam upon the position of the knob is kept in it. Any defects in the heating element may cause the unit to be replaced by a new one.

a) Maintenance

1. In steam iron box, distilled water only be used.
2. After the use of iron box, the water in the container should be removed completely with the help of steam control valve.
3. The salt deposits inside the iron box should be cleaned with the help of vinegar. The vinegar is mixed with water and is rinsed inside two or three times to clear the salt depositions in it.

7.2.4 Trouble shoot chart

S.No.	Defects	Reasons	Remedies
1	Iron box not gets heated.	1. No electric supply. 2. Heating element is not connected with supply. 3. Loose connection in heating element.	1. Correct the electric supply. 2. Connect the supply to the heating element properly. 3. Heating element should be connected properly.
2	Heat produced in the iron box is not adequate.	1. Voltage drop. 2. Thermostat knob not fitted properly. 3. Loose connection in thermostat.	1. Correct the voltage. 2. Proper fitting of thermostat knob should be done. 3. Thermostat connection should be done properly
3	Heat produced is exceeding the setting point kept.	1. Short circuit in Thermostat.	1. Short circuit in thermostat is corrected. 2. Emery sheet should be used for cleaning the terminal ends to avoid short circuit.
4	Clothes are sticking in the sole plate while ironing.	1. Abnormal heat produced. Due to that thermostat terminals contact with one another. 2. Bottom of the sole plate is corroded.	1. Terminals of thermostat should be connected correctly. 2. The corrosion in the sole plate should be cleaned by applying non corrosion things.
5	Iron box is getting electric shock.	1. Supply wire may contact with body of the iron box.	1. Connect the supply wire without touching the metal parts of the iron box. 2. Earth connections should be properly checked.

7.3 INDUCTION STOVE

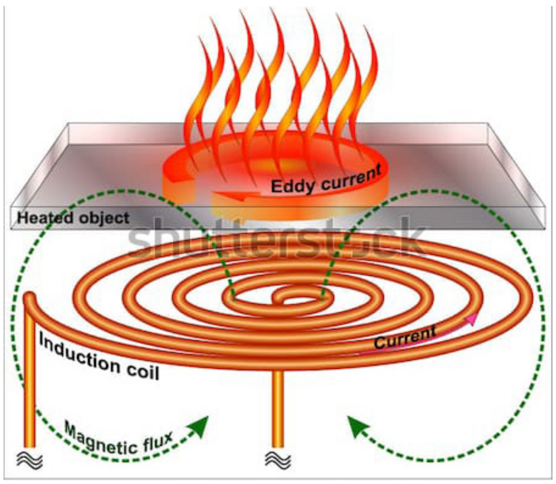

Fig 7.6 *Induction stove*

Induction stove is widely used in places where there is not having LPG gas connection facility. Induction stove is commonly used in hospitals and temporary exhibitions. The construction is shown in the fig. 7.6. This type of stove has no smokes and flames. The utensils kept over the induction will not get much heated. Only the things kept inside the utensil alone gets heated. Now-a-days, these type of stoves are widely used in Asia, Europe and America.

Induction heating is the process of heating an element or appliance electrically by the principle of electro magnetic induction. The heat is generated in this type of stove is by means of the eddy currents produced in the induction coils.

The types of the Induction stove are classified as

a) Single type
b) Dual type and
c) Four type

7.3.1 Construction

Induction stove is made up of non-corrosive stainless steel. Heating element is fixed on the top of the stove, in which utensils were kept. Three pin plugs are used as supply terminal in this stove. Rubber bush is kept at the bottom of the stove for grip. In this, various facilities like child lock safety, timer, temperature indicator and cooking options were included.

7.3.2 Working principle

An alternating supply is made to flow through the resonant coil, which leads to the generation of oscillating magnetic field. The magnetic field induces an electric current inside the cookware. The induction cook top works with cookware made of certain materials which have specific properties. The Induction stove transfers electrical energy by induction from a coil of wire into a metal vessel that must be ferromagnetic. The coil is mounted under the cooking surface, and a high frequency of alternating current is passed through it. The current in the coil creates a dynamic magnetic field. The magnetic field induces whirling electrical eddy currents inside the pan, turns into heat. Heat from the pan flows directly into the food or water kept inside the container, and by conduction method it gets heat.

High production of heat is the specialty of this stove. No heat losses will occur. This type of stove can be used in all climatic condition.

7.3.3 Advantages

i) Function is faster than other types of stoves.
ii) Easy to clean.
iii) Stains produced in this can be easily cleaned with cloth.

iv) Cost is less.

v) No noise occurs while functioning.

vi) Burns or wounds will not be caused when touched.

7.4 BREAD TOASTER

A Bread toaster, or a toast maker, is an electric small appliance designed to toast sliced breads by exposing it to radiant heat, thus converting it into toast. It is portable device and easy to carry.

7.4.1 Types

The most common household toaster is classified as

i) Ordinary type bread toaster, and

ii) Automatic type.

Ordinary type of bread toaster is not used in now-a-days.

7.4.2 Automatic bread toaster

a) Construction

Electric bread toaster looks like a rectangular box and is used for toasting the bread slices as shown in fig. 7.7. In this, two gaps are provided, in which two bread slices are put for toasting. The gap is adequate for bread slices to go inside.

b) Working principle

The bread slices are kept in the place of bread resting container, and put the lever down to make the bread slices to get in. Then close the top of the toaster with lid, and allow the supply to get toasted. After the bread slices gets toasted, the thermostat which is connected in series with electric supply disconnect the supply and pushes the lever up. Now the toasted slices came out with golden colour.

Fig 7.7 *Bread toaster*

Bread toaster contains three heating elements and they are in front, middle and back side of the toaster. The centre heating element is the main element for toasting. A resting thick sheet is kept inside the toaster and is attached with a lever. A Thermostat, the heat control device is connected in series with heating element and to the supply. Three pin power cords are used as supply wire for the appliance. Handle is made of hard plastics which insulates the heat and electric supply. A tray is kept below the toaster, in order to collect the waste particles of bread.

The use of Thermostat is to allow and disconnect the power supply when the toaster is not in use.

7.4.3 Timer switch

Timer switch is a safety switch for the bread toaster. It limits the electric supply and saves electric energy.

7.4.4 Defects, reasons and remedies of electric bread toaster

S.No.	Defects	Reasons	Remedies
1	Supply is given, but the toaster not functioning	1. There may be open circuit or short circuit in the power cord. 2. The supply terminals not connected with heating element.	1. Open circuit or Short circuit in the power cord should be checked before giving the supply. 2. Connect the terminals of the heating element correctly.
2	Getting electric shock while using the toaster	Electric supply terminal is contacting with metal parts of the toaster.	The contact of supply terminal on the metal part should be properly insulated.
3	When switch is 'ON', the fuse gets melted	Short circuit in the toaster.	Short circuit should be identified and gets rectified.

7.5 MICROWAVE OVEN

A microwave oven is an electrical appliance that heats and cooks food by exposing it to electro magnetic radiation. The topics covered are:

1. Introduction
2. Types
3. Components
4. Working principle

1 Introduction

Microwave oven is a home appliances for commonly used cooking a variety of foods and reheating the previously cooked. Microwave oven heats the food with microwaves, which is in a form of electro magnetic wave similar to radio waves.

A magnetron is a device inside the oven produces microwaves. The microwaves reflect the interior of the oven and causes the water molecules in food to vibrate. This vibration results in friction between molecules, which produces heat that cooks the food.

Fig 7.8 *Microwave oven*

2. Types

Three types of microwave oven are:

a. Solo microwave oven
b. Grill microwave oven
c. Convection microwave oven

(a) Solo microwave oven

Fig 7.9 *Solo microwave oven*

The fig 7.9 shows the solo microwave oven. The solo model are the basic used model in micro wave ovens. In this type, the magnetron inside produces micro waves and it can do heating and boiling. It cannot perform the roasting and baking.

(b) Grill microwave oven

Fig 7.10 *Grill microwave oven*

The fig 7.10 shown grill type, the micro wave ovens are provided with heating coils. In this, the oven is heated by coils induce a grilling or roasting process. It creates browning on the surface of the food particle.

(c) Convection microwave oven

Fig 7.11 *Convection microwave oven*

The main parts of convection microwave ovens are a heating element to create heat and to circulate the air within the oven.

3. Components

The main components of the microwave oven are

a. High voltage transformer
b. High voltage capacitor
c. High voltage diode
d. Cavity magnetron
e. Micro controller
f. Wave guide and
g. Cooling fan.

a. High voltage transformer

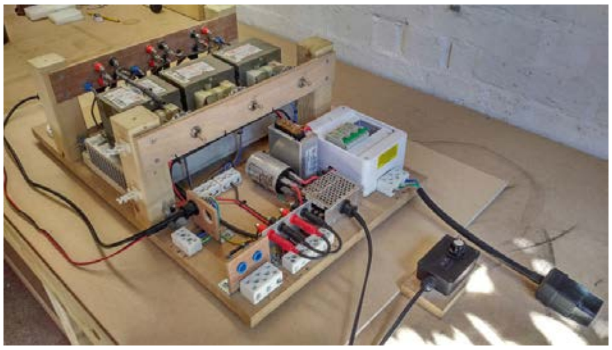

Fig 7.12 *High voltage transformer*

The microwave oven requires more power than the normal voltage taken by the domestic electrical wiring. A step-up transformer with a high-voltage output is placed inside the oven to fulfil this. The input 230 V power source is increased to a high voltage before being fed to the cavity magnetron.

b. High voltage capacitor

High voltage capacitor is connected with the transformer and magnetron through diode. It automatically charged and discharged when required and delivers high energy to the magnetron as shown in fig 7.13

Fig 7.13 *High voltage capacitor*

c. High voltage diode

High voltage diode is used in the microwave oven for protecting them from high voltage.

Fig 7.14 *High voltage diode*

d. Cavity magnetron

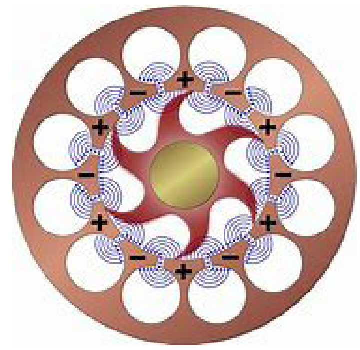

Fig 7.15 *Cavity magnetron*

Another component in a microwave oven is cavity magnetron, which is a high-powered vacuum tube that converts electrical energy into long-range microwave radiations.

e. Microcontroller

Fig 7.16 *Microcontroller*

A microcontroller is a device which allows communication between a user and a machine. It is a controlling unit with one or more processing cores, memory, and programmable input or output peripherals. It processes the user's instructions and displays them on a seven-segment display or an LED screen, depending on the model of the oven.

4. Working principle

Microwave ovens work on the principle of electro magnetic energy converted into thermal energy. Electro magnetic energy refers to the radiation of electro magnetic

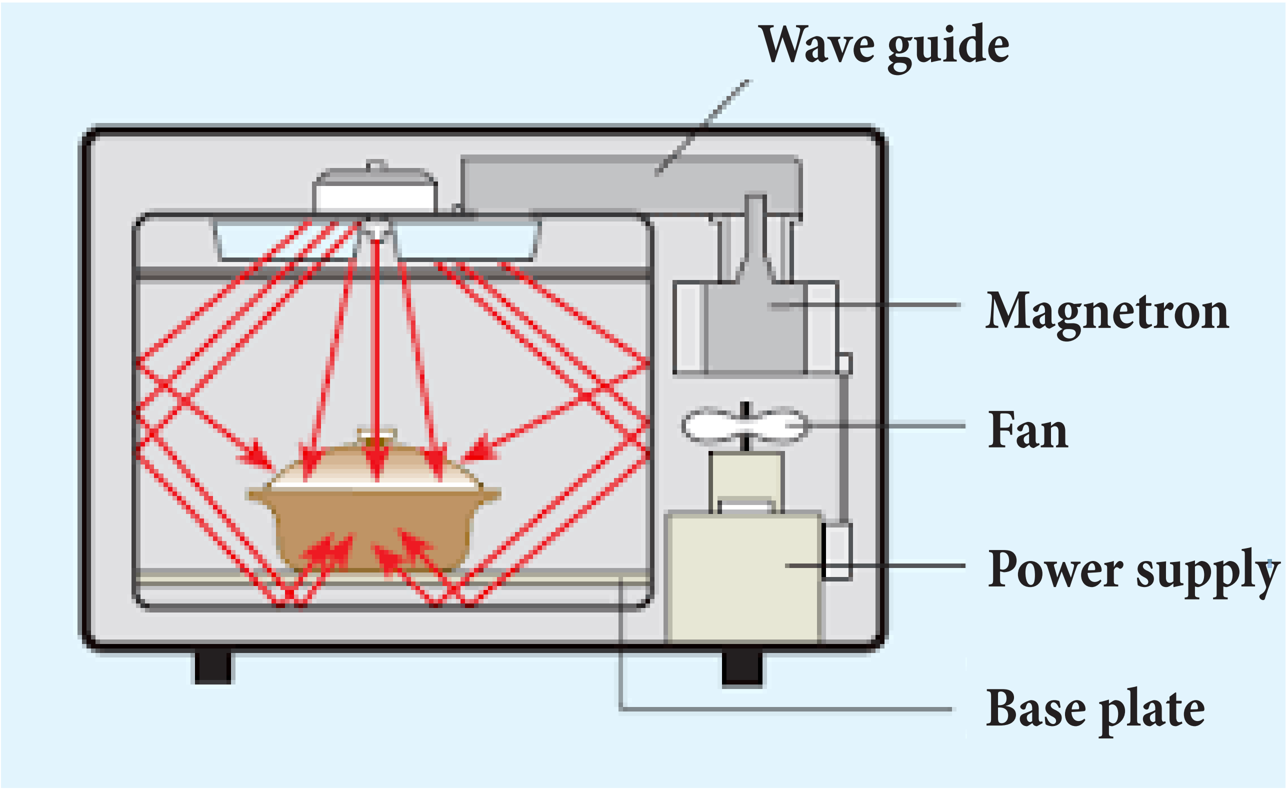

Fig 7.17 *Main parts of microwave oven*

waves comprising an electrical field and magnetic field, oscillating perpendicular to each other. When a polar molecule, falls in the path of electro magnetic radiations, and oscillates to align equally.

Due to molecule friction and collision, energy is lost from the dipole, resulting in heating. The water molecules present inside the food products contact with microwave radiations, by heating the food.

7.5.1 Advantages and disadvantages of microwave oven

Advantages

1. Cooking time is short
2. Destruction of nutrients is less
3. No physical change of foods
4. Melting process is easy

Disadvantages

1. Constraint is there with metal container
2. Heat force control is difficult
3. Water evaporation (Dehydration) occurs
4. Uneven cooking (hot and cold spots) takes place
5. Surface toasting is impossible

7.5.2 Energy rating

The energy efficiency of microwaves does not vary more. A small microwave, rated at 600-800 watts, is generally more energy-efficient than a larger one, rated at 850-1650 watts.

7.5.3 Precautionary steps followed while using microwave oven

1. For all electrical appliances, it is important to follow the instruction specified in the manual for operation with safety precautions.

2. Use microwave safe cookware which has been specially designed.
3. If the door of the oven is opened or bent or broken the appliance wont works.
4. Standing before the oven is not advisable when it is in use.
5. Liquid materials should not be heated over a specified temperature. It will cause condensation and affect the life of the oven.

7.6 COFFEE PERCOLATOR

Water is heated through electric supply, and that hot water is mixed with coffee powder, coffee water is prepared. This appliance is called coffee percolator.

Coffee percolator is divided into two types.

1. Ordinary or Non-automatic type coffee percolator
2. Automatic type coffee percolator

7.6.1 Parts

The main parts of coffee percolator are listed below:

1. Heating element
2. Cylindrical shape body
3. Water container
4. Vertical tube or Percolating tube
5. Coffee basket
6. Top cover
7. Container for coffee water
8. Outlet for coffee water
9. Handle

7.6.2 Construction

Coffee percolator is portable device as shown in fig. 7.18. In this, the coil is made up of Nichrome and is used as heating element. Because of its high resistance in the coil, the electrical energy is converted into heat energy. The appliance is cylindrical in shape and is made up of iron coated with lead. Water is poured into the container. A coffee basket is kept above the vertical tube. In some appliances, the lid is made up of glass. In certain type of coffee percolator, separate chamber for hot water and coffee water are provided. Handle is made up of non-conductive materials like Bakelite, which resists heat produced in it.

7.6.3 Working principle

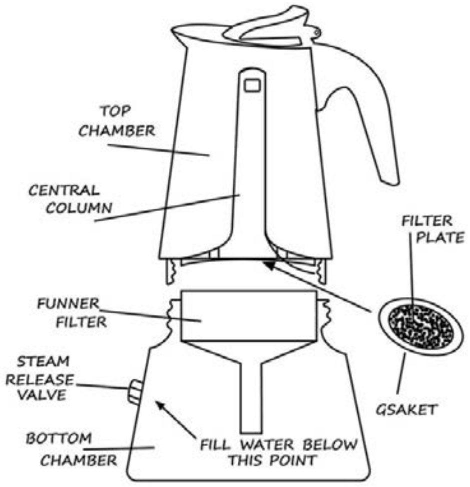

Fig 7.18 *Coffee Percolator*

First the percolator lid is opened, and water is poured inside, through the percolating tube. Coffee powder is poured to the required quantity in the coffee basket and close the lid. If the supply is given, the water in the container gets heated and the steam of the water goes towards percolating tube, and soaks the coffee powder in the basket. Now the essence of coffee water is collected from the bottom of the container through a tap. Any leakage or holes in the tube, this percolator will not function.

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7.7 GEYSER

A geyser is a heating appliance which is used in the places where hot water is required. Normally tubular type of heating element is used in this appliance. Nichrome is the heating element used in all heating appliances. Due to the high resistance in the heating element, the electrical energy is converted into heat energy, and the water gets heated. Thermostat, in the appliance regulates the heat produced in it.

The geyser is available in various rating of 15, 25, 35 and 50 litres and is also available from 1000 to 5000 watts.

7.7.1 Construction

1. Container

Geyser is an appliance used for getting a huge quantity of hot water and is for domestic purposes. It is cylindrical in shape and contains two containers such as

1. Inner container
2. Outer container.

Inner container is made up of brass and is coated with lead to avoid corrosion. Outer container is made of steel coated with paint. In between the inner and outer container a glass wool is used to protect the hot water from the outer atmosphere and moisture. Also, it prevents the hotness from inner container to outer container.

2. Water inlet pipe

The inlet pipe is provided to allow the water to go inside the inner container. A valve is fixed to regulate the flow of water into it.

3. Water outlet pipe

Outlet pipe is the pipe used for collecting the hot water from the geyser. The outlet pipe is bent on the top, in order to collect hot water uniformly.

4. Heating element

Tubular type of heating element is used as a heating element. Nichrome, the mixed alloy, is used as a heating element in all heating appliances.

5. Thermostat

Thermostat is a bi-metallic strip used to control the heat and is connected in series with the heating element to get the determined value of heat fixed in the setting position.

6. Vent pipe

When we want to shift the geyser or replace the heating element, the water in the geyser is to be removed completely. During that time, this vent pipe is used to drain the water inside the container.

7. Pressure release valve

In order to release the pressure inside the geyser from explosion, pressure, release valve is used. Also, it maintains the level of water inside the container.

8. Positive plate

The positive rod itself accepts the corrosion produced and preserves the steel container from corrosion.

Geyser is of two types. They are

i. Non pressure type geyser and
ii. Pressure type geyser

7.7.2 Non pressure type geyser

Non pressure type geyser is used in places where small quantity of hot water is required.

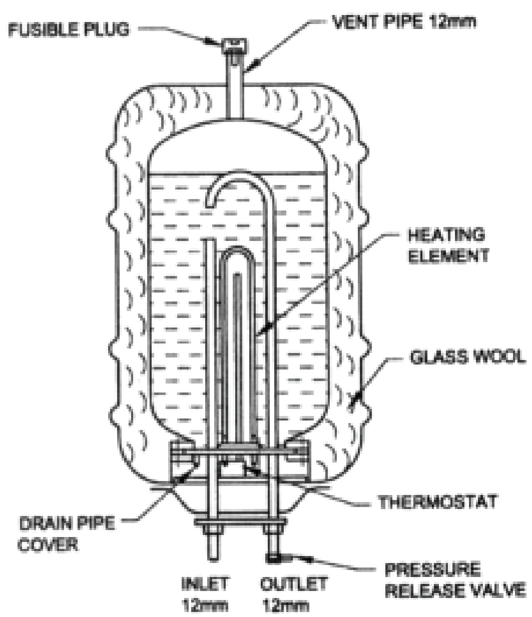


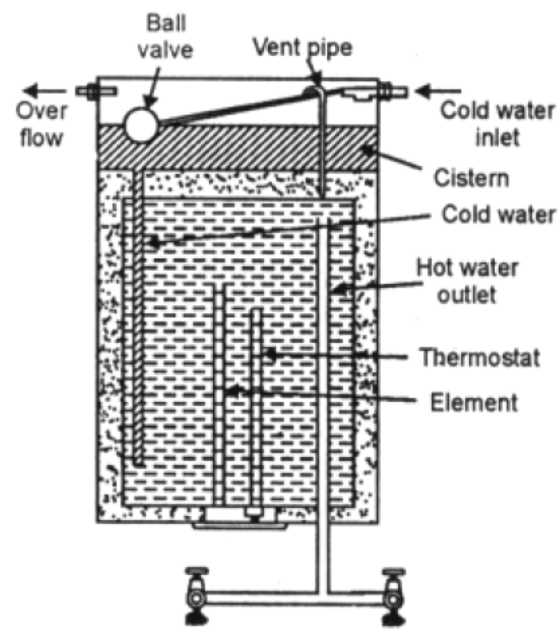
Fig 7.19 *Non pressure type geyser*

a) Working principle

When an electric supply is given to the geyser, the electrical energy makes the heating element to get heated gradually. The conversion of electrical energy into heat energy is due to Nichrome, which is having a very high resistance value. Now the heat conducts water and makes it hot. The setting position of thermostat automatically stops the electrical input in the appliance. After the heat gets reduced, the thermostat immediately connects with electric supply and makes the water again to get heated. The density of hot water is lesser than cold water. Hence the hot water is on the top and cold water in the bottom of the geyser.

7.7.3 Pressure type geyser

For requirement of large quantity of hot water, in a multi-storied building, pressure type of geyser is used. In this type, the water in the appliance is controlled by float valve.



7.20 *Pressure type geyser*

The working principle of this type is similar to that of non-pressure type geyser. In this water pressure is controlled by a floating valve. Being the outlet pressure is high, this type of geyser is used in multi-storied building for getting hot water. This type of geyser is fixed in one place and hot water can be collected in various rooms.

7.8 ENERGY CONSUMPTION OF APPLIANCES

The best way to compare the cost of running different appliances is to look at their energy consumption, which is a measure of how much energy they consume in Watts.

In our house, the consumption of home appliances are given below.

SI No	Advantage	Power	Usage of time	Consumption/ year
1	Iron box	750w – 1000 w	5 hrs/week 48 weeks	260 Kwh
2	Induction stove	1500 w	1.5 hrs/day 365 days	821 kwh
3	Water heater	1000 – 2000 w	30 min/days 240 days	180 Kwh
4	Coffee percolator	500 – 1000 w	10 min/day 335 days	42 Kwh
5	Microwave oven	2000 – 2500 w	1.5 hrs/week 48 weeks	162 Kwh
6	LED television	20 – 60 w 0-3 sleepy mode	4 hrs/day 335 days	54 Kwh 2.2 Kwh (sleepy mode)
7	Washing machine	2500 – 3000 w	4 hrs/week (0.9 Kwh/cycle) 48 weeks	173 Kwh
8	Refrigerator	150 – 200 w	365 days	220 Kwh
9		60 w – 70 w	12 hrs/Day 365 Days	263 Kwh
10	Mixer grinder	750 w	20 min/day 365 days	90 Kwh
11	Wet grinder	150 w	40 min/day 40 weeks	21 Kwh
12	1HP motor pump	746 w	30 min/day 365 days	136 Kwh

GLOSSARY

Pilot lamp — அறிகுறி விளக்கு
Thermostat — வெப்ப நிலைப்பி
Bi-metallic strip — ஈருலோகத் தகடு
Pressure release valve — அழுத்தம் அகற்றும் வால்வு
Induction stove — தூண்டல் அடுப்பு
Geyser — நீர் சூடேற்றும் கலன்

Q A

PART A

T01RC

Mark 1

Choose the correct answer:

1. Which is not connected with heating appliances?
   a. Electric stove
   b. Electric iron box
   c. Room heater
   d. Electric fan

2. In which appliance, a small water tank is kept over the heating element.
   a. Pressure type geyser
   b. Steam iron box
   c.Coffee percolator
   d. Electric soldering iron

3. The use of control valve in an electric steam iron box is to
   a. prevents water and steam not to go top
   b. control water alone
   c. control steam alone
   d.control heat alone

4. What type of water can be used in steam iron box?
   a. Ordinary water
   b. Hot water
   c. Cold water
   d.Pure distilled water

5. Mica sheet is a
   a. non-conductive material
   b. non-resistive to heat
   c. conductive material
   d. easily combustible

6. Which metal, the heating element is made up of?
   a. Brass
   b. Nichrome
   c. Aluminium
   d. Copper

7. Due to__________, the electric energy is converted into heat energy
   a. low electric supply
   b. low resistance
   c. high resistance
   d. high electric supply

8. The ratio of heat in heating appliances is
   a. I^2Rt
   b. I^2R^2t
   c. IR^2t
   d. IRt^2

9. __________is used in indicating lamp.
   a. Incandescent lamp
   b. Light Emitting Diode lamp
   c. Tube light
   d. Compact fluorescent lamp

10. The appliance which induces hot waves from electromagnetic field is
    a. Electric iron box
    b. Hair drier
    c. Induction stove
    d. Electric kettle

11. According to________, induction stove will function
    a. Law of conservation of energy
    b. Ohms law
    c. Flemings rule
    d. Faraday's law

12. How many bread slices are toasted in a bread toaster simultaneously?
    a. 2 b. 3
    c. 4 d. 5

13. In heating appliances, thermostat is connected in ________
    a. series
    b. parallel
    c. series – parallel
    d. earth

14. Use of percolating tube in coffee percolator is
    a. to get coffee water
    b. outlet for steam
    c. to get hot water
    d. to store coffee powder

15. To avoid corrosion in an inner container of geyser ________ coating is used
    a. Lead b. Chromium
    c. Nickel d. Copper

16. Use of glass wool in geyser is ________
    a. to retain the water hotness as it is
    b. to retain the water chillness as it is
    c. to get more heat
    d. to get less heat

17. The use of fusible plug in geyser is to
    a. increase pressure
    b. release pressure
    c. get more heat
    d. get less heat

Q A

PART B

Mark 3

Answer the questions in briefly

1. State the types of electric iron box.
2. What is the use of small water tank in steam electric iron box?
3. What is the use of control valve in steam electric iron box?
4. State the maintenance tips of steam electric iron box.
5. What is the use of pressure plate in electric iron box?
6. What is the use of sole plate in electric iron box?

7. State indicating lamp.
8. What is induction stove?
9. What are the uses of induction stove?
10. Define bread toaster.
11. Define microwave oven.
12. Mention the parts of the microwave oven.
13. List the types of microwave oven.
14. What is the use percolating tube in coffee percolator?
15. What is coffee percolator?
16. State geyser.
17. Write down the types of geyser?
18. What is the use of fusible plug in geyser?

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain the functions of thermostat in an electric steam iron box.
2. Tabulate the troubles, reasons and remedial measures of an electric bread toaster.
3. Explain advantages and disadvantages of microwave oven.
4. What is the safety precaution to be followed while using microwave oven?
5. Draw and explain the construction of coffee percolator.
6. Explain the pressure type geyser.

Q

PART D

Mark 10

Answer the questions not exceeding two page

1. Draw and explain the construction and working principle of an electric steam iron box.
2. Tabulate the defects, reasons and remedial measures of an electric steam iron box.
3. Explain the construction and working principle of an electric induction stove with suitable sketch.
4. Explain the construction and working principle of an electric bread toaster with sketch.
5. Explain types of microwave oven and its working principle.
6. Explain the construction and working principle of an electric coffee percolator with sketch.
7. Explain the construction and working principle of pressure type geyser with neat diagram.
8. Explain the construction and working principle of non-pressure type geyser with neat diagram.

Reference books

1. 'A text book of Electrical Technology' Volume II and Volume III by B.L. Theraja and A.K. Theraja, S. Chand & Company Ltd.

LESSON 8

Motor appliances

15PBG

LEARNING OBJECTIVES

The objective of this lesson is to know about the electric motor, components, types, operation, winding, its type and appliances such as fan, washing machine, and water pump. Also to know about the advantages, disadvantages, faults, reasons and its remedial measures.

Table of Content

8.1 Motor - Introduction

8.2 Parts of motor

8.3 Types of motor

8.4 Working principle of motor

8.5 RPM of motor

8.6 Winding

8.7 Electric fan

8.8 Electric washing machine

8.9 Electric pump

8.1 MOTOR - INTRODUCTION

A motor is an electro-mechanical device (Fig 8.1). It converts electrical energy into mechanical energy. Motors are designed to produce rotary or linear motion when their electric current and magnetic field interact with each other which is commonly known as electromagnetic interaction. The cross-section of the motor is shown in fig 8.2.

Electrical energy → Motor → Mechanical energy

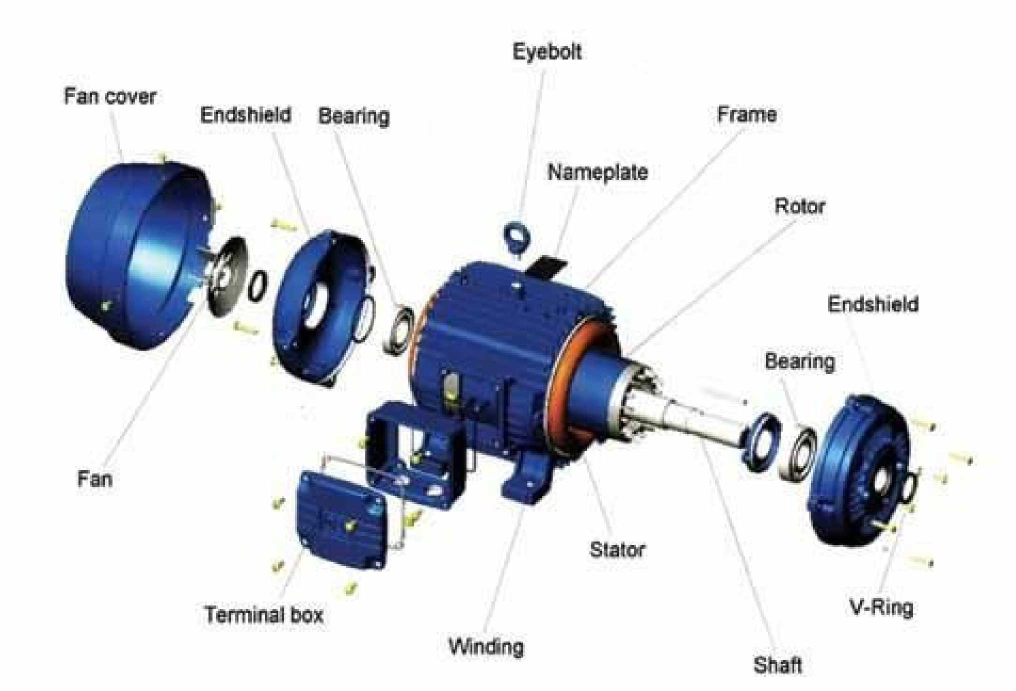


Fig 8.1 *Internal construction of a motor*

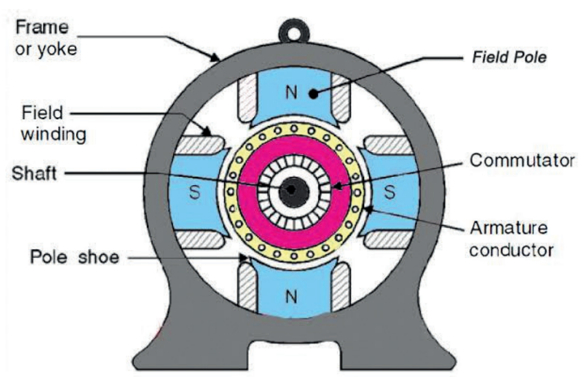


Fig 8.2 *Cross section of a motor*

8.2 PARTS OF MOTOR

The important parts of moter are

1. Field and field winding
2. Armature and Armature winding
3. Yoke
4. Teeth
5. Slot insulation
6. Brushes
7. Shaft

1. Field and field winding

A Field coil is an electromagnet used to generate the required magnetic field. It is fixed in the stator.

2. Armature and Armature winding

Armature is the rotating part of the motor. In the armature, the conductors are housed within the armature slots. The windings are arranged in the armature slots to produced electric field.

3. Yoke

The Yoke of the motor is made up of cast iron or steel. It is an integral part of the stator or the static part of the motor. Its main function is to form a protective covering which covers the inner parts of the motor and provide support to the armature.

4. Magnetic poles

The north-seeking pole of a magnet is called a north magnetic pole. The south-seeking pole is called a south magnetic pole.

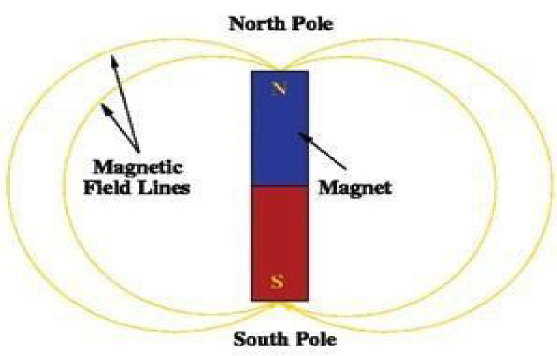


Fig 8.3 *Magnetic poles*

5. Slot insulation

The conductors are housed in the slots provided in the motor.

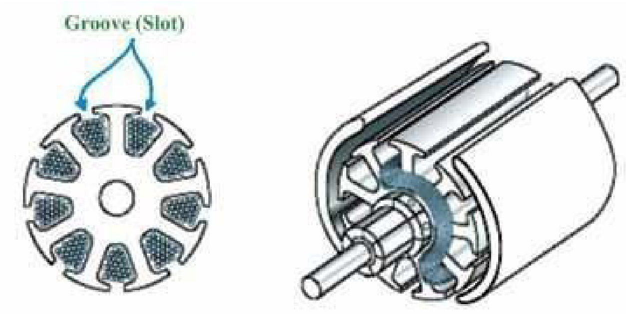


Fig 8.4 *Slot insulation*

6. Brushes

A carbon brush is a device above the commutator placed in a shaft that carrying current between wires and moving parts. Typical applications include alternators, dc motors, and generators.

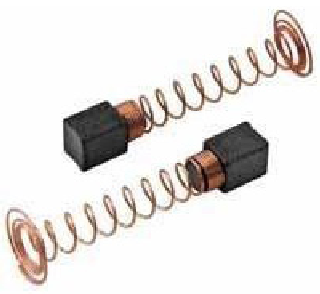


Fig 8.5 *Carbon brushes*

7. Shaft

A shaft is a rotating part of the machine, usually circular in shape, which is used to transmit mechanical power from one part to another.

Fig 8.6 *Shaft*

8.3 TYPES OF MOTOR

Generally, there are two types of motors. They are

- AC motors
- DC motors
- Special elecric motors

AC Motors

AC motors run in AC supply. Alternating current motors can be further classified into two types. They are

1. Synchronous AC motors
2. Asynchronous AC motors – It can be subdivided into single phase and three phase

DC motors:

DC motors run in DC supply.

Special elecric motors:

The motor runs for specific applications are called as special electric motors

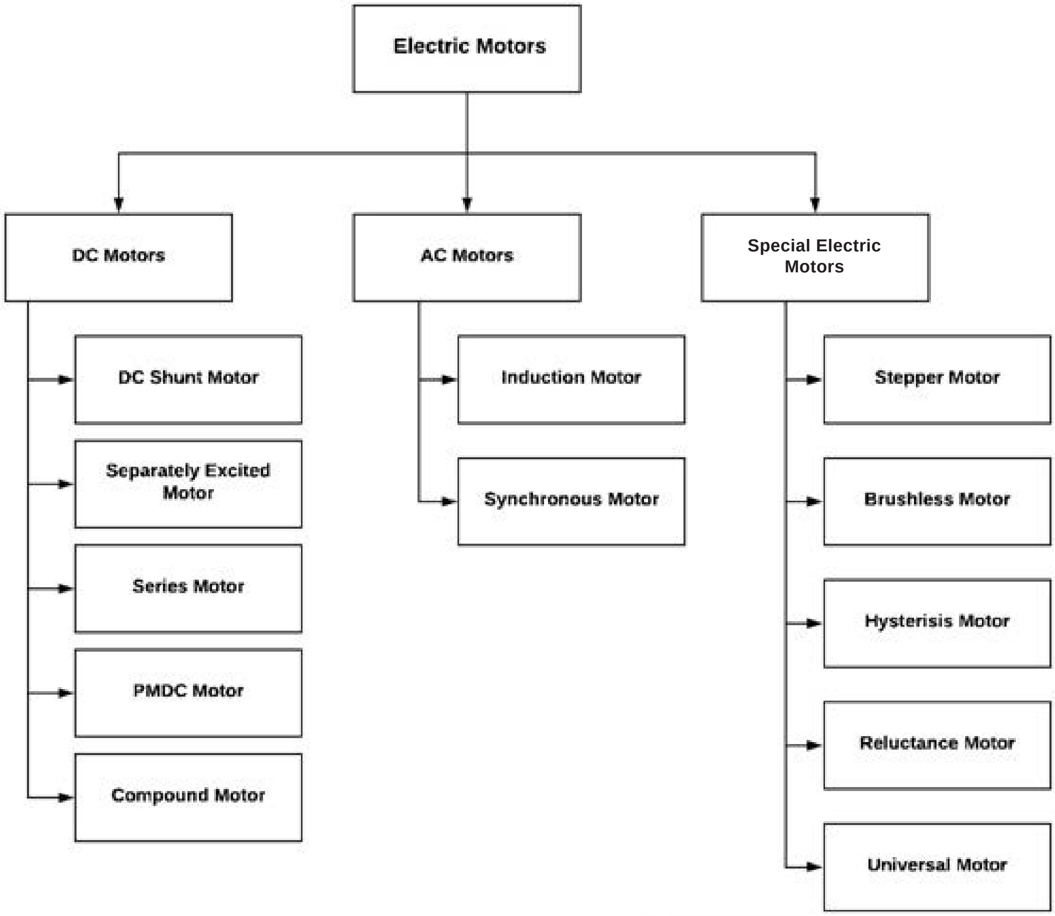


Fig 8.7 *Types of motor*

8.4 WORKING PRINCIPLE OF MOTOR

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The basic working principle of a motor is "whenever a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force". A current-carrying conductor is placed perpendicular to the magnetic field so that it experiences a force.

The direction of this force is given by Flemings left-hand rule and its magnitude is given by,

$$F = BIl \text{ (Newton)}$$

Here,

F- Force, B - Magnetic flux density, I - Current, l - Length of the conductor

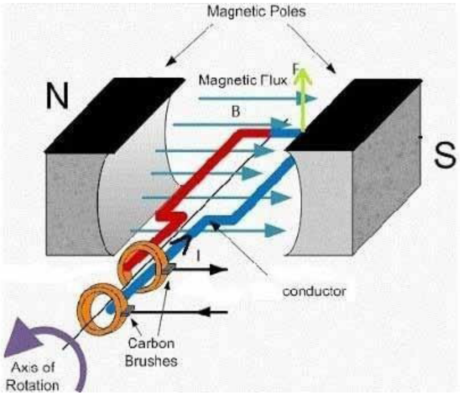


Fig 8.8 *Motor*

Advantages of motor

- Low power demand on start.
- Controlled acceleration.
- Adjustable operational speed.
- Controlled starting current.

Disadvantages of motor

Humming noise is also a very big problem.

Applications of motor

- Drilling machine
- Water pumps
- Grain
- Hoist
- Washing machine

8.5 RPM OF MOTOR

RPM is a measurement used to describe a motor's speed. It stands for revolutions per minute and describes the rate at which the rotor is revolving, which is the number of times the rotor shaft completes a full rotation each minute.

The device used to measure revolution per minute of motor

1. Analog tachometer
2. Digital tachometer

1. Analog tachometer

Analog tachometer is electronic instrument to know the revolution for a time period – revolution per minute (RPM).

Fig 8.9 *Analog tachometer*

2. Digital tachometer

Digital tachometers are relatively straightforward meters that measure the rotational speed of motors and machinery in a digital display.

Fig 8.10 *Digital tachometer*

8.6 WINDING

A conducting material wounded or coiled about an object in order to produce electro magnetic flux is called winding.

Types of winding

1. Lap winding
2. Wave winding

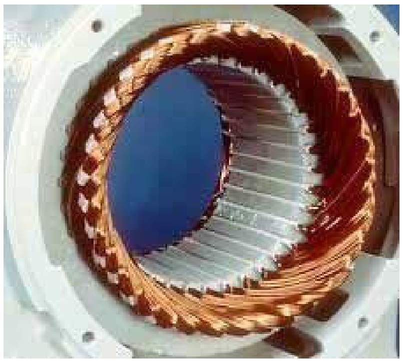


Fig 8.11 *Winding*

1. Lap winding

In lap winding, the conductors are joined in a way that their parallel paths and poles are equal in number. The end of each armature coil (coil 1 and coil 2) is connected to the adjacent segment on the commutator as shown in fig 8.12

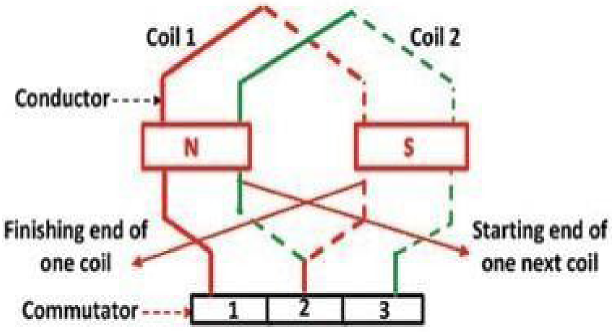


Fig 8.12 *Lap winding*

The lap winding is mainly used in low-voltage, high-current machine applications.

2. Wave winding

In wave winding, only two parallel paths are provided between the positive and negative brushes. An armature winding in which two coils are connected in series and follow each other on the surface of the armature like a wave shape is assumed as shown in the fig 8.13

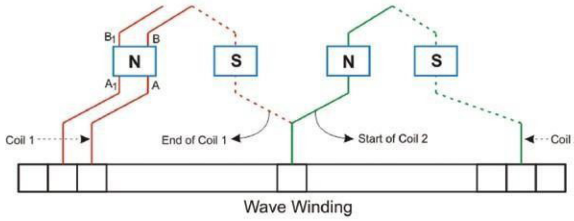


Fig 8.13 *Wave winding*

In this winding, the conductors are connected to two parallel paths irrespective of the number of poles of the machine.

The wave winding is mainly used in high voltage, low current machines.

8.7 ELECTRIC FAN

For domestic and industry applications, electric motors based fans are used. The normal electric fan are classified according to the usage as follows:

1. Ceiling fan
2. Table fan and
3. Exhaust fan

1. Ceiling fan

This type of electric fan is fixed in the ceiling of the roof as shown in fig. 8.14, and operates in AC supply. The energy conversion is from electrical to mechanical energy and gives cool air inside the room.

Fig. 8.14 *Ceiling fan*

The parts of the ceiling fan are

i) Stator
ii) Rotor
iii) Blades
iv) Bearings
v) Down rod

i) Stator

The stator is provided with insulated silicon steel plate as shown in fig. 8.15 Both the starting and running coils are wounded with 90^0 electric degrees.

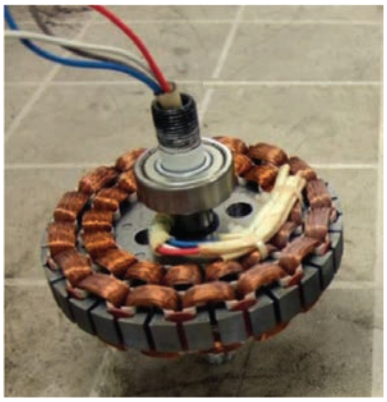


Fig. 8.15 *Stator*

ii) Rotor

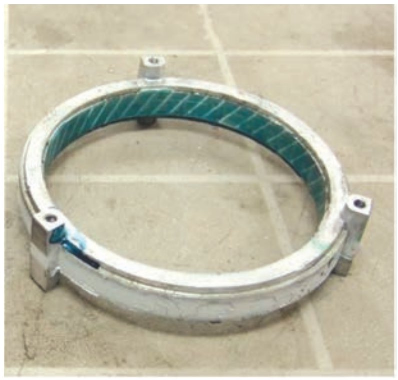


Fig. 8.16 *Rotor*

The rotating part of the squirrel cage rotor type is as shown in fig. 8.16 Only in ceiling fan stator is kept inside and rotor is in outside of the fan.

iii) Blade

The blades are made of a steel plate or aluminum plate, as shown in fig. 8.17, and are usually fixed with three or four blades. The blades cover the stator and rotor of the end plates.

Fig. 8.17 *Blade*

iv) Bearing

The bearings are placed on the top and bottom of the fan, used to reduce friction in rotating parts and also to reduce the noise while in motion.

Fig. 8.18 *Bearing*

v) Down rod

The down rod is made up of hard steel, according to the length required. One side of rod is fitted in ceiling hook, and the other side is fitted to the fan.

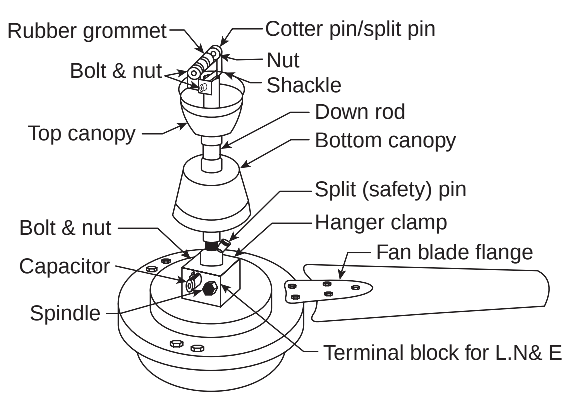


Fig. 8.19 *Structure of the fan*

Working principle of Celling fan

Fig 8.19 shows the structure of an electric fan. When an electric supply is given to the fan, the current passes to main and auxiliary winding and produce rotating magnetic field. The 2.5 micro farad capacitor is connected in series with the auxiliary winding. Due to the production of rotating magnetic field, the blades connected with the rotor rotate and air flow will be circulated to the area where required.

Usually the blades are available in various sizes like 900 mm, 1050 mm, 1200 mm, and 1400 mm respectively.

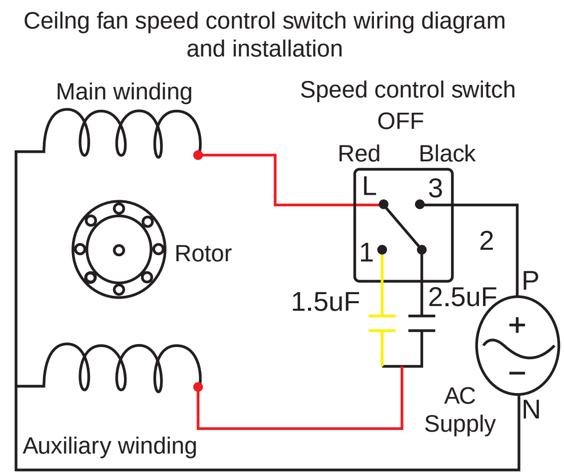


Fig. 8.20 *Circuit diagram*

Fan regulator

Fan regulator is used to control the speed of the fan. Its structure is shown in fig. 8.21. It is connected in series connection with an electric supply. It is connected between supply and fan.

Fig. 8.21 *Fan regulator*

2. Table fan

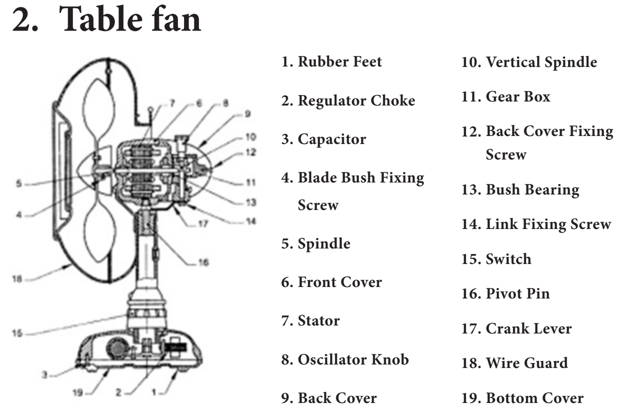


Fig. 8.22 *Table fan*

This type of fan is portable and can be used at any place where we required. In this, single phase permanent capacitor motor is used. Table fan is available in various colours as shown in fig. 8.22. Table fans are also available in various types like pedestal type, wall fitting type etc.,

The parts of the table fan are

i) Stator
ii) Rotor
iii) Blades
iv) Bearings
v) Oscillating mechanism

Note: The above parts descriptions are similar to ceiling fan and exhaust fan. (Except oscillating mechanism)

Working principle

When an electric supply is given to the fan, the current passes to the main winding and secondary winding and produces rotating magnetic field. Due to the production of rotating magnetic field, the blades connected with the rotor rotate and air flow will be circulated. Usually the blades are available in various sizes from 100 mm to 400 mm.

3. Exhaust fan

Fig. 8.23 *Exhaust fan*

The exhaust fan is as shown in figure 8.23, is used to exhaust the unwanted air present inside rooms, cinema theatres, marriage halls, factories, homes, industries, kitchens and toilets.

Working principle

Its structure is similar to that of table fan. Capacitor is not used in this type. This fan exhausts heats produced during the summer season, creating low pressure inside of the room and causes cool air to enter in. The sweep of the fans are available from 230 mm to 380 mm.

8.8 ELECTRIC WASHING MACHINE

Electric washing machines are used in houses in large number. We use washing machine for washing and drying of clothes.

Types

i) Semi-automatic washing machine
ii) Automatic washing machine
   a. Top load washing machine
   b. Front load washing machine

8.8.1 Semi automatic washing machine

a) Construction

Semi-automatic type of washing machine is for washing the clothes and is shown in fig. 8.24. This appliance is controlled by timer which control and regulate the time of washing according to the type of cloths and also dries the cloth after washing.

Fig. 8.24 *Semi automatic washing machine*

Capacitor start induction motor is used in this type of washing machine. The speed of the washing cylindrical container is proportional to the rotating speed of the mounting vessel. The clothes were washed in the method of wave up mode.

b) Working principle

After putting the dirty clothes inside the washing machine, soap powder is put into it, proportionate to the clothes to be washed, and water inlet tape is allowed to flow the water inside the container. The agitator rotates right and left and the dirts in the clothes are removed. Then the dirty water is removed through the outlet spout pipe. After the dirty water fully went out, the fresh water re enters and rinses the washed clothes to make clean. The drier then squeezes the water in the

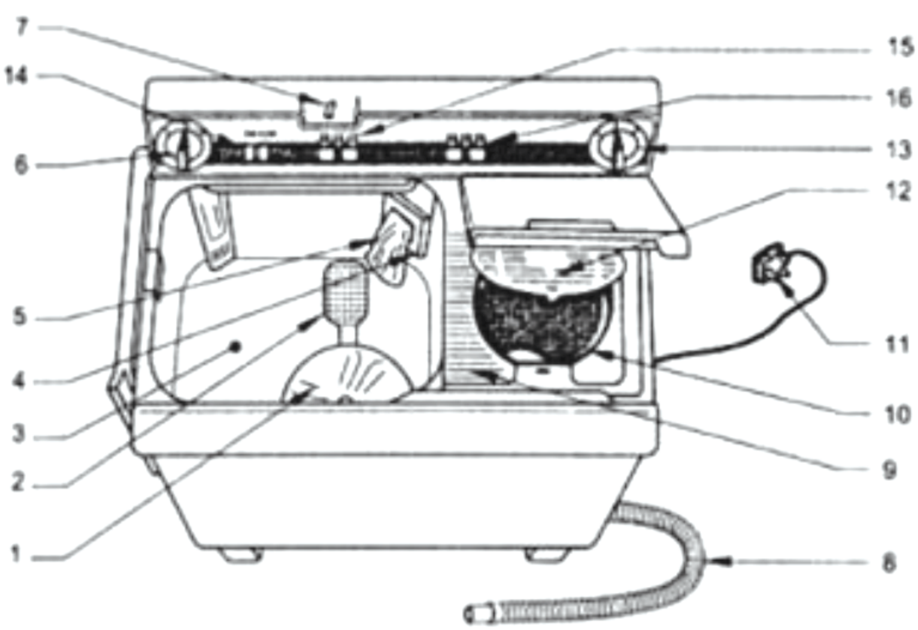


Fig. 8.25 *Internal contruction*

1. Agitator
2. Water filter
3. Washing cylinder
4. Water level selector
5. Cotton filter
6. Washing time control
7. Water inlet pipe
8. Vent pipe
9. Purifier
10. Rotating cylinder
11. Three pin plug
12. Squeezing cylinder lid
13. Squeezing time control
14. Agitator terminal junction
15. Water control tap
16. Water controling knob

washed clothes and make dry. This type of appliance is said to be as semi-automatic washing machine as shown in fig. 8.25. In this, the motor rotates and rinses the clothes with water and makes clean.

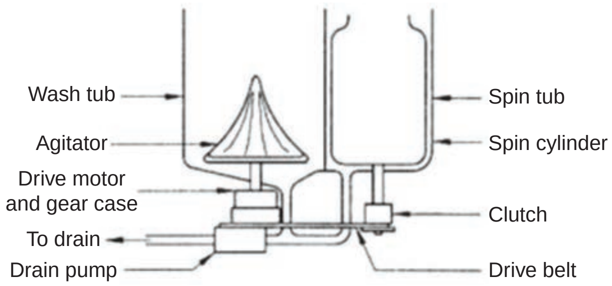


Fig. 8.26 *Construction diagram*

8.8.2 Automatic washing machine

The automatic washing machine is of two types.

1. Top load (open) washing machine.
2. Front load (open) washing machine.

1) Top load washing machine

a) *Construction*

In this type, washing machine, contains a single drum which is used for both washing and drying the clothes. A capacitor start induction motor is used in this washing machine. Water inlet and outlet pipes are connected for the water flow to go in and out.

Fig. 8.27 *Top load washing machine*

b) Water inlet tube time control

In this type of washing machine, a controlling device is mounted. The machine is automatically operated with the washing machine and the water is inserted into the inlet tube.

c) Water outlet tube time control

It works in two ways.

1. Drip out the washed dirty water
2. It is also used to squeeze and remove water from the cloth.

d) Water tank

This washing machine has two tanks.

1. Inner tank
2. Outer tank

Water tanks are made up of steel sheet coated with zinc to prevent corrosion inside the tank. Put the clothes in the inner tub and washing machine perform the tasks like washing, rinsing and squeezing. The inner tank contains small holes in this pot which is used for removal of dirty water. The outer tank is made up of steel and painted to protect from corrosion. In between inner and outer tank, Glass wool is provided in order to protect the hotness from the inner tank, and protect from chillness not to affect the inner tank.

e) Agitator

The agitator is a roller shaped hard plastic and is placed in the middle of the inner tank. The knife edge part of agitator makes the cloths to rotate it, in front and back with soap mixed water. This removes the dirty in the clothes.

f) Electric motor

The fractional horse power motor is used in washing machine. When the supply is given, the agitator rotates along with motor with the setting position according to the quantity of the cloth. Single phase 230-volt, 50 Hz supply is given to this motor.

g) Circuit board

The circuit board combines various electronic components. The mechanism of the machine will be set in advance according to the size and type of fabric used in the washing machine. This circuit determines the duration of washing the clothes, quantity of water, detergent quantity and time duration.

Working principle

The motor is operated by a time control device and it automatically divides all the works. This technique is called neuro muscular technology and works in the micro operating system. This method of functioning depends upon the type of clothes used and its dirty.

In this, clothes to be washed along with soap powder are put in the inner container of the washing machine. Dirty clothes are rotated up and down with soap powder by water. This process takes place for a fixed time duration.

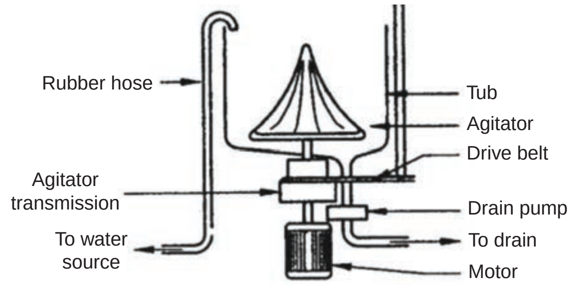


Fig. 8.28 *Agitator*

The inner tub of the washing machine has many holes. Water is sucked out to the outer tub from the inner container by centrifugal force. Water is drained out from the outer tub through a drain vent pipe. When the dirty water is drained out, fresh water is filled into the inner tub again. Agitator rinses the clothes. In this process the chemicals present in the soap are removed. After this process is completed, water in the machine is again drained out through the outer pipe.

After water is drained, the clothes kept in the container are rotated at a high speed and the water in the clothes is removed by the centrifugal force. After this cycle takes place for a certain period of time, the excess water in the clothes are squeezed out with the help of a time controlling device. Now the clothes are washed and are ready to be dried.

2) Front loading washing machine

Fig. 8.29 *Front load washing machine*

The structure and functioning of front loading washing machine are similar to that of top loading washing machine.

A cylindrical type of vessel is used in the front loading washing machine instead of the agitator in the upper loading washing machine. With the help of a roller-shaped container, the cylinder spins. As this event continues, the clothes are well washed in soapy water.

The impeller is fixed in the cylindrical vessel inside a front loading washing machine. This cylinder vessel is in horizontal position. The impeller fixed to this rotating vessel mixes detergent with water and rubs the clothes together to remove the dirt.

In some types of front loading washing machine, a heating element is placed on the bottom of the pipe to get warm water. Washing the clothes with warm water cleans the clothes quickly.

8.9 ELECTRIC PUMP

Electric pump is used to suck water from underground to tank. When the motor is turned on, due to the vacuum created by the centrifugal force, water is sucked out to a required place. A single phase motor is sufficient for domestic level, since 2000 to 5000 litres of water per day is required.

Based on the structure, the various types of pumps are given below:

1. Centrifugal pump
2. Jet pump
3. Submersible water pump
4. Air compressor

8.9.1 Centrifugal pump

The centrifugal pump is a simple electric motor appliance as in fig. 8.30. Normally, 0.5 to 3 horse power single phase capacitor start induction motor is used in centrifugal pump. By using centrifugal force, water is sucked and delivered. This is called a centrifugal pump.

Parts of a centrifugal pump

i) Basement plate
ii) Water pump box
iii) Impeller
iv) Shaft
v) Rope and box
vi) Bearings

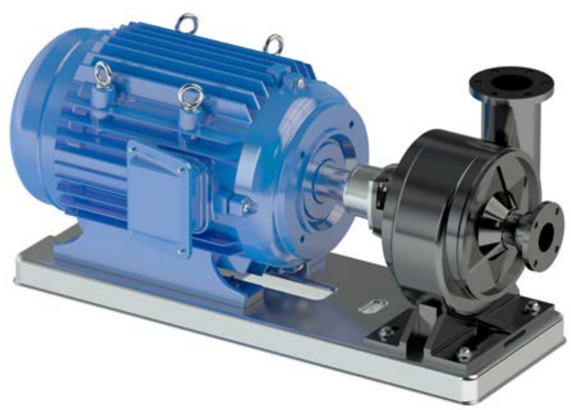


Fig. 8.30 *Centrifugal pump*

i) Basement plate

The basement plate is made up of cast iron or hard steel metal. It is fitted over the base plate with bolts and nuts.

ii) Water pump box

This is usually made up of close-grained cast iron. The vertical plane at the centre of the casing is split into two halves with flanges tightened together by bolts and nuts with gasket for leak proof.

iii) Impeller

Impeller is a rotating part of mechanism made up of cast iron or steel metal in centrifugal pump as shown in fig. 8.31. By centrifugal force the water is delivered with uniform pressure without any vibration.

Fig. 8.31 *Impeller*

Types

1. Open type impeller.
2. Closed type impeller.

iv) Shaft

It is made of stainless steel, to avoid rusts in the shaft while using salty water. The portion of the shaft which works inside the casing is usually fitted with gun-metal sleeve and hence no chance of depreciation will occur. The gun metal sleeve can be replaced when it gets worn out, and it increases the life span of the shaft.

v) Rope and box

The main purpose of the rope and box is,

i) to prevent leakage of air on the suction side.
ii) to prevent leakage of water on the delivery side due to pressure.

The packing material consists of rings of soft cotton, woven yarn, impregnated with graphite and tallow. The gland bolts should only be tightened lightly, to prevent leakage.

Modern pumps are fitted with mechanical leak-proof seals. Basically it is made up of softer materials like rubber, leather or plastic with nice finishing. It keeps cool with the water inside the pump. Otherwise it causes friction in the shaft and gets heated. This makes the pump function to get stop. It is very important that a centrifugal pump should not be allowed to run without water.

Fig. 8.32 *Internal system*

vi) Bearing

Ball, roller and bush bearings are often used. Usually ball and roller bearings are lubricated with oil and grease.

a) Working principle of centrifugal pump

The impeller starts rotating after the pump is filled with water and is run by a generator or a steam engine as shown in fig. 8.33. When the impeller rotates, due to the centrifugal force, low pressure will be produced. Due to the low pressure, water is sucked in.

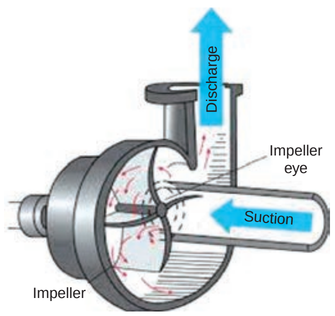


Fig. 8.33 *Internal section view*

The impeller converts the mechanical power into rotating force. Due to conversion of rotating force into pressure force, the water is delivered with the help of water pump box. The amount of energy on the surface of the water is directly proportional to the velocity of the impeller.

If the speed and size of the impeller is high, the force produced in the water will be high. When the water delivers from impeller, primarily it creates friction in the pump box. Secondly, the speed of water is converted into pressure force due to the friction produced in the delivery side. Hence, the pressure of the water is equivalent to the speed of rotation by the impeller.

a) Friction power

When the water passes through the pipe, it creates friction inside the pipe. The friction produced inside the pipe will be according to the speed of the water. Due to this, more power is required to pump the water up. Because of friction produced inside the water pipe, power loss is occurred. The power used to compensate this is called as friction force. It will be good, if the length of the suction pipe is less. The flow of water in higher diameter produces less friction.

b) Suction power

Suction conditions are some of the factors which affect the centrifugal pump operation. A pump cannot pull or "suck" water up into suction pipe, because water does not have tensile strength. When a pump creates suction, it is simply reducing local pressure by creating a partial vacuum (Sucks out the air above the water). External pressure acting on the surface of the liquid pushes the liquid up the suction pipe into the pump.

i) Static suction head

The static suction head refers to the vertical height of the water absorbed in well or the horizontal center at the water pump from the water level of the underground tank. Suction head does not depend upon the length of the pipe. It is from the water level to the pump centre and not from the foot valve or the bottom of the well.

ii) Static delivery head

The static delivery head indicates the vertical height from the horizontal line of the water to the water delivered to the water tank. This does not indicate the length of the delivery pipe.

iii) Priming

When the suction pipe and pump is filled with water, the air inside the pipe should be removed. This method is said to be priming. Before starting the pump, ensure that the pipe and pump is filled with water. The centrifugal pump should not run without water.

Friction occurs when the shaft is rotated. The water is used as a cooling agent to reduce the heat.

If the pump runs without water, the excess heat will be produced and the rotor will burn and cause damage. Therefore, the pump does not run without water in the suction pipe.

8.9.2 Jet Pump

Jet pumps are used to draw water from a well through a suction pipe in order to provide potable water or domestic water pressure. It is mounted above ground and are non-submersible and more popular in warmer climates or areas with high water tables.

Fig. 8.34 *Jet pump*

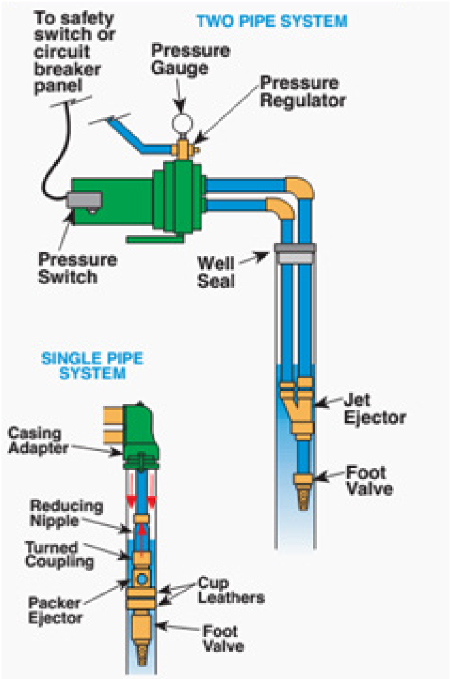


Fig. 8.35 *Fitting of Jet pump*

Other common applications include light commercial or residential irrigation and supplying water for sprinkler systems.

Jet pumps come in two variations: deep well and shallow well. The type of jet pump most suitable for your application will be dependent on the depth of your well. Shallow well jet pumps are used to transport water from wells as deep as 25 feet. Deep well jet pumps are generally used for depths up to about 200 feet. Deep well jet pumps can move larger volumes of water more quickly and over longer distances than shallow well pumps. Please note that altitude can affect the specific depth to which a pump can draw water from

8.9.3 Submersible pump

Fig. 8.36 *Submersible pump*

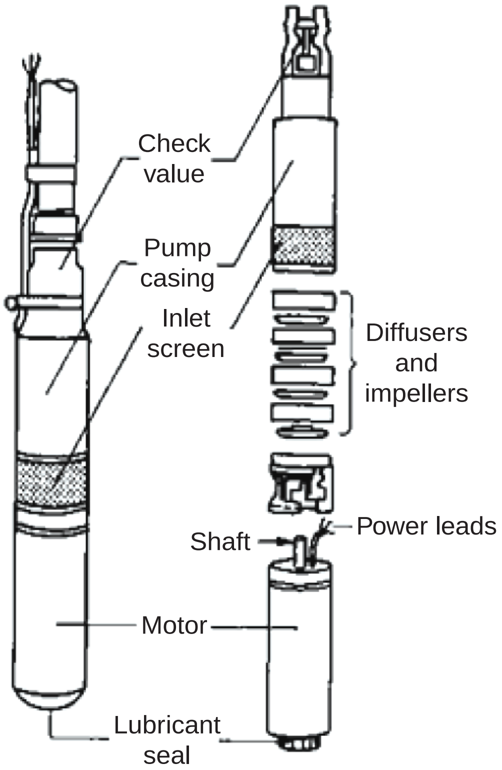


Fig. 8.37 *Inner system*

Fig. 8.36 and 8.37 shows the picture of the modern electric water pump. It consumes

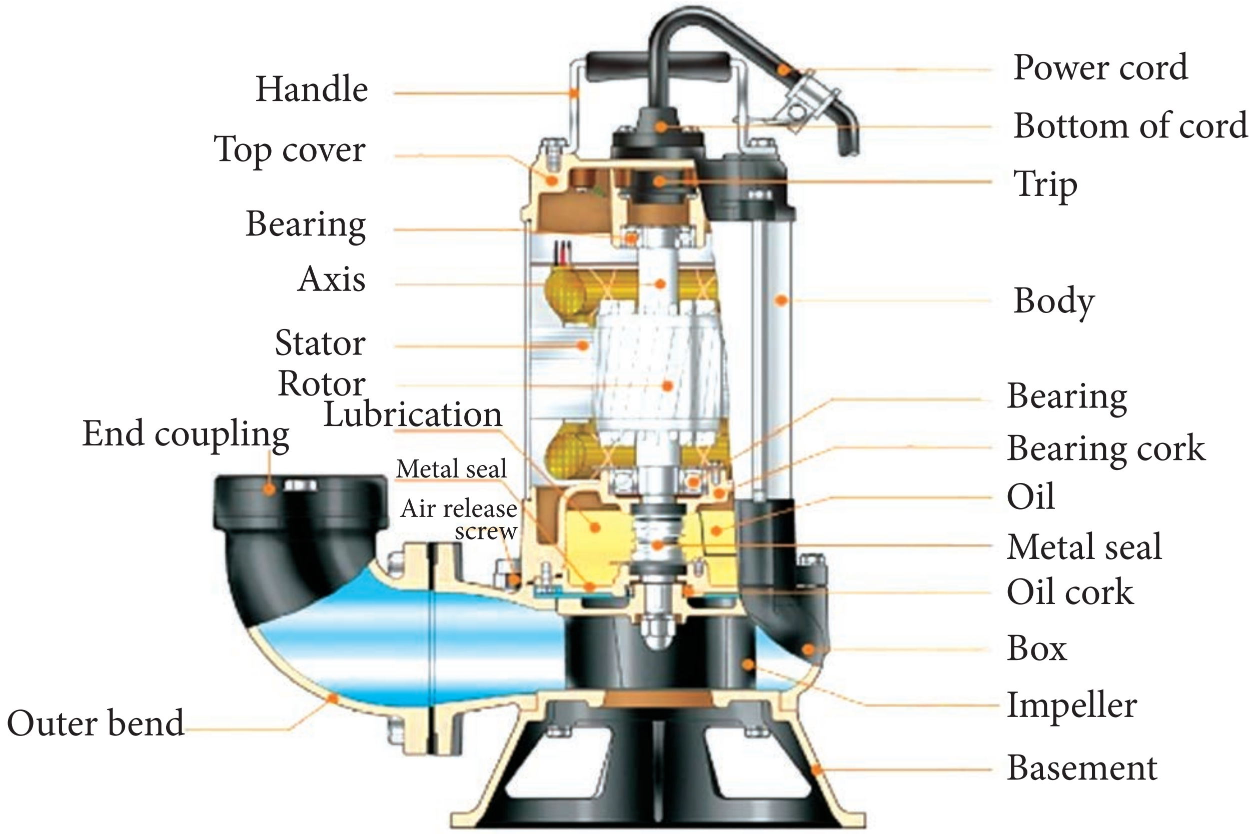


Fig. 8.39 *Internal structure of submersible pump*

less power and run smoothly without noise. This type of pump works to a level of water below 1000 feet. These types of pumps are commonly used in all places.

8.9.4 Air compressor

Fig. 8.38 *Air compressor*

The air compressor shown in fig. 8.38 is a water pump used in the bore well. It creates water bubbles when going into the foot valve with air pressure. It has slightly special features than jet pump. It is used to pump water up to 300 feet with a capacity of 2 HP. The 1.5 HP pumps can deliver water up to a level of 275 feet.

When the compressor pump is running, the noise will be slightly higher. When depreciation occurs in either shaft or bearing in the compressor, oil ring will get damaged and possibility of water gets mixed with oil. Hence, proper maintenance is essential.

8.9.5 Defects, causes and remedies of electric pump

Sl. No.	Defects	Causes	Remedies
1.	No movement in the pump.	1. Packing of the rope in the pump is tight. 2. The bearings are damaged. 3. No power supply.	1. Loose the tightened packing. 2. Check the bearing and lubrication or change the bearing. 3. Check whether the supply is live.
2	Pump is working. But water is not delivered.	1. No water in the suction pipe. 2. Delivery pipe valve is closed. 3. Water level is below foot valve.	1. The suction pipe must be filled with water. 2. Open the valve in the delivery pipe. 3. Increase the length of the suction pipe or increase the blow-up efficiency and set it below the water level.
3	Pump works on short time and deliver small quantity of water and then stopped.	1. Water leakage. Water level decreased in the suction pipe. 2. There is a defect in the electric motor and the starter.	1. Leakage in the water pipe is rectified. The pipe length in the suction area should be increased. 2. Test the circuit of the electric motor and starter with the help of test lamp.
4.	Excessive vibration and noise in the pump	1. Alignment is changed. 2. Loose fitting in connecting screws. 3. No lubrication in the bearing. 4. Shaft is slightly bent. 5. Block in the impeller and friction is in the box.	1. Check alignment. 2. Tight the screws. 3. Apply the grease on the bearing or change the bearing. 4. Change the shaft. 5. Clean the rusts in the impeller and check before to fit.
5	Cracks in the impeller	1. Cracks due to soil or hard objects. 2. Holes on the top of the impeller	1. Clean it and then fix it. 2. The holes should be closed with the washer.

GLOSSARY

Sweep	-	வீச்சு
Oscillation mechanism	-	அலைய வைக்கும் அமைப்பு
Exhaust fan		காற்றை வெளித்தள்ளும் மின்விசிறி
Semi – automatic type		குறைத் தானியங்கி வகை
Rinsing		அலசுதல்
Centrifugal pump		மையவிலக்கு நீரேற்றி

Shaft	சுழற்தண்டு
Impeller	துருத்தி
Priming	கிட்டித்தல்
Submersible motor	நீர் மூழ்கி மின்னோடி
Pump -	நீரேற்றி

QA

PART A

EBCM3

Mark 1

Choose the correct answer

1. Rotating diameter of the fan is called
   a) Fan connection
   b) Length of the fan
   c) Fan sweep
   d) Fan size

2. Which type of motor is used in the electric fan
   a) Permanent capacitor induction motor
   b) Capacitor start and capacitor run induction motor
   c) Shaded pole motor
   d) Universal motor

3. Which type of fan is used to release smokes and dust?
   a) Ceiling fan
   b) Table fan
   c) Pedestal fan
   d) Exhaust fan

4. Name the washing machine which contains agitator technique.
   a) Semi-automatic
   b) Automatic
   c) Top loading washing machine
   d) Front loading washing machine

5. In which function the soap powder is removed in the clothes?
   a) Washing function
   b) Rinsing function
   c) Dryer function
   d) Exhaust function

6. How many drums are in semi-automatic washing machine
   a) 1
   b) 2
   c) 1 or 2
   d) 3

7. Which part is used to produce centrifugal force?
   a) Scroll cover
   b) Blocking box
   c) Shaft
   d) Impeller

8. Impeller is made up of
   a) Galvanized steel.
   b) Brass.
   c) Cast iron or gun metal.
   d) Copper metal alloy.

9. Velocity imparted by the impeller to the water is converted to pressure by the
   a) Casing or volute
   b) Stuffing box
   c) Spindle
   d) Gland box

10. To ensure that the pump remains always primed it is necessary to have
   a) valve on delivery side should be open
   b) suction side should not be kept open
   c) foot valve is not leaking
   d) gland packing should not be leaking.

11. Pressure developed by the centrifugal pump is always specified in
   a) feet b) feet/min
   c) litres d) kg/cm^2

12. Static suction head and static delivery head is always represented by
   a) feet
   b) Kg/cm^2
   c) vertical height
   d) distance measured along the pipes

Q A

PART B

Mark 3

Answer the questions in brief

1. Name the type of motor used in the ceiling fan and table fan.
2. List out the parts of a ceiling fan.
3. Define - sweep.
4. What are the types of fan?
5. What is the use of a regulator in an electric fan?
6. How the speed of the table fan can be changed.
7. What is the use of a capacitor in ceiling fan?
8. Name the two types of automatic washing machine.
9. What type of technology is used in semi-automatic washing machine?
10. Define - Agitator.
11. What type of force makes fluid's rotation in the centrifugal pump?
12. What is priming in centrifugal pump?
13. What happens when the pump is rotated in the opposite direction?
14. What is called the suction head?
15. What is called the delivery head?

Q A

PART C

Mark 5

Answer the questions in one page

1. Explain briefly the construction of an electric motor used in electric fan.
2. Explain the oscillating mechanism of a table fan.
3. Explain the working principle of the exhaust fan and state its use.
4. What is the working principle of the rope in pump?
5. What is an impeller and write its type?
6. What is the functions of a impeller?
7. Briefly explain about friction power.

Q A

PART D

Mark 10

Answer the questions in two page

1. Write short notes for the following in a ceiling fan.
   a) Bearing
   b) Down rod
   c) Regulator
2. Tabulate the common defects, causes and its remedies in the table fan.
3. Explain the construction and working principle of top loading washing machine.
4. With a neat sketch explain the construction and working principle of the semi-automatic washing machine.
5. Explain the construction and working principle of the centrifugal pump with neat diagram.

Reference book

1. A text book of ‘Electrical Technology’ Volume-III B.L.Theraja and A.K.Theraja, S.Chand & Company Ltd.

Reference internet source

1. http://www.wikipedia.org
2. https://www.electrical4u.com

LESSON 9

Electric mixer / Juicer/ Grinder and Water purifier

X2BTV

LEARNING OBJECTIVES

The main objective of this lesson is to know about repairs and maintenance of home appliances such as mixer, juicer grinder and water purifier.

Table of Content

9.1 Introduction
9.2 Electric mixer
9.3 Electric juicer
9.4 Electric grinder
9.5 Water purifier

9.1 INTRODUCTION

The Electric mixer, Juicer and Grinder are the electrical household appliances used for domestic purposes. It is important to know about the operating principles and repairing of the appliances for its successful operation.

9.2 ELECTRIC MIXER

An electric mixer is an electric appliance used for grinding the food products to make it as powder or paste. It is a portable device, which can be operated in a vertical position only. Mixer grinder is available in various sizes and comes with three jars.

9.2.1 Types of jars

The various types of mixer jars are noted below.

1. Dry jar
2. Wet jar
3. Chutney jar
4. Multi-purpose jar

1) Dry jar

The jar which is used for grinding dry particles is called a dry jar. This jar is smaller in size and has no gasket in the lid.

2) Wet jar

The jar is used for pulping of vegetables for soups, lassi, milkshakes wet masalas, chutneys and preparing the batter for dosas, vadas ad iddlies. This jar is having a big gasket in the lid.

3) Chutney jar

The chutney jar is used to prepare chutneys, masalas (or) nuts in small quantities. To lock the chutney jar, the base unit is placed over the locking arm to the right side of the knob.

Fig 9.1 *Electric mixer*

4) Multi-purpose jar

In a multipurpose jar, it consists of four different types of blades for the operation. They are

1. Juicer blade,
2. Dry grinder blade,
3. Grater blade and
4. Whipping blender blade.

9.2.2 Types of Blades

Blades are used for grating coconut, cucumber, crushing ice, almond, cashew nuts, dry fruits, etc. The different types of blades used in electric mixer are

1) Wet grinder blade
2) Dry grinder blade
3) Juicer blade
4) Chutney grinder blade
5) Blender blade
6) Mincer blade and
7) Whipping blade

The jar can be used according to the requirement of things and quantities.

9.2.3 Working process

The working process of mixie can be understood from the following steps.

1. Place the mixer always on a clean and dry surface.
2. Keep away from heat and water.
3. Fix the jar properly.
4. Fix the top of the lid tightly.
5. Use the proper three-pin socket
6. Properly earthed and switch on the supply.

9.3 ELECTRIC JUICER

An electric juicer is an appliance used to extract juice from fruits, herbs, leaf greens and vegetables. It crushes, grinds and squeezes the juice out of the pulp. This process is called juicing. The fig 9.2 shows the outlook image of a juicer.

Fig 9.2 Main parts of electric juicer

9.3.1 Different types of electric juicer

The different types of juicer are

1. Manual style reamer
2. Centrifugal type juicer,
3. Masticating juicer,
4. Twin gear juicer and
5. Juice press.

1. Manual style reamer

Reamers are used for squeezing juice from citruses such as grape fruits, lemons, limes and oranges. Juice is extracted by pressing or grinding a halved citrus along with a juicer's rigid conical center and discarding the rind.

2. Centrifugal type juicer

A centrifugal type of juicer is also known as a fast juicer and is the most popular type. It takes the fresh fruits and vegetables through a feed tube and directly into contact with a blade that runs at a speed of 6000 to 14000 RPM. The juice is thrown by the centrifugal force of the spinning basket towards the sides collected in a jug.

3. Masticating juicer

Masticating juicers are known as slow juicers. In this, a slow gear is used to crush the fruits and force against a speed of 80 to 100 RPM. The juice is pulpy, foamy and can be bitter to taste.

4. Twin gear juicer

In this type, twin gear utilizes two gears that spin and pull the product in and chew it up. The gears extract the juice by pushing the product into a decreasing size.

5. Juice press

A juice press is the only type of juicer that actually contains a press, and therefore is the only true and cold press juicer. Juice presses are commonly referred to as two-stage juicers since there are two stages. First, the product is ground up into pulp, then the juice is slowly extracted by pressing the pulp under thousands of pounds of pressure.

9.3.2 Components of electric juicer

The components of an electric juicer are

1. Motor,
2. Body or Base housing,
3. On / Off switch.
4. Three pin power cord,
5. Juice container,
6. Pulp container

1. Motor

The machine makes the other juicer parts move to perform their functions. It is powered by electricity and to make mechanical movements.

2. Body or Base housing

The body provides the outer part which covers the juicer motor. It is of non conductive materials. It conceals the motor to make it safer to use the appliance.

3. On/Off switch

The On / Off switch turns the juicer ON and OFF. Some juicers have control over speed number. In which, we can choose how fast to require to rotate the juicer.

4. Three pin power cord

The power cord is the wire which connects the juicer to an electric supply.

5. Juice container

It is the container where the juice is collected, ready for drinking. Usually, this juice container is made of glass or transparent plastic materials.

6. Pulp container

The pulp container is made of stainless steel or plastic materials. In this where the pulp would be dispensed.

9.3.3 Repairs, causes and the remedies of an electric mixer and electric juicer

S.No.	Defects	Reasons	Remedies
1	The appliance is not functioning.	1. Either no voltage or low voltage.	1. Check the voltage with the help of a multimeter and act accordingly.
		2. Open circuit in field winding or armature winding	2. Test the continuity of field or armature winding with the help of test lamp and rectify it.
		3. The power cord wire is opened or does not have continuity.	3. Check the continuity of the power cord and ensure its continuity.
2	The motor is not running for the rated supply voltage.	Due to an overload of things in the jar the safety switch opened.	Load accordingly to the quantity and release the safety switch.
3	The motor is not running in a specific speed	The connection in the regulator knob is not properly connected.	Check the regulator knob connection and connect properly.
4	Overheat is produced in the appliance while in use.	1. Short circuit in field or armature winding.	1. Test the coil and ensure it is not short-circuited.
		2. Worn out bearing or defects in bearing	2. Bearing should be replaced.

9.4 ELECTRIC GRINDER

The appliance electric grinder is used in the domestic and hotels for the preparation of food grains into paste or batter. It consists of granite stones that rotate inside a metal drum with the help of an electric motor and the food grains get crushed between the stone and drum.

9.4.1 Types of grinder

The various types of grinder are

1. Old stone wet grinder,
2. Tabletop wet grinder,
3. Tilting table top wet grinder and
4. Commercial wet grinder

1. Old stone wet grinder

Old stone wet grinders are used in the early days as traditional and now they are being used in villages and small towns. Electric supply is not required for this type.

2. Tabletop wet grinder

Tabletop Wet grinder consists of granite stones which rotate inside a metal drum with the help of an electric motor and the food grains get crushed between the stone and drum. It is portable and easy to maintain.

3. Tilting table top wet grinder

Tilting table top wet grinders are solid and utilize less space. This type of wet grinder is mostly used in domestic which don't make high noise and easy to clean.

4. Commercial wet grinder

Commercial wet grinder is used in the places where huge quantities of batter is required (or) food grind are caused. This type is used only in hotels and commercial food preparation areas.

9.4.2 Components of electric wet grinder

1. Circulating stone

A circulating stone is a solid stone in which the graining particles were gets battered.

2. Rubber belt

The belt is a hard-drawn insulated rubber that connects the motor shaft to the drum for rotating.

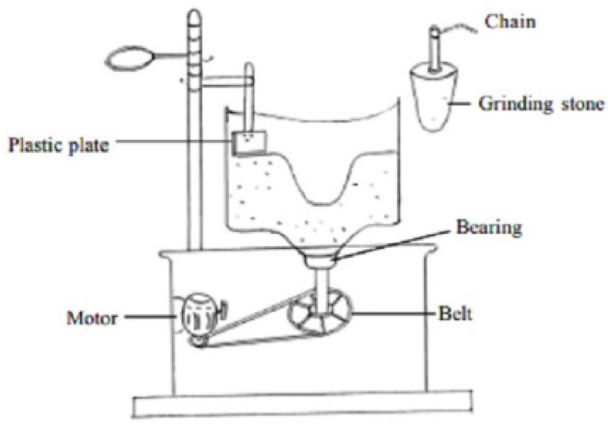


Fig 9.3

3. Motor

A motor is a rotating machine that transforms electrical energy into mechanical energy and makes the container drum rotate for grinding. It is fitted below the drum table as in fig.

4. Shaft and pulleys

The main purpose of the shaft and pulley is used to connect the motor and the drum with the help of a belt.

5. Plastic plate

The plastic plate is fitted with the drum used to circulate the batter to grain according to the density of batter required.

6. Bearing

Bearing is a connective device used in the handle and bottom of the drum to rotate easily.

9.4.3 Trouble shoot chart of an electric grinder

S.No.	Defects	Reasons	Remedies
1	When the supply is ON, the grinder is not functioning.	1. Low supply	1. Ensure the supply is normal and ON.
		2. Power cord is not connected properly.	2. Connect the power cord properly without loose connection.
		3. Loose wire connection in the motor of the grinder table.	3. Connect the wire properly to the grinder table.
2	While in ON supply, the fuse gets melted.	1. Short circuit occurs in the winding.	1. Test the winding and ensure short circuits do not occur.
		2. Phase wire gets short-circuited with neutral in the socket.	2. Connect phase and neutral wire properly.
3	Motor running. But the grinder drum is not rotating	1. Belt is loosened.	1. Belt has to be replaced and ensure it is tight.
		2. Worn out belt.	2. New belt has to be changed.
4	Sound is produced while running the motor.	1. Not applying lubrication.	1. Lubrication has to be applied.
		2. Bearings get worn out.	2. Replace the bearing.
5	Noise occurs at the bottom of the grinder drum.	1. Lubrication not applied in the bearing below the drum.	1. Apply lubrication in the bearing of the drum.
6	While the appliance is ON, the metal parts get shocked.	1. Supply wire may have a chance of contacting the conductive parts of the appliance due to improper insulation. (Earth connection)	1. Find out the area and insulate it properly.

9.5 WATER PURIFIER

Introduction

Pure, clean and safe drinking water is most important to live. Growing population, industrial development and environmental degradation are causing the water to pollute. So, purification water is important for safe drinking.

Natural water contains more minerals that are essential to human being. But if it exceeds the limit, it causes so many diseases.

A good water purifier is an appliance which removes the excess salts, suspended particles and microbes, and retains its essential vitamins and minerals.

9.5.1 Electrical circuit diagram of water purifier

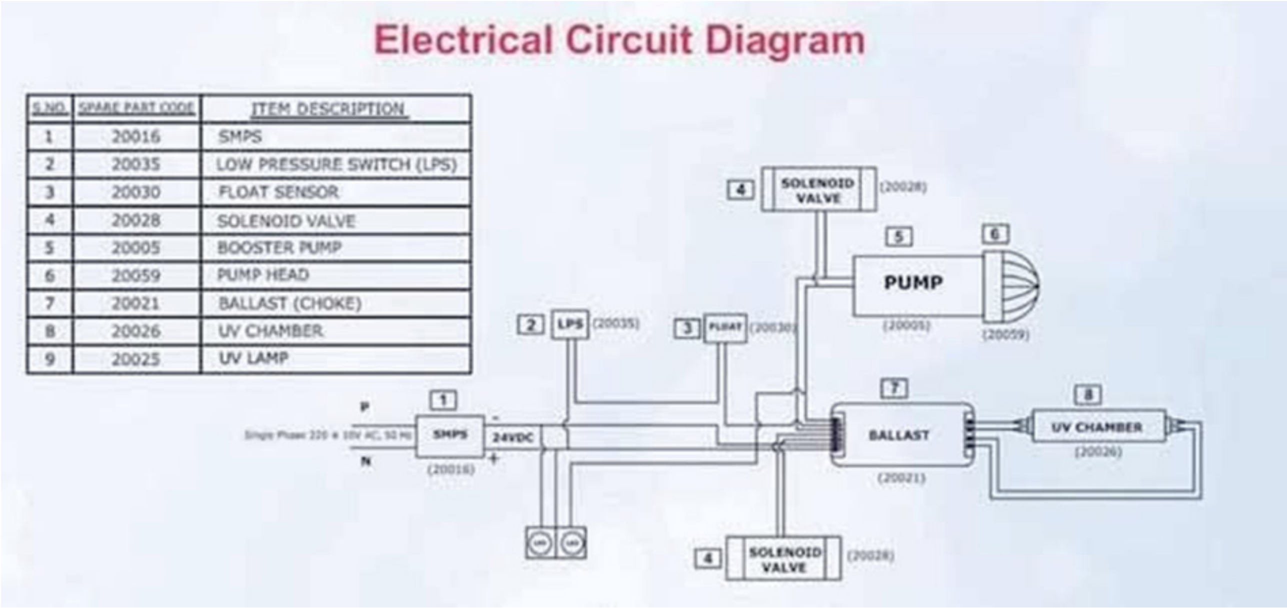


Fig 9.4 Circuit diagram of water purifier

The water purifier is a device that purifies impure water to pure water. The diagram 9.5 shows the various parts of the water purifier like sediment filter, carbon filter, RO booster pump, etc.

9.5.2 Water flow diagram

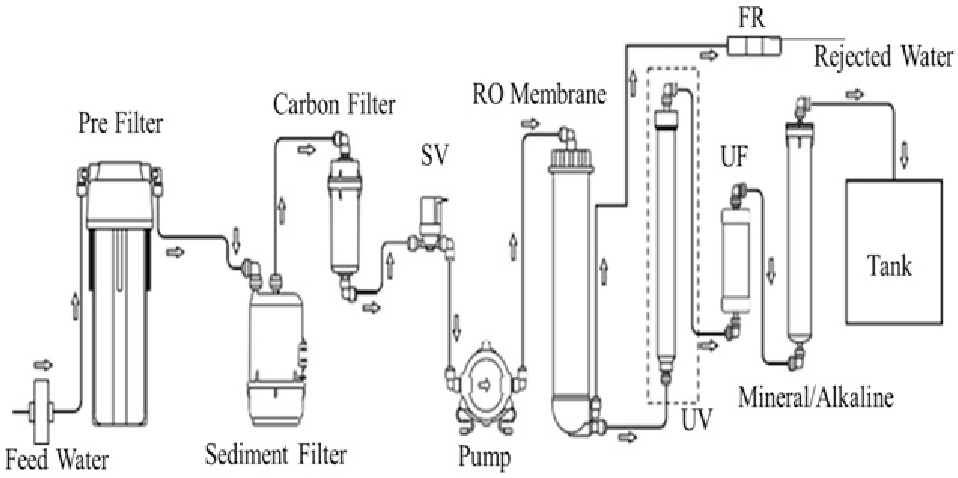


Fig 9.5 Main components of water purifier

Fig 9.4 shows the various valves and switches used in the water purifier. Solenoid valves are used for controlling the water flow at the input side. Float valves are used for controlling the water at the storage end.

9.5.3 Water purification process and different layers

Membranes are made up of very thin sheets of synthetic plastic material which have very fine holes or pores. The size of pores is varied according to the types of water purification like Micro filtration membranes (MF), Ultra filtration membranes (UF), Nano - filtration membranes (NF) and Reverse Osmosis (RO) membranes.

The types of membranes used in Reverse Osmosis water purifiers have the smallest pores which are just a little larger than the size of a water molecule. Hence it allows pure water molecules to pass easily but will stop the passage of larger molecules of salts and organic chemicals.

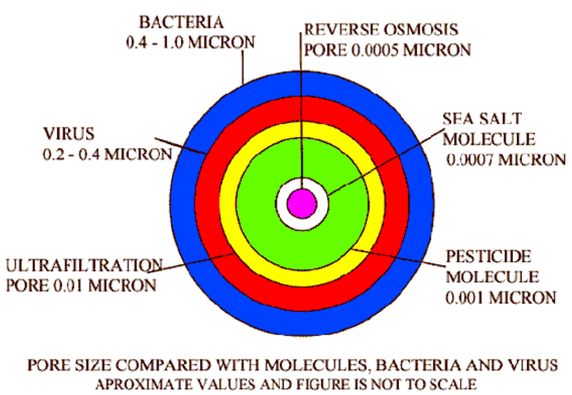


Fig 9.6 Types of membranes

The fig. 9.6 is a graphical representation of the pore sizes of different types of membranes used to purify water and how the pore sizes of types of membranes compare with the size of salt molecules, viruses, etc.

9.5.4 Different layers of filter

Depending on the water purification methods water purifiers are can be classified into 5 types.

1. Sediment filter

This type of filter purifies water like RO and UV. The particles which are collected at the bottom of the water are known as sediment. Sediment may be rust flakes of metal pipes, sand, or mud particles and removes turbidity of water. Basically, it filters the unwanted dust, impure particles present in the water.

2. Activated carbon filter

Activated Carbon is a form of carbon that is divided into small pieces and activated from charcoal. Activated Carbon removes the waterborne disease which is present in pesticides and heavy metal makes water tasteless and bad smell. Activated Carbon is most effective to remove chlorine from water.

3. Reverse Osmosis filter (RO)

In an RO water purifier, a semi-permeable membrane is used to purify the water. In this process, the dissolved solids like arsenic, fluoride, lead, chlorine, nitrates and sulphates are trapped and filtered through the RO membrane and get purified water.

4. Ultra violet filter (UV)

UV or Ultra violet water purifier is a proven technology that kills water-borne diseases which cause microorganisms, pathogens such as bacteria, viruses and cysts. UV water purifier consists of a UV lamp tube through which water has to pass for purification. When running water is exposed to UV light, germs like bacteria and viruses are destroyed and made inactive.

5. Ultra filtration filter (UF)

In Ultra filtration, the hollow fibers of the membrane are made of a thin layer that is used to separate water and impure particles present in water. When water feed through the UF membrane, the suspended solids, bacteria and viruses were retained in the UF membrane. The UF filter is similar to RO technology, the only difference is RO can block very minute particles, whereas UF blocks large particles.

GLOSSARY

Electric mixer	—	மின் கலக்கி
Electric juicer	—	மின் சாறு பிழி கருவி
Electric grinder machine	—	மின்அரவை இயந்திரம்
Batter	—	மாவு
Portable	—	எளிதில் எடுத்துச் செல்ல
Chores	—	வேலைகள்
Gasket	—	அடை வளையம்
Grater blade	—	அரம் போன்ற கத்தி
Centrifugal	—	மைய விலக்கு
Masticating	—	மென்மையாக்குதல்
Pulp	—	கூழ்
Water purifier	—	நீர் சுத்தகரிப்பான்
Degradation	—	சீரழிவு
Microbes	—	நுண்ணுயிரிகள்
Sediment filter	—	வண்டல் வடிகட்டி
Membrane	—	சவ்வு
Rust	—	துரு
Turbidity	—	கொந்தளிப்பு
Proven technology	—	அங்கீகரிக்கப்பட்ட தொழில்நுட்பம்
Rind	—	தோல்
Cyst	—	நீர்க்கட்டி

Q A

PART A

Mark 1

Choose the correct answer:

1. Mixer is an electric appliance used for
   a. Grinding the food products to make it powder.
   b. Cutting of food products.
   c. Mixing of food product materials.
   d. Grinding of hard products only.
2. An electric mixer is a
   a. Static appliance.
   b. Portable and operated only in vertical.
   c. Mechanical appliance.
   d. Unstable appliance.
3. Which jar is used for grinding dry particles?
   a. Wet jar
   b. Chutney jar
   c. Dry jar
   d. Glass jar
4. For, pulping of vegetables and fruits __________ jar is used.
   a. dry jar
   b. chutney jar
   c. glass jar
   d. wet jar
5. For, preparation of small quantities of masala, we use ________ .
   a. chutney jar
   b. wet jar
   c. dry jar
   d. glass jar
6. The appliance used for extracting juice from fruits and vegetables are __________
   a. Grinder
   b. Juicer
   c. Mixer
   d. Beater
7. Which type of juicer is having a rigid conical center?
   a. Centrifugal type
   b. Masticating type
   c. Manual style reamer
   d. Twin gear type
8. Which juicer is the fast and most popular type?
   a. Manual style reamer
   b. Masticating juicer
   c. Twin gear juicer
   d. Centrifugal type juicer

9. Which juicer is known as slow juicer?
   a. Masticating juicer
   b. Twin gear juicer
   c. Manual style reamer
   d. Centrifugal type juicer

10. What is the speed of centrifugal type juicer?
   a. 3000 RPM to 5000 RPM
   b. 6000 RPM to 14000 RPM
   c. 5000 RPM to 7000 RPM
   d. 7000 RPM to 9000 RPM

11. The revolution speed of masticating juicer is _________
   a. 40 RPM to 60 RPM
   b. 60 RPM to 80 RPM
   c. 80 RPM to 100 RPM
   d. 100 RPM to 120 RPM

12. The juicer that spins, pulls and chews are belongs to _________
   a. manual style reamer
   b. centrifugal type juicer
   c. masticating juicer
   d. twin gear juicer

13. The appliance for preparation of batter is _________
   a. mixer
   b. grinder
   c. juicer
   d. purifier

14. Which grinder does not require electricity?
   a. Table top wet grinder
   b. Tilting tabletop wet grinder
   c. Old type stone wet grinder (Manual)
   d. Commercial wet grinder

15. Which type of grinder runs with low noise?
   a. Old type stone wet grinder (Manual)
   b. Table top wet grinder
   c. Commercial wet grinder
   d. Tilting table top wet grinder

16. The shaft and pully is connected with the help of _________ in grinder.
   a. rod
   b. belt
   c. coupling
   d. bolt and nut

17. For easy rotation, _________ is used in grinder.
   a. starter
   b. gear
   c. bearing
   d. plate

18. The appliance which purifies the impure water is _________
   a. juicer
   b. mixer
   c. grinder
   d. water purifier

19. Activated carbon is most effective to remove _________ from water.
   a. chlorine
   b. salt
   c. iodine
   d. bacteria

20. Solid particles like arsenic, fluoride, lead etc. are filtered in which layer?
   a. Ultraviolet
   b. Reverse osmosis
   c. Activated carbon
   d. Ultra filtration

21. Which layer kills micro-organisms, bacteria, virus and cysts?
    a. Activated carbon
    b. Reverse osmosis
    c. Ultraviolet
    d. Ultra filtration

22. Large suspended particles present in water is filtered in ________ layer.
    a. ultraviolet
    b. reverse osmosis
    c. ultra filtration
    d. activated carbon

Q A

PART B

Mark 3

Answer the questions in briefly

1. Write about an electric mixer?
2. List out the types of jar in an electric mixer.
3. Name the type of blades used in a mixer.
4. Define – Electric juicer.
5. Write down the types of juicers.
6. List out the components of juicer.
7. What is called a grinder?
8. What are the various types of grinder?
9. List out the components of wet grinder.
10. Write short note about water purifier.
11. Name the different layers of filter.

Q A

PART C

Mark 5

Answer the questions not exceeding one page

1. Write about the functions of various parts of an electric juicer.
2. Write about the components of an electric juicer.
3. Write about the components of wet grinder.
4. Draw the electrical circuit diagram of a water purifier.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Tabulate the repairs, causes and the remedies of an electric juicer.
2. Draw the diagram of wet grinder and explain the types of grinder.
3. Tabulate the trouble shoot chart of a grinder.
4. Explain the water purification process and its different layers of filter.

LESSON 10

Electric Vehicles

LEARNING OBJECTIVES

The objectives of this lesson is to know about electric vehicles and its components, plug-in hybrid vehicles, fuel cell vehicles, types of hybrid vehicles, energy storage of electric vehicles and energy management system.

In modern trend, the vehicles manufacturing is based on the electric supply as the source of energy. On that basis the scope of the unit has been presented to balance the fuel cost.

Table of Content

10.1 Introduction
10.2 Types of electric vehicles
10.3 Hybrid electric vehicles
10.4 Drive train
10.5 Series drive trains
10.6 Parallel drive trains
10.7 Energy storage and energy management system

10.1 INTRODUCTION

Electric Vehicles (EVs) are the vehicles that are either partially or fully powered on electric power. Electric vehicles have low running costs because they have fewer moving parts for maintenance and are environmentally eco-friendly. Consequently, electric vehicles are the only zero-emission vehicles (ZEVs) possible.

On-road, electric vehicles include electric cars, electric buses, battery electric buses, electric trucks, electric bicycles, electric motorcycles and scooters etc. Off-road vehicles include electrified all-terrain vehicles and tractors. In the year 1827, the first car powered by an electric motor was launched.

Comparison of conventional internal combustion engine (IC) vehicles to Electric vehicles

S.No.	Internal combustion engine vehicles	Electric vehicles
1	Power train: Internal combustion engine	Powertrain: Electric motor
2	Fuel: Petrol or Diesel	Fuel: Battery
3	Running cost is high	Running cost is low
4	Noisy while operation	Quiet during operation
5	Emits greenhouse gases	Emission free
6	Refilling is easy	Lacks in charging

10.2 TYPES OF ELECTRIC VEHICLES

1. Battery electric vehicles
2. Hybrid electric vehicles/Plug-in hybrid electric vehicles

10.2.1 Battery Electric Vehicles (BEV or EV)

The concept of the battery electric vehicle or simply electric vehicle is essentially simple and is shown in Figure 10.1. An electric vehicle consists of

1. Battery - that provides electric energy,
2. Electric motor - that drives the wheels through transmission.
3. Controller - that regulates the energy flow to the motor.

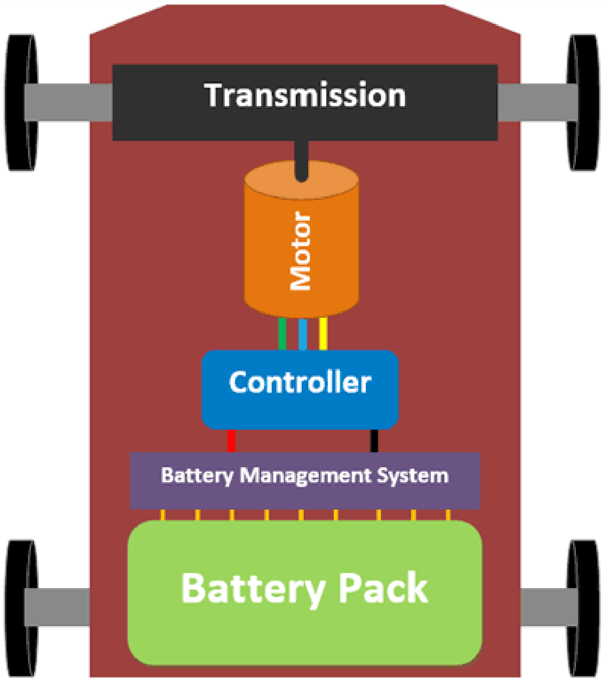


Fig.10.1 *Lay-out diagram of Electric vehicle*

1. Battery

Batteries are the fuel source for an electric vehicle. It provides electric energy needed by the electric motor. The battery must be designed based on the rating of the motor and charging system that a vehicle utilizes. Different types of rechargeable batteries are available now which includes lead-acid, nickel metal hydride, and lithium-ion batteries that recharging is taking place while the vehicle is in movement.

a. Lead-acid battery

The lead-acid batteries are made with lead. It is a rechargeable battery and has relatively low energy density. Lead-acid batteries can be designed to be high power and are inexpensive, safe, and reliable.

Fig.10.2 *Lead-acid battery*

b. Lithium-ion battery

The fig 10.3 is shown a Lithium-ion battery is a type of rechargeable battery used in electric vehicles and portable electronic equipments. It is having higher energy density than typical lead-acid or nickel-cadmium rechargeable batteries.

Fig.10.3 *Lithium-ion battery*

2. Electric motor

In electric vehicles, the electric motor is the only device which converts electrical energy into mechanical energy. Batteries are the fuel tanks of an EV, the motors are the Engines of them. There are many types of motors used for scooters, bikes and cars is totally different form the one another. The commonly used electric vehicles are brushless DC (BLDC / HUB) motors, brushed DC motors and AC Induction motors. The fig 10.4 shows the exploded view of electric vehicle motor.

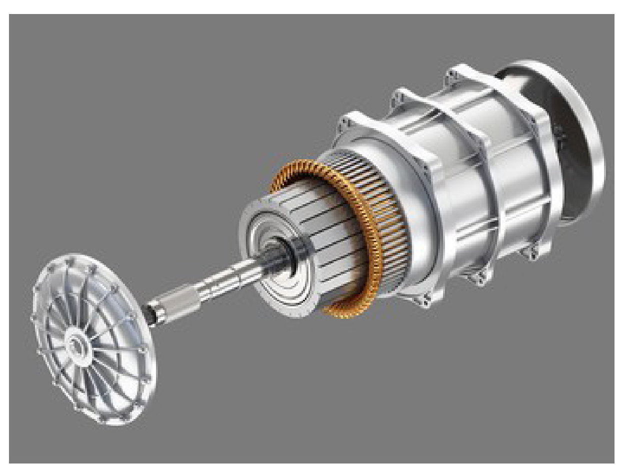


Fig.10.4 *Electric motor*

AC motor is less expensive and lighter in weight. But the DC motor has a simple controller, making the combination less expensive. The main disadvantage of the AC motor is the cost of the electronic package needed to convert (invert) the battery's direct current to alternating current for the motor.

The DC motor and controller system is still used today in some electric vehicles to keep the cost cheaper. However, with the advent of better and less expensive electronics, a large number of today's electric vehicles are using AC motor and controller systems because of their improved motor efficiency and lighter weight.

3. Controller

The electric vehicle controller is having the electronics package that operates between the batteries and the motor to control speed and acceleration.

The controller transforms the battery's direct current into alternating current (for AC motors only) and regulates the energy flow from the battery.

Unlike the carburettor, the controller will also reverse the motor rotation (so the vehicle can go in reverse), and convert the motor to a generator (so that the kinetic energy of motion can be used to recharge the battery when the brake is applied).

The main operation of controller is seen from the diagram fig 10.5 shown below.

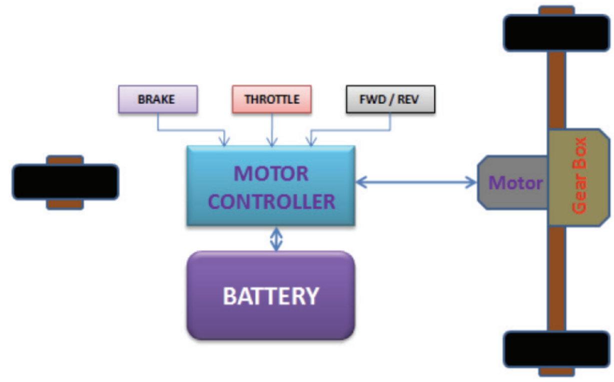


Fig.10.5 *Electric vehicle controller*

10.3 HYBRID ELECTRIC VEHICLES

Hybrid electric vehicles consists of various types and the degree to which each function as an electric vehicle also varies. The most common form of HEV is the hybrid electric car, although hybrid electric trucks, buses, boats and aircraft also exist.

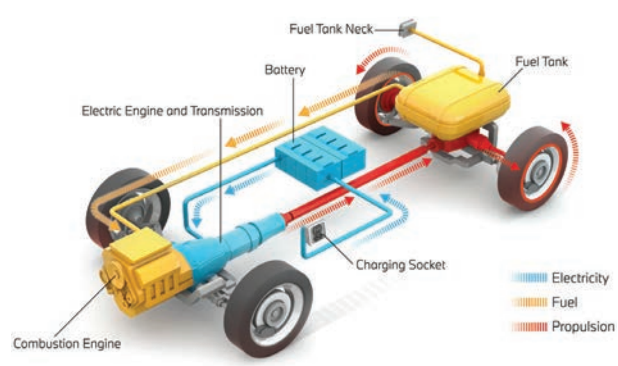


Fig.10.6 *Componentes of Hybrid electric vehicles*

10.3.1 Plug - in Hybrid Vehicle

A plug-in hybrid vehicle consists of both a combustion engine and an electric motor. Each one is capable of powering the vehicle on its own. Plug-in hybrid use regenerative braking as their energy source, but they can also be plugged in to recharge the battery.

Plug-in hybrid electric vehicle have both engine and electric motor to drive the car. Like regular hybrids, they can recharge their battery through regenerative braking. They differ from regular hybrids by having a much larger battery, and being able to plug into the grid to recharge. The battery pack in a PHEV is generally larger than in a standard hybrid electric vehicle. The larger battery pack allows the vehicle to operate predominantly on electricity during short trips.

For longer trips, a PHEV can draw liquid fuel from its onboard tank to provide a driving range similar to that of a conventional vehicle. An onboard computer decides which fuel should be used when, depending on the mode which the vehicle operates most efficient in.

The battery can be charged by plugging into an electric power source, through regenerative braking, and by the internal combustion engine. In regenerative braking, kinetic energy normally lost during braking is captured and stored in the battery.

10.3.2 Fuel Cell Electric Vehicles (FCEV)

How a fuel cell electric vehicle works?

Cars powered by hydrogen are considered as electric vehicles, because oxygen and hydrogen are converted to electric energy, which then powers the electric motor with a battery. It recaptures the energy that is lost during braking and stored again it in a battery.

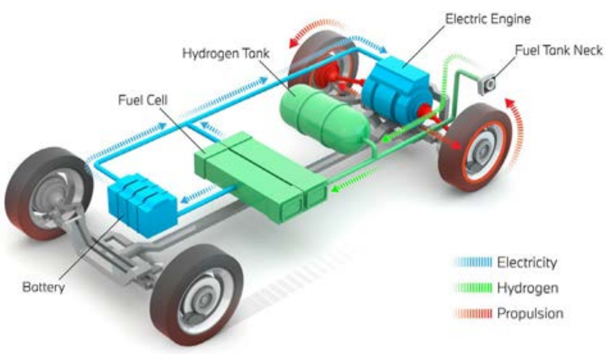


Fig.10.7 *Components of Fuel Cell Electric Vehicles*

Fuel cell electric vehicles create their own electricity on board. Hydrogen in the fuel cell reacts with oxygen in the air, thereby generating electricity, which is used to power the electric motor, similar to a battery electric vehicle. As a result, they emit water vapour and warm air. The production of hydrogen requires a large amount of electricity is an ecological disadvantage in it. On the top, the hydrogen must be transported to petrol stations.

Fuel cell electric vehicles have a range similar to that of future battery-powered electric vehicles. An advantage of this is, it takes short time to fill the tank just like a petrol / diesel car. In future, there would be having a little difference between operating a fuel cell electric vehicle and a petrol car.

It is also expensive to manufacture fuel cell systems. Because platinum is needed for the catalytic converter.

10.4 DRIVE TRAIN

A drive train is the combination of components that deliver power from a motor to the vehicle's wheels.

In hybrid-electric vehicles, the drive trains design how the electric motor works in conjunction with the conventional engine. The drive train affects the vehicle's mechanical efficiency, fuel consumption, and purchasing price.

There are three types of drive trains

1. Series drive trains
2. Parallel drive trains
3. Series / parallel drive trains

10.5 SERIES DRIVE TRAINS

Hybrids that use a series drive train only receive mechanical power from the electric motor, which is run by either with battery or a gasoline-powered generator.

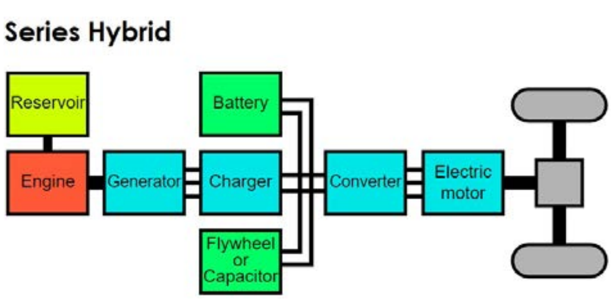


Fig.10.8 *Block diagram of series drive trains*

10.6 PARALLEL DRIVE TRAINS

In hybrids with parallel drive trains, the electric motor and internal combustion engine can provide mechanical power simultaneously.

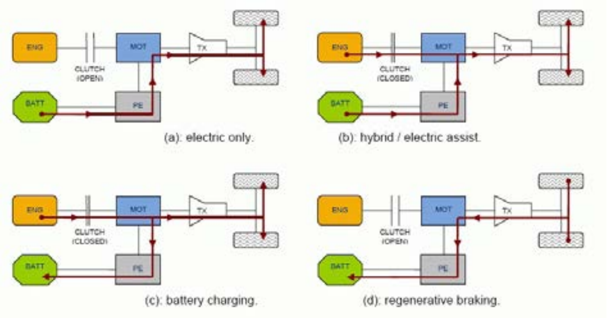


Fig.10.9 *Block diagram of parellel drive trains*

10.6.1 Series / parallel drive trains

Series / parallel drive trains enable the engine and electric motor to provide power independently or in contact with one another.

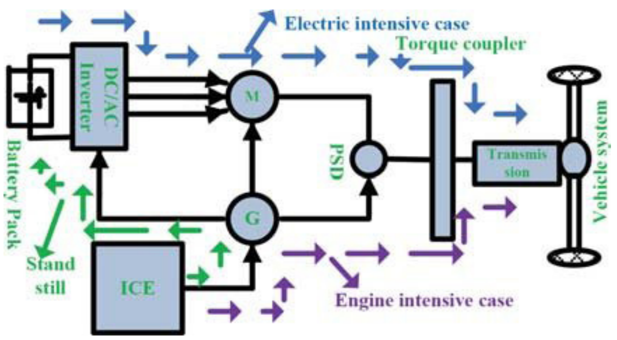


Fig.10.10 *Block diagram of series parellel drive trains*

10.7 ENERGY STORAGE AND ENERGY MANAGEMENT SYSTEM

(a) Energy storage

The evolution of energy storage and management systems along with more efficient motor were needed to replace the polluting and complex internal combustion engine.

Pure electric vehicles adopt a variety of benefits like...

a. Simpler and reliable infrastructure
b. Cheaper and less maintenance
c. Low transportation cost
d. Full power available at entire RPM range
e. Taxes reduction through subsidies

An electric vehicle can charge 80% power from house plug-in.

(b) Energy management

The energy management systems include all the various ways used to reduce cost, weight, and energy consumption while simultaneously increasing range and reliability. Hybrid energy storage describes the current prerequisites for the adoption of electric vehicles. Despite the fact that numerous techniques and controlling modules have ageing, over sizing, and power losses, consider driver behaviour, traffic, storage characteristics, and power splitting. As a result, the life of the battery and efficiency will be increased.

The availability of latest technologies such as Plug-in hybrid electric vehicle or Fuel cell vehicle, pure electric vehicles have the highest efficiency ie 67% as power output.

Now-a-days in latest technologies, we are using the ultra capacitors to lower the temperatures and minimized peak current. So we are getting the reduced power losses. Hence the operational cost is very less.

Hybrid energy storage systems can be created by combining multiple energy storage units. The energy storage system consists of a battery and an ultra capacitor. While the battery requires energy for a long time, the ultra capacitor can compensate the instant power demands.

The types of energy storage technologies are

a. Gravity energy storage
b. Flywheel energy storage
c. Superconducting magnetic energy storage systems.

In future, Gravity energy storage system with high-capacity energy storage will be assigned as new technology.

GLOSSARY

Predominantly — **பெரும்பாலும்**

QA

PART A

Mark 1

Choose the correct answer:

1. In what year was the first car powered by an electric motor?
   a) 1911
   b) 1827
   c) 1962
   d) 1899
2. What percentage of electrical vehicle charging happens at home?
   a) 50%
   b) 75%
   c) 80%
   d) 90%
3. Which of the following is not type of hybrid electric vehicle?
   a) Plug-in hybrid
   b) Series hybrid
   c) Parallel hybrid
   d) Natural gas for vehicles
4. The hybrid electrical vehicles consists of
   a) internal combustion engine and electric motor
   b) two electric motor
   c) natural gas vehicle engine and electric motor
   d) petrol engine and electrical motor
5. Which battery is used electrical vehicles?
   a) Lithium-iron battery
   b) Lead-acid battery
   c) Dry cell
   d) Voltaic cell
6. What voltage is likely to be available from the battery of an electric and hybrid vehicle?
   a) 12 v
   b) 300 v
   c) 40 v
   d) 55 v
7. The __________ regulates the energy flow to the motor in battery electric vehicles
   a) controller
   b) battery
   c) petrol
   d) power supply
8. In regenerative braking __________ normally lost during braking and stored in the battery.
   a) Mechanical energy
   b) Kinetic energy
   c)Electrical energy
   d) Chemical energy

9. Pure electric vehicles are having the highest efficiency of __________
   a) 47%
   b) 57%
   c) 67%
   d) 77%

10. How many type of energy storage technology consists of?
    a) 3
    b) 5
    c) 7
    d) 9

PART B

Mark 3

Answer the questions in briefly

1. What is called an electric vehicle?
2. State hybrid electric vehicles.
3. List out the types of electric vehicles?
4. What are the difference between electric vehicle and hybrid electric vehicle?
5. What is drive train?
6. State lithium-iron battery.
7. What are benefits of pure electric vehicles.

PART C

Mark 5

Answer the questions not exceeding one page

1. Explain controller of electric vehicles
2. Explain series and parallel hybrid drives with schematic diagram.
3. Explain the energy management system of an electric vehicle.

Q A

PART D

Mark 10

Answer the questions not exceeding two page

1. Explain and draw the schematic diagram of battery electric vehicle.

Reference book

1. 'Electric & Hybrid Vehicles' by AK Babu, Khanna Book Publishing Co (p) Ltd

MODEL QUESTION PAPER

Basic Electrical Engineering Theory

Time Allowed 3.00 hours **STD:11th** **Maximum Marks: 90**

PART A

Mark 1

Choose the correct answer: 15 × 1 = 15

1. Switch should always be connected with
   a) neutral wire
   b) earth wire
   c) phase wire
   d) link wire
2. Electrical circuit breaker is like a
   a) resistance
   b) capacitance
   c) switch
   d) inductance
3. Which type of fire extinguisher is used for metal and electric fire?
   a) Water filled extinguisher
   b) Gas filled extinguisher
   c) Foam extinguisher
   d) Dry powder extinguisher
4. The permanent magnet is used in
   a) dynamo
   b) energy meter
   c) transformer
   d) loud speaker
5. A Battery is used to store __________ energy.
   a) heat
   b) electrical
   c) chemical
   d) solar
6. When diode is reverse biased, it acts as
   a) conductor
   b) insulator
   c) biasing
   d) semi-conductor
7. Transformer is a
   a) rotating device
   b) electronic device
   c) static device
   d) computing device
8. Conservator is a
   a) main tank of a transformer
   b) protective device of a transformer
   c) earthing system of transformer
   d) cooling device
9. Mica sheet is a
   a) non-conductive material
   b) non resistive to heat
   c) conductive material
   d) combustible material
10. The appliance which induces hot waves from electromagnetic field is
   a) Electric iron box
   b) Hair drier
   c) Induction stove
   d) Kettle

11. Rotating diameter of the fan is called
    a) Fan connection
    b) Length of the fan
    c) Sweep of the fan
    d) Size of the fan
12. The unit of centrifugal pump pressure is
    a) feet
    b) feet/sec
    c) liter
    d) Kg/cm^2
13. Which type of juicer is having a rigid conical center?
    a) centrifugal type
    b) masticating type
    c) manual style reamer
    d) twin gear type
14. For easy rotation, ________ is used in grinder
    a) starter
    b) gear
    c) bearing
    d) plate
15. Which battery is used in electrical vehicle?
    a) Lithium ion battery
    b) Lead-acid battery
    c) Dry cell
    d) Voltaic cell

Q A

PART B

Mark 3

Answer any ten questions. Q. No. 28 is compulsory $10 \times 3 = 30$

16. Write about semi-conductor.
17. List out the types of fire extinguisher.
18. State Maxwell cork screw rule.
19. What are precautions followed in a battery?
20. State the type of batteries.
21. Write a short note on fixed resistor.
22. What are the protective devices of transformer?
23. State the types of microwave oven.
24. What is the use of fusible plug in geyser?
25. List out the maintenances of a washing machine.
26. What are the various types of grinder?
27. State lithium ion battery.
28. Write down the types of geyser?

QA

PART C

Mark 5

Answer any five questions. Q. No. 35 is compulsory $5 \times 5 = 25$

29. Explain the differences between electromotive force and potential difference.
30. Write seven features about lead-acid and a lithium ion battery.
31. Draw a diagram of series and parallel inductor circuit.
32. Explain why transformer does not work on DC supply.
33. Explain the function of thermostat in an electric steam iron box.
34. What are the functions of the impeller?
35. Draw the electrical circuit diagram of a water purifier.

QA

PART D

Mark 10

Answer the following questions. Draw diagrams wherever necessary. $2 \times 10 = 20$

36. Explain hysteresis loop with a diagram.

(or)

Explain the constructions and working principle of RL series circuit.

37. Explain the construction and working principle of an induction stove with a neat sketch.

(or)

Explain the construction and working principle of semi-automatic washing machine.

Basic Electrical Engineering

PRACTICAL

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CLASS XI

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EXPERIMENT 1

Study of hand tools and wiring

Aim:

To study about various hand tools and measuring equipments for wiring.

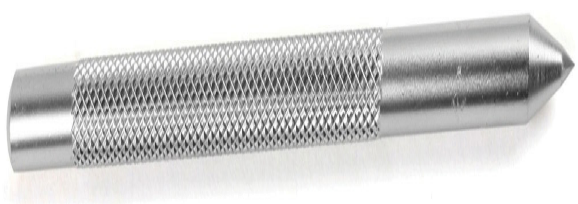
Tools/equipments to know:

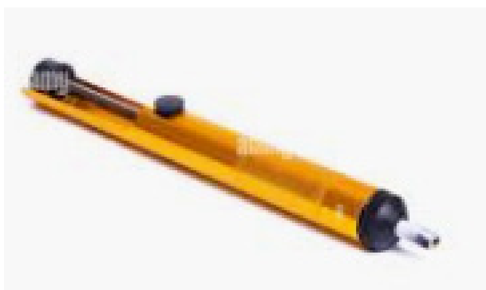
i) Hand tools for wiring:

S.No	Name of the hand tool/ Equipment	Picture of the hand tool/Equipment	Uses
1	Combinational plier		Combinational plier is used for cutting, twisting, pulling, holding and gripping the wires and objects.
2	Long nose plier		Long nose pliers are used for holding small objects in places where fingers cannot reach.
3	Round nose plier		Wire hooks and loops could be made using the round nose plier.

4	Wire cutter		Wire cutter is used for cutting copper or aluminium wires having small diameter.
5	Screw driver		Screw driver is used for tightening or loosening screws.
6	Electrician knife		Electrician knife is used for removing the insulation of cables and cleaning the wire surface.
7	Line tester		Line tester is used to indicate the supply in a particular equipment.
8	Ball peen hammer		Ball peen hammer is made up of special steel and is used for straightening and bending nails. The handle is made up of hard wood.

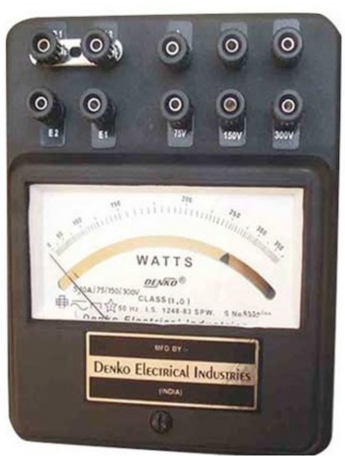
9	Rawl jumper		Rawl jumper is used for making holes in bricks, concrete wall and ceiling.
10	Pipe jumper		Pipe jumper is used with a hammer to make holes in wall which is required for wiring.
11	Mallet		Mallet is used for straightening and bending of thin metallic sheets.
12	Try square		Try square is used to check whether the object is plane, perpendicular or at right angle.
13	Measuring steel tape		Measuring steel tape is used for measuring the dimension of the wiring installation and general measurements.
14	Hacksaw		Hacksaw is used for cutting the wooden objects.

15	Pincers		Pincers are used for extracting nails from the wood.
16	Firmer chisel		Firmer chisel is used for chipping, scrapping and grooving the woods.
17	Poker		Poker is a long sharp tool used for making pilot holes on wooden articles to fix screws.
18	Spanner		Spanner is used for loosening and tightening of nuts and bolts.
19	Ring spanner		Ring spanner is used in place where the space is restricted.
20	Center punch		Center punch is used for making and punching holes on metals.
21	Hand drilling machine		Hand drilling machine is used for making holes in thin metal sheets or in wooden objects.

22	Electrical drilling machine		When power is available, electrical drilling machine is convenient and it is an accurate tool for drilling holes on wood and metal objects.
23	Soldering iron		A *soldering iron* is used to solder (connect) pieces of wire with the help of soldering lead.
24	Desoldering iron		It is a manually-operated device which is used to remove unwanted soldered lead from a printed circuit board.

ii) Measuring equipment in electrical circuit:

S.No	Name of the measuring equipments	Picture of the equipment	Uses
1	Ammeter (MI)		Ammeter is used to measure the current in the circuit. MI ammeters are used measure both AC & DC.

2	Ammeter (MC)		Moving coil type of ammeters are used to measure only DC current.
3	Voltmeter(MI)		Voltmeter is used to measure the potential difference (in volts) in the circuit. MI voltmeter is used to measure AC & DC.
4	Voltmeter (MC)		Moving coil type of voltmeter is used to measure only DC voltage.
5	Wattmeter		Wattmeter is used to measure power in the circuit.

6	Energy meter (Single phase)		Energy meter is used to measure the consumption of electrical energy by the load.
7	Energy meter (Three phase)		Three phase energy meter is used to measure the electrical energy in three phase circuits.
8	Power factor meter		Power factor meter is used to measure the phase angle between the voltage and current.
9	Multimeter		Multimeter is used to measure the electrical quantities like voltage, current both in AC and DC resistance etc.

10	Clamp meter		Clamp meter is used to measure the current in the live conductor.
11	Frequency meter		Frequency meter is used to measure the frequency of AC signal in Hertz.
12	Tachometer		Tachometer is used to measure the number of rotation or speed of a motor.
13	Megger		Megger is used to measure the insulation value of a resistance in mega ohms.

14	Earth tester		Earth tester is used to measure the value of earth resistance in low range.
15	TDS meter		Total dissolved solids (TDS) meters are used to measure the level of solid content in water.

Result:

Thus, the concept of hand tools and safety tools for wiring and measuring equipments were studied and known.

EXPERIMENT 2

Wiring joints

Aim:

To prepare various type of wiring joints.

Practical procedure

Prepare simple twist joints
↓
Prepare married joints
↓
Prepare britannia T joints

Tools and materials required:

S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Diagonal cutting plier	150 mm	1 No
2	Combination plier	200 mm	1 No
3	Stainless steel rule	300 mm	1 No
4	Wooden mallet	75 mm	1 No
5	Electrician's knife	100 mm	1 No
6	Hand vice	50 mm	1 No
7	PVC insulated copper wire	1/1.12	3 m
8	PVC insulated copper wire	1/1.40	3 m

9	PVC insulated copper wire	7/20	2 m
10	PVC insulated wire	3/20	2 m
11	GI wire	4 mm 30 cm	2 Nos
12	Copper wire	4 mm 30 cm	2 Nos
13	Hard drawn copper wire	4 mm dia	0.5 m
14	Tinned copper wire	0.91 mm	4 m

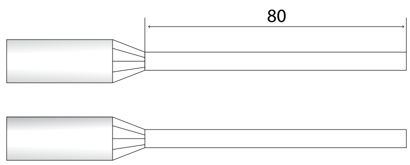
Procedure:

Task 1: Prepare simple twist joints

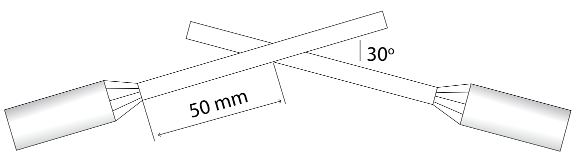
Step 1: Take two pieces of 1/1.12 copper wire of 0.5 meter length.

Step 2: Measure and mark 80mm on, each length of the wire.

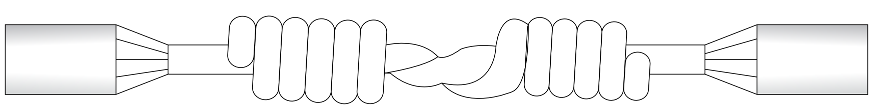
Step 3: Remove PVC insulation from each conductor for a length of 80 mm as shown below.



Step 4: Place the conductor together about 50 mm from the ends with an angle of 30 degree as shown below.



Step 5: Twist the conductor tightly around each other in opposite direction at least six turns each side with the help of pliers as shown below.



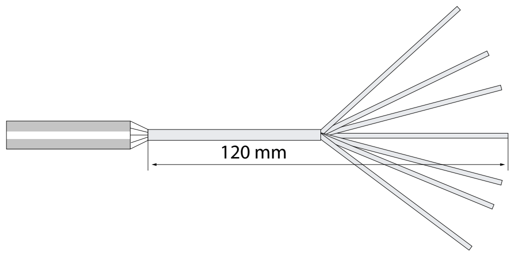
Task 2: Prepare married joints

Step 1: Take two pieces of PVC copper wire 7/20 each 0.5 meter in length.

Step 2: Mark the wire about 120 mm from the wire, in both wires.

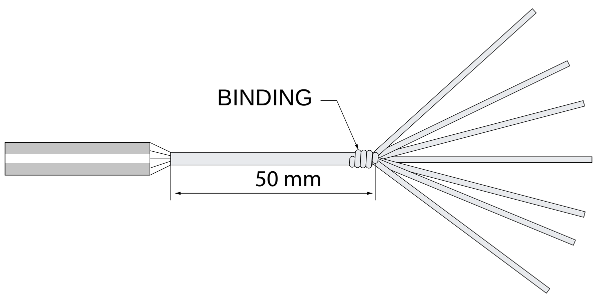
Step 3: Remove the PVC insulation for 120 mm on both the wires.

Step 4: Re-twist the strands back to its original direction for 70 mm at the ends as shown below.

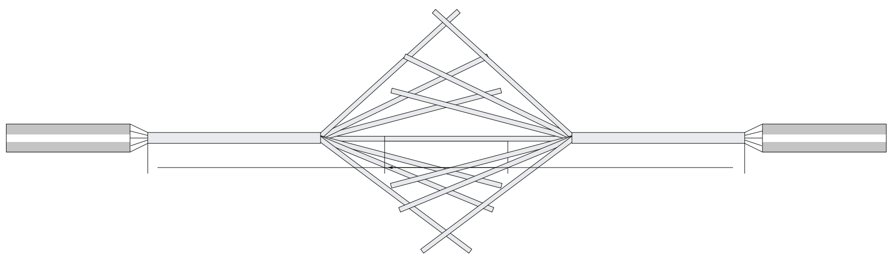


Step 5: Cut the center strand of the wire for 70 mm and twist closely.

Step 6: Bind on the twisted part of one wire end as shown below.



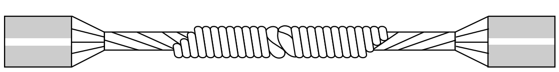
Step 7: Interlace the strands keeping the centres butt as shown below.



Step 8: Hold the wire end (which is not bind) in one hand and twist the strands of the other wire (bind one) over one by one, closely and tightly. Each strands are twisted half a turn at a time.

Step 9: Remove the bind which is made in step 6.

Step 10: Repeat the step 8 on the other side with the second wire end as shown below.

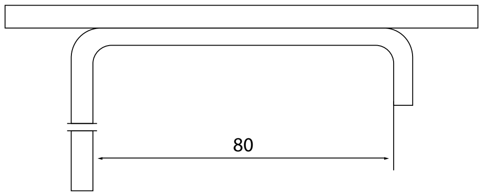


Task 3: Prepare Britannia T joints

Step 1: Take two pieces of hard drawn copper wire 4 mm with 0.2 m.

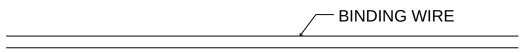
Step 2: With the help of the mallet straighten the wire.

Step 3: Bend any one conductor at one end as shown below.



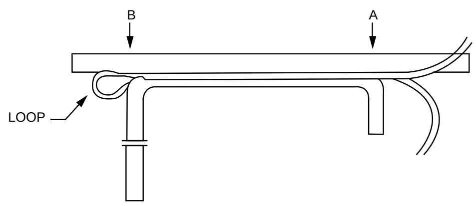
Step 4: Hold the two conductor to be joined with the help of hand vice.

Step 5: Take a binding wire and straighten it.



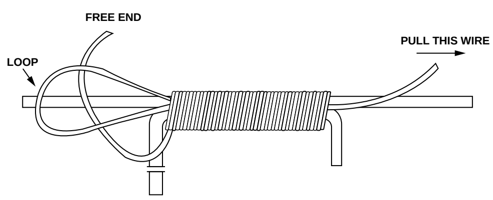
Step 6: Form a loop in binding wire leaving one end about 250 mm at the right side of the joint.

Step 7: Place the binding wire formed in the groove formed between the conductors as shown below.



Step 8: Start binding the wire tightly over the joint from position "A" to position "B".

Step 9: Insert the free end of the wire inside the loop as shown below.



Step 10: Grip the 250 mm loose end of the wire with a plier then carefully pull it. So that the loop and the free end of the wire go inside the joint.

Step 11: Wrap the free end over the conductor as shown below.

BRITANNIA TEE JOINT

Result:

Thus, the various wiring joint such as simple twist joint, Married joint, Britannia T joints were done.

EXPERIMENT 3

Verification of Ohm's law

Aim:

To determine the resistance value of two given coils of wire by using Ohm's law.

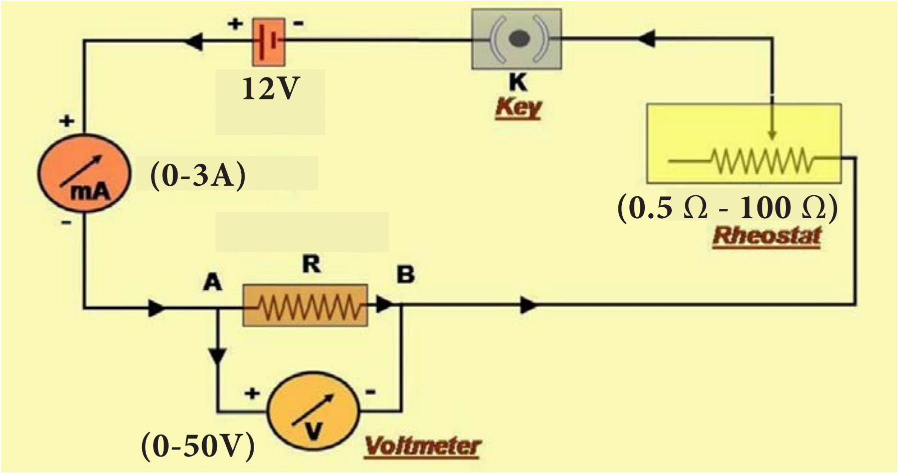
Tools and meterials required:

S.No	Name of the apparatus	Range	Quantity
1	Battery	12V	1
2	Plug key	One way	1
3	Ammeter	(0-5A), MC	1
4	Voltmeter	(0-50V), MC	1
5	Rheostat	0.5 Ω - 100 Ω	1
6	Resistance	5 Ω	1
7	Connecting wires	-	As required

Procedure:

Connect the circuit with the components as shown below.

After the connection is made check it with the subject faculty.



Step 1: Keep the rheostat in Maximum resistance position.

Step 2: Record the corresponding volt and current readings.

Step 3: Take at least five set of readings, by varying the rheostat.

Step 4: With the help of ohm's law, $R = V/I$ determine the resistance value.

Step 5: Tabulate the readings as per the table given below.

Tabulation:

Sl. No	Voltage (volts)	Current (Amps)	Resistance (ohms)
1.			
2.			
3.			
4.			
5.			

Result:

The resistance of two coils of wire R1 = ____________________ohm.

R2 = ____________________ohm.

EXPERIMENT 4

Appliance test board

Aim:

To know the method of testing of domestic appliances by using appliance test board.

Practical procedure:

Tips about test board

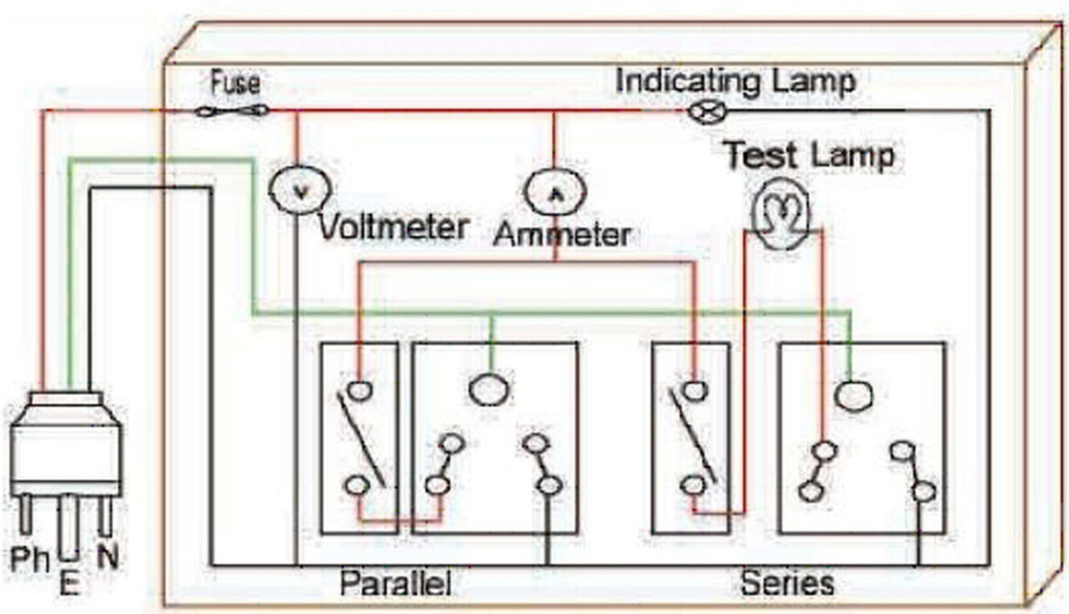
↓

Preparation of appliances test board

↓

Testing for appliances test board

Procedure:



Tools and materials required:

S.No	Name of the apparatus/ components	Range/value	Quantity
1	Screw driver	5 mm	1
2	Combinational plier	150 mm	1
3	Line tester	500V	1
4	Electrician knife	100 mm	1
5	Poker	100 mm	1
6	Electrical drilling machine	(6-12 mm) 230V, 350W	1
7	Ball peen hammer	-	1
8	Hacksaw frame with blade	300 mm	1
9	Wooden board	12” X 8”	(1 Piece)
10	Five pin socket	230V, 6A	2
11	Fuse unit	230V, 16A	1
12	One way switch	230V, 6A	2
13	Lamp holder	BC 230V	1
14	Lamp	230V, 200W	1
15	Three core power cord	15A	5 meter
16	Ammeter	(0-5A) MI	1
17	Voltmeter	(0-300V) MI	1
18	Copper wire	1/18	3 meter
19	Indicating lamp	230V	1
20	Three pin plug	230V, 15A	1

Task 1: To prepare an appliance test board individually

Step 1: Take required a size of a wooden board.

Step 2: Provide holes wherever necessary.

Step 3: Fix the switches, socket, fuse, indicator, ammeter and voltmeter properly.

Step 4: Make connection as per circuit diagram.

Task 2: To know the method of testing the appliance test board

Step 1: Connect the given appliances to the socket where test lamp is connected in series.

Step 2: The brightness of the lamp and the faults are specified below.

S.No	Glow of lamp	Result
1	If the lamp glows at lesser brightness than as usual.	Appliance is in good condition.
2	If the lamp glows at its usual brightness	Appliance is short circuited.
3	If the lamp does not glow.	Appliance is open circuited.

Result:

- The method of testing the domestic appliance with the help of appliance test board was done properly.

The value of current and voltage in ammeter and voltmeter are respectively.

Current = ___________ Amps

Voltage = ___________ Volts

EXPERIMENT 5

One lamp controlled by a regulator

Aim:

To learn the method of doing one lamp controlled by a regulator and observe the illumination of the lamp.

Procedure:

Know the resistance offered by the regulator

↓

Connect the lamp with regulator

Tools and materials required:

S.No	Name of the apparatus/ components	Range/Value	Quantity
1	Multimeter (Digital)	AC supply (0 to 250 volts) A Resistance up to 50 Meg ohm.	1 No
2	Seven step non modular regulator	220V, 80W	1
3	Incandescent lamp	230V, 100W	1
4	PVC pipe	19 mm	5 Feet
5	PVC clamp	19 mm	4 No
6	Wooden screw	25 x 6 mm, 35 x 6 mm, 45 x 8 mm	Each 5 No
7	Teak wood box	4 x 4 inch	1 No
8	Round block PVC	3 ½ inch	1 No
9	Holder	Batten type	1 No
10	Copper wire multi strand	1 Sq.mm	As required
11	Wiring tool kit box		1 No
12	SPT switch	230V, 5A	1 No
13	Teak wood board	3½,’ x 2½,’	1 No

Task 1: To know the resistance offered by a regulator

Step 1: Collect all the required accessories and check the specification and its condition.

Step 2: Ensure the safety of work by wearing proper gloves.

Step 3: With the help of multi-meter, connect the rotatory switch resistance mode.

Step 4: Connect the red terminal of the multi-meter to one end of the regulator and black terminal to the other end.

Step 5: Measure the value of resistance offered by the regulator by adjusting it from minimum to maximum.

Task 2: Connect the lamp with regulator

Step 1: Regulator, switch, teak wood box are fitted accordingly with the help of tools and materials.

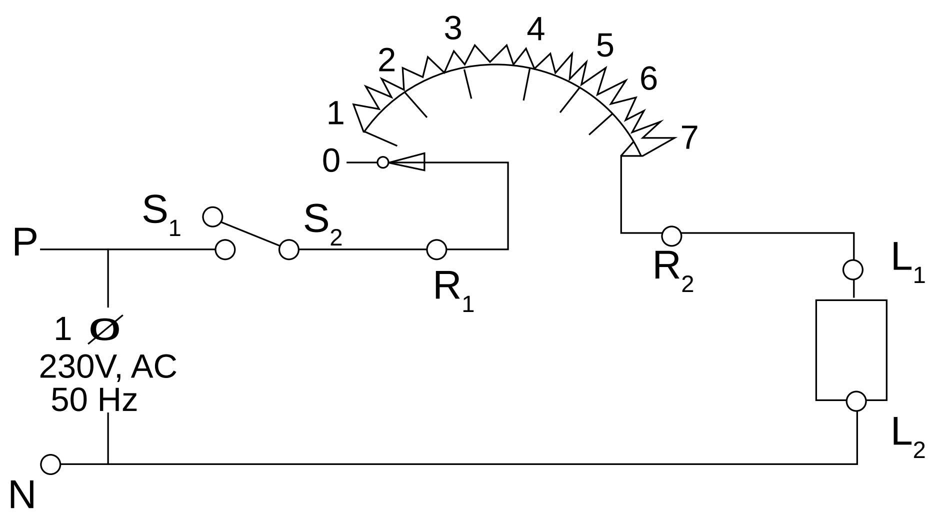
Step 2: Hole should be made for PVC pipe and wooden box, and smooth it with file.

Step 3: Fix tightly the PVC pipe of 1 feet length in the teak wood board for incoming supply.

Step 4: Fix the teak wood box with proper screws.

Step 5: Tight the PVC pipe of 1 Feet length is fixed vertically over the teak wood box.

Step 6: Fix the batten holder and the round block tightly.



Step 7: Do the connection diagram as per the circuit shown above.

Result:

Thus, the luminous output of the bulb was observed by connecting the regulator in series.

EXPERIMENT 6

Staircase wiring

Aim:

To do the practical method of doing staircase wiring using 2 way switch.

Practical procedure:

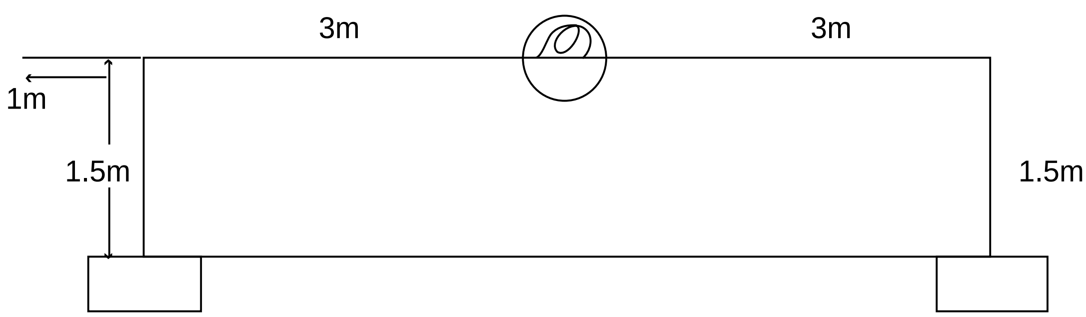
Direct connection wiring

↓

Cross connection wiring

Task 1: Direct connection wiring

Section 1 Line Diagram



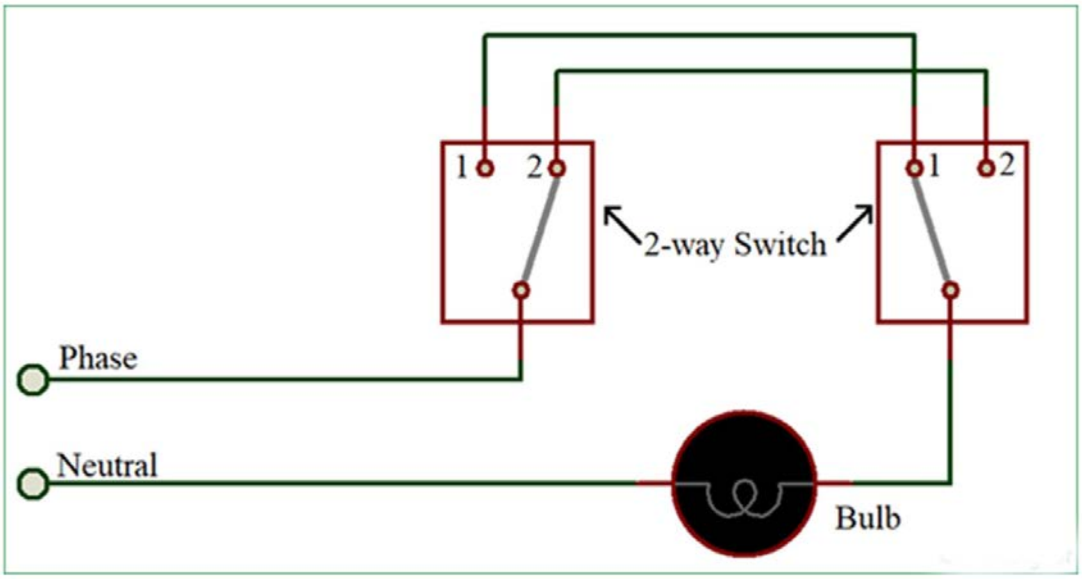
Line diagram of direct connecton wiring

Tools and materials required:

Sl. No	Tools and materials	Range	Quantity
1	Screw driver set	All size	Each 1 No.
2	Combinational pliers (Insulated)	150 mm	1
3	Line tester	230V	1
4	Electrician knife	100 mm	1

5	Electrical drilling machine	(6-12 mm) 350W	1
6	Ball peen hammer	0.5 kg	1
7	Hack saw blade	12”	1
8	Measuring tape	3 m	1
9	Poker	100 mm	1
10	Try square	Medium	1
11	Connector	-	1
12	Wooden box	4” x 4”	2
13	¾” PVC pipe	10 Feet	3 Nos.
14	1/18 Copper wire	1/18	20 Meter
15	‘L’ Bend	3/4”	5 Nos.
16	Two way switch	230V, 6A	2 Nos.
17	Holder	BC 230V	2 Nos.
18	Junction box	3 way	2 Nos.
19	3/4” clamps	3/4” inch	20 Nos.
20	Screws	1 inch	40 Nos.
21	Screws	1.5 inch	4 Nos.
22	Insulation tape	Roll	1
23	Bulb	230V, 60W	1

Procedure:



Step 1: Connect as per the circuit diagram.

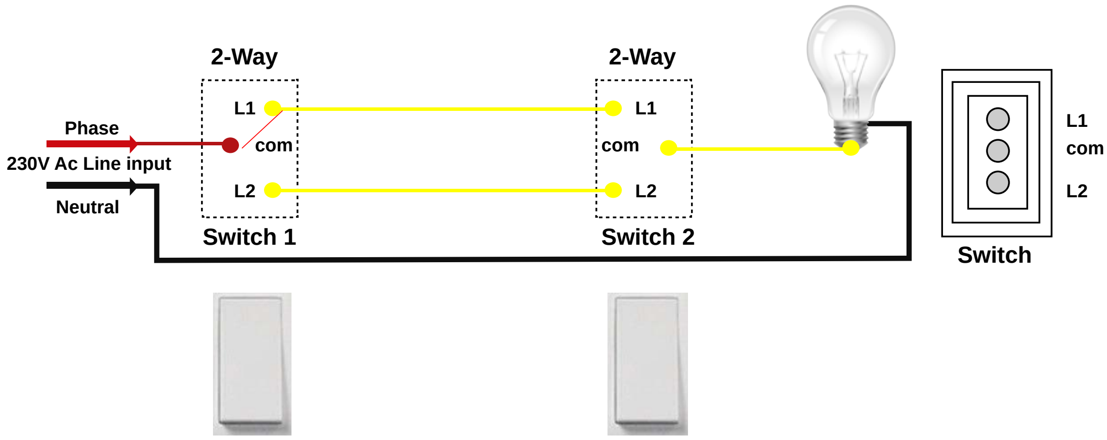
Step 2: Connect phase wire directly to the center point of the first two way switch.

Step 3: The first terminal of the first two way switch is connected to the first terminal of the second two way switch.

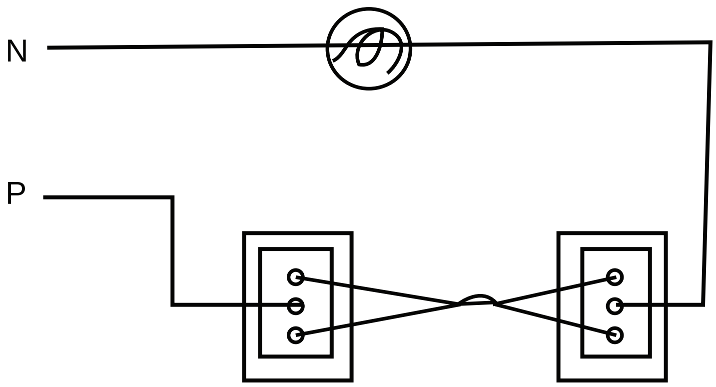
Step 4: Then the second terminal of the first two way switch is connected to second terminal of the second two way switch.

Step 5: The centre point of second switch is connected to one terminal of the bulb holder.

Step 6: Then, another terminal of the bulb is connected to the neutral wire.



Task 2: Cross connection wiring



Step 1: For cross connection, the first point of switch-1 is connected to the second point of switch-2.

Step 2: Then the second point of switch-1 is connected to the first point of switch-2.

Result:

The stair case wiring was completed and the lamps are glowing.

EXPERIMENT 7

Godown wiring

Aim:

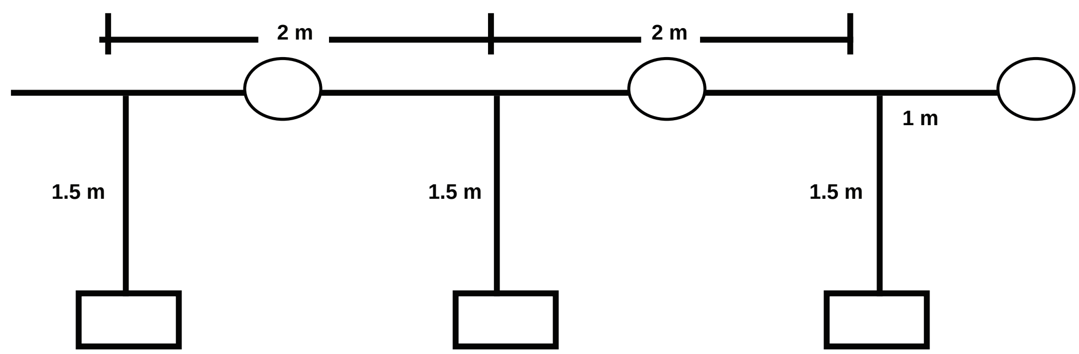
To do the godown wiring with line diagram.

Practical procedure:

Identification of line diagram

↓

Connection of Godown wiring



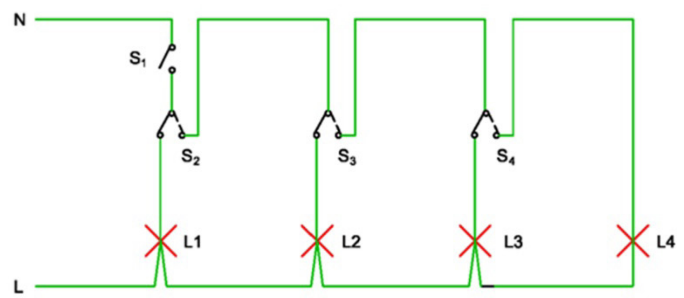
Line diagram of godown wiring

Tools and materials required:

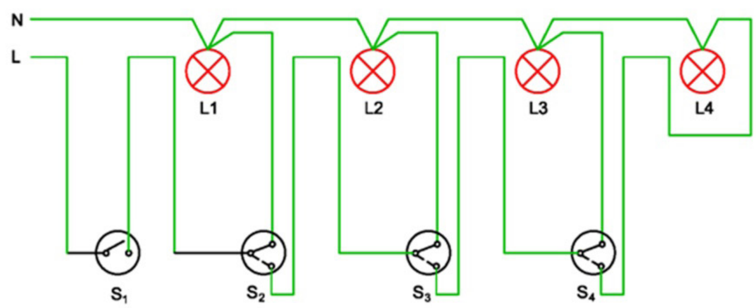
Sl. No	Tools and materials	Range	Quantity
1	Screw driver Set	-	Set box
2	Combinational pliers	150 mm	1
3	Line tester	250V	1
4	Electrician knife	100 mm	1
5	Electrical drilling machine	(6-12 mm) 350W	1
6	Ball peen hammer	0.5 kg	1
7	Hack saw blade	12”	1
8	Measuring tape	3 m	1
9	Poker	100 mm	1
10	Try square	Medium	1
11	Connector	-	1
12	Wooden box	4” x 4”	4 Nos.
13	PVC pipes	10.0”	6 Nos.
14	Copper wire	1/18	40 Metre
15	‘L’ Bend	3/4”	12 Nos.
16	One way switch		1 No
17	Two way switch	230V, 6A	3 Nos.
18	Holder	230V, 6A	4 Nos.
19	Junction box (3 way)	BC 230V	4 Nos.
20	Clamps	3/4”	30 Nos.
21	Screws	1”	60 Nos.
22	Screws	1½ “	6 Nos.
23	Insulation tape	-	1 Roll
24	Bulb	60W	4 Nos.

Procedure:

Task 1: Connection diagram for godown wiring

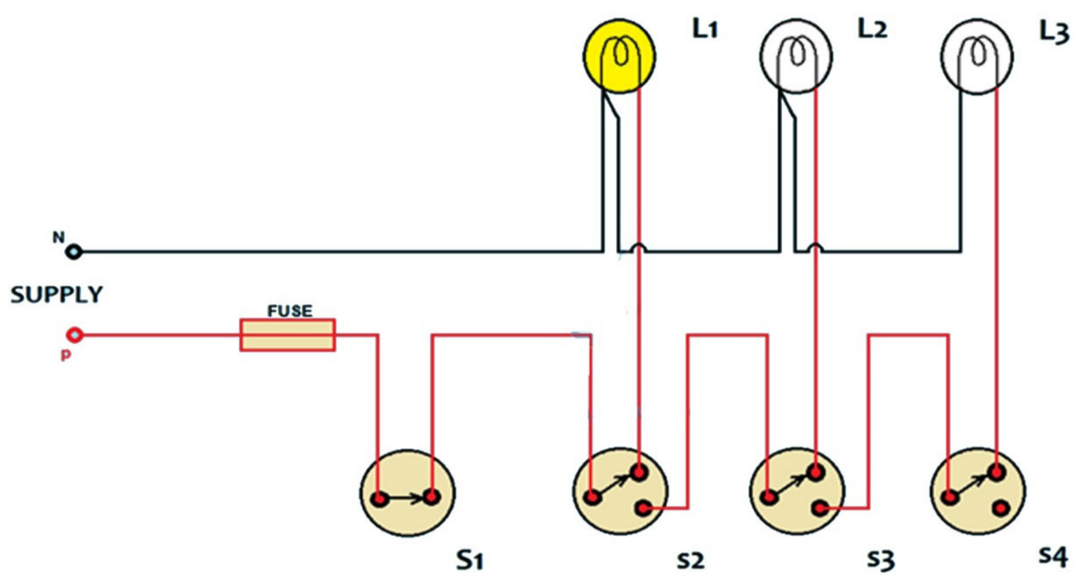


SCHEMATIC DIAGRAM OF GODOWN WIRING

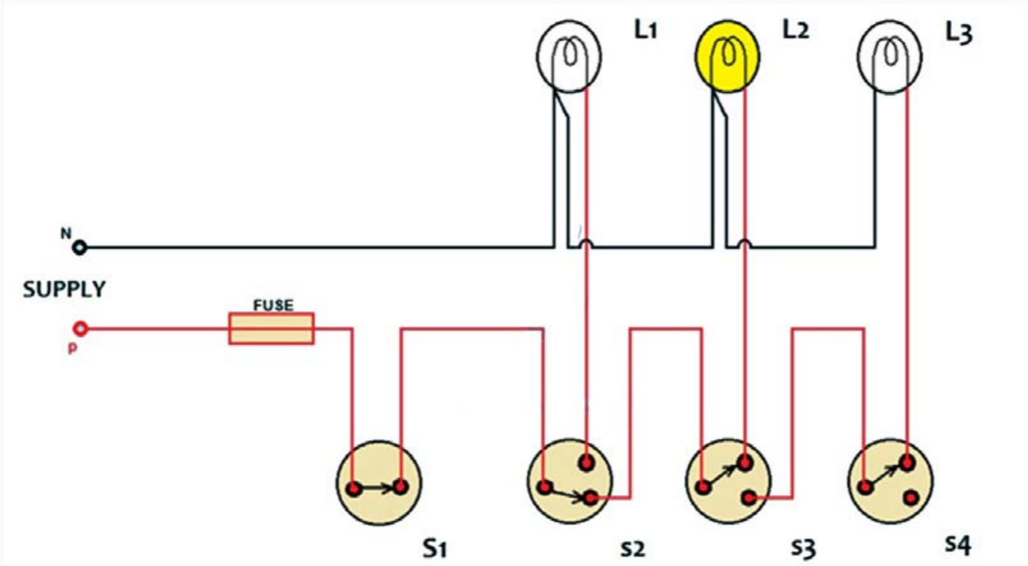


WIRING DIAGRAM OF GODOWN WIRING

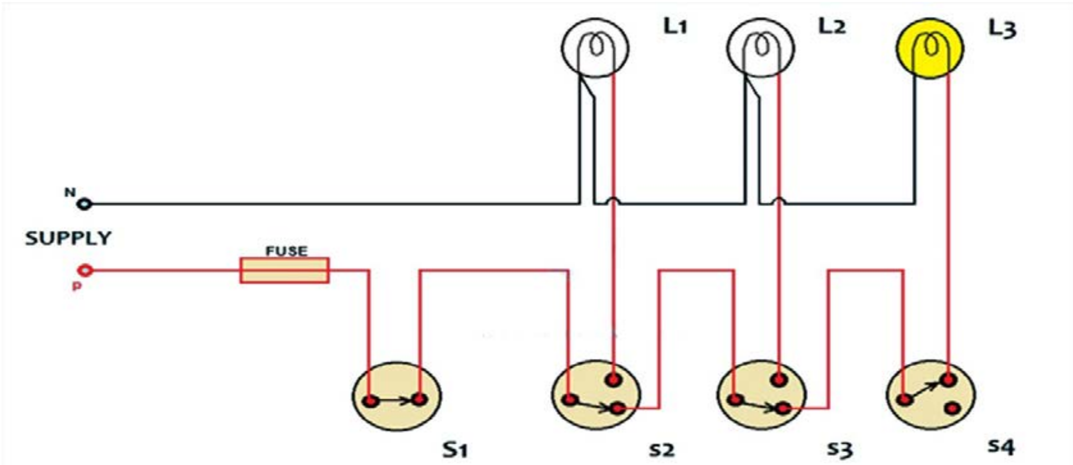
Step 1: Mark out the area where godown wiring has to be done.
Step 2: Fix the PVC pipe with clamps and screws and fix the junction box.
Step 3: Pull the wire with the help of spring inside the PVC pipe and connect switch properly.



Step 4: The second terminal of the first two way switch is connected to the center point of the second two way switch.



Step 5: The second terminal of the second two way switch is connected to the center point of the third two way switch.



Step 6: Then the second terminal of the third two way switch is connected to one end of the bulb holder No. 4.

Step 7: One end of the third two way switch is connected to bulb holder No. 3.

Step 8: One end of the second two way switch is connected to the bulb holder No. 2.

Step 9: One end of the first two way switch is connected to the bulb holder No. 1.

Step 10: All the second terminal of the bulb holder 1, 2, 3 and 4 is connected to Neutral supply. Now the circuit is completed.

Result:

Thus, the method of doing Go-down wiring has been done by using line diagram.

EXPERIMENT 8

OC and SC test on single phase transformer

Aim:

To Conduct OC and SC test and calculate total loss in single phase transformer.

Practical procedure:

Open circuit test

↓

Short circuit test

↓

Calculation of total loss in single phase transformer

Tools and materials required:

S.No	Name of the Tools/ Equipments	Range/Value	Quantity
1	Voltmeter	(0-300V) MI	1 No
2	Ammeter	(0-10A) MI	1 No
3	Wattmeter	(0-150V) LPF (0-2A) Dynamometer type	1 No
4	Wattmeter	(0-300V) UPF (0-10A) Dynamometer type	1 No
5	Transformer single phase	1 KVA, 230/115 V	1 No
6	Autotransformer single phase	1KVA, (0 – 270)V	1 No
7	ICDP switch	230V, 10A	1 No
8	Copper wire	2 Sq.mm	As req.

Procedure:

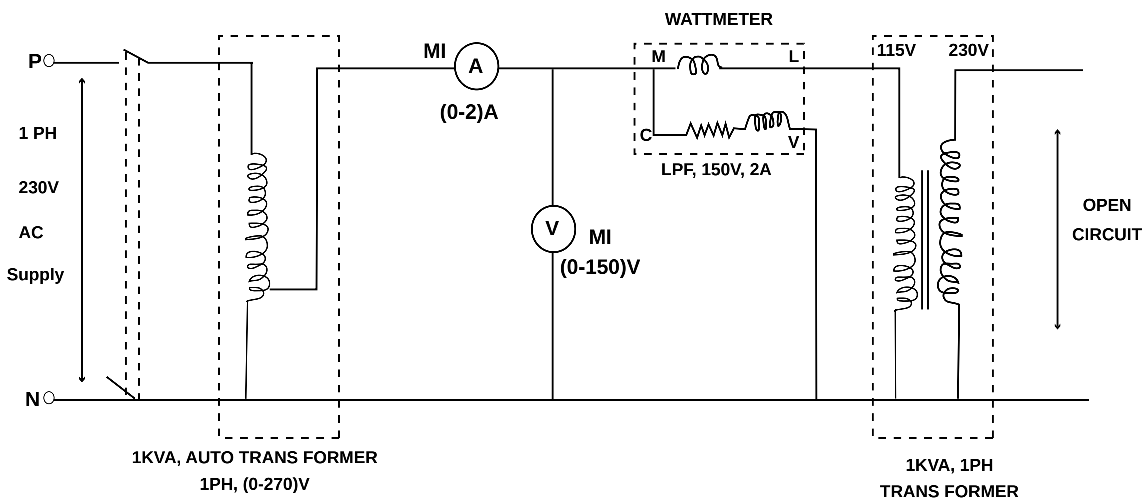
Note: OC test should always be conducted on the LV side and SC test should be on HV side.

Task 1: Open circuit test on single phase transformer

Step 1: Read the name plate details and identify the LV and HV sides of transformer.

Step 2: Connections are made as per the circuit diagram given below.

OPEN CIRCUIT TEST



Step 3: Before switching ON the supply, check whether the rotating knob in the auto transformer is in zero volt.

Step 4: Switch ON the ICDP.

Step 5: With help of auto transformer, gradually increase the voltage to the transformer up to rated voltage of LV side (115V).

Step 6: Note the meter readings in the table given below.

OPEN CIRCUIT TEST:

S.NO	Voc (Volts)	Ioc (Amps)	Woc(watts)
1			

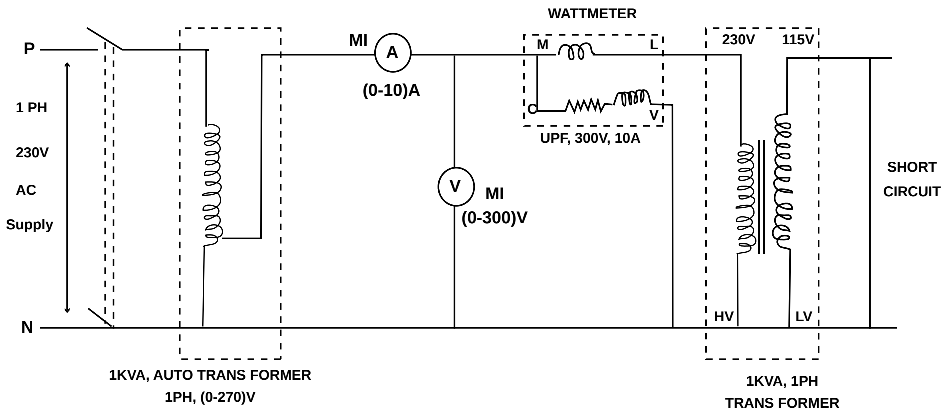
Step 7: Gradually decrease to zero volt by auto-transformer then switch OFF the ICDP.

Task 2: SC test on single phase transformer

Step 1: Connections are made as per the circuit diagram given below.

Step 2: Make a short circuit between LV terminals as in the circuit diagram given below.

SHORT CIRCUIT TEST



Step 3: Before switching ON the supply check whether the rotating knob in the auto transformer is in zero volt.

Step 4: With help of auto transformer gradually increase the voltage to the rate of load current less than 10 A.

Step 5: Note the readings in the table given below.

SHORT CIRCUIT TEST:

S.NO	Vsc (Volts)	If (Amps)	Isc (Amps)	Wsc(watts)

Step 6: Gradually decrease the voltage to the zero value by auto-transformer then switch OFF the ICDP.

Step 7: Calculate the full load loss by adding both wattmeter reading measured from open circuit and short circuit test.

Task 3:

The full load losses in the single phase transformer is calculated and given below,

i) Iron loss = ______________watts

ii) Copper loss = ____________watts

iii) Total Loss = _______________watts

Result:

The OC and SC test for a single phase transformer is conducted and calculated its total loss

EXPERIMENT 9

Testing of Active and Passive components

Aim:

To test the terminals of active and passive components.

Practical procedure:

Identification of active components

↓

Identification of passive components

↓

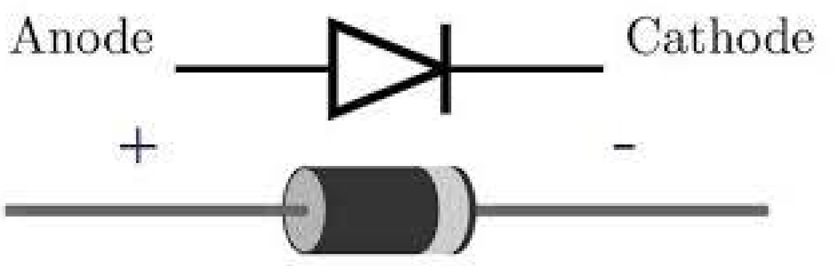
Testing of active and passive components

Tools and materials required:

S.No	Name of the tools/Instruments	Range	Quantity
1	Digital multi meter	AC/DC	1 No
2	Diode	1N4001	1 No
3	Transistor	BC547, BC557	Each 1 No
4	SCR	TYN 616	1 No
5	Carbon composition resistor	1000 0hms	1 No
6	Inductor	100 mh	1 No
7	Capacitor	63V, 100uf	1 No

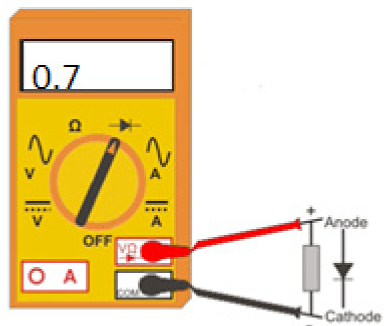
Procedure 1: Identifying and testing of Active components:

Task 1: Testing the diode



Step 1: Set the multi meter in diode position using selector switch.

Step 2: Place the red and black lead of the multi meter to the anode and cathode i.e. forward bias). Note the reading and verify with table 1.



Step 3: Now reverse the multi meter leads, red and black to cathode and anode of the diode respectively. (i.e. Reverse bias). Note the reading and verify it with table 1.

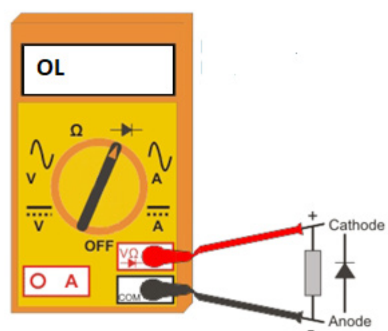


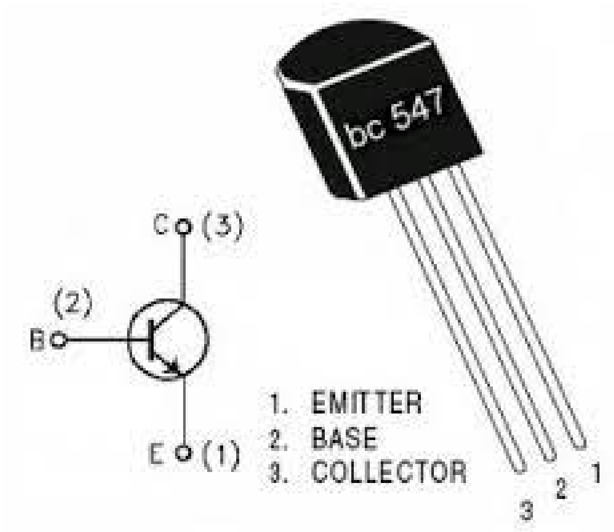
Table 1:

	Multi meter leads			
S.No	Red (Positive)	Black (Negative)	Mode of operation	Multi meter reading
1	Anode	Cathode	Forward bias	0.7
2	Cathode	Anode	Reverse bias	OL (Open Loop)

Step 4: If the reading matches with table 1, then the diode is in good condition, else diode is defective.

Task 2: Testing the NPN transistor

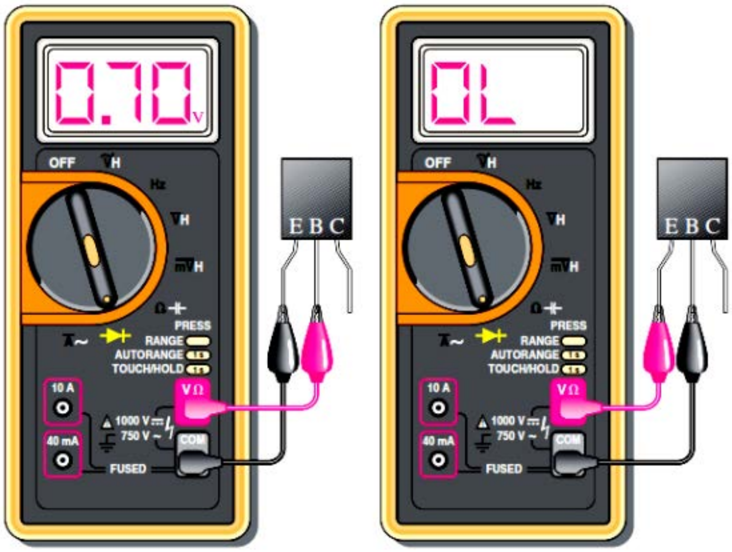
Step 1: Identify the terminals of NPN transistor (BC 547) Emitter, Base and Collector from the data sheet.



Step 2: Set the multi meter in diode test position using selector switch.

Step 3: Place the red and black lead of multi meter on the base and emitter terminal of the transistor respectively. (i.e. forward bias). Note the reading and verify with table 2.

Step 4: Reverse the multi meter leads red and black on emitter and base terminal of transistor respectively. (i.e. reverse bias). Note the reading and verify with table 2.



Step 5: Place the red and black lead of multi meter to the base and collector terminal of transistor respectively (i.e. forward bias). Note the readings and verify with table 2.

Step 6: Reverse the multi meter leads, with red and black of multi meter to the collector and base terminal of transistor respectively. (i.e. reverse bias) and verify the reading with table 2.

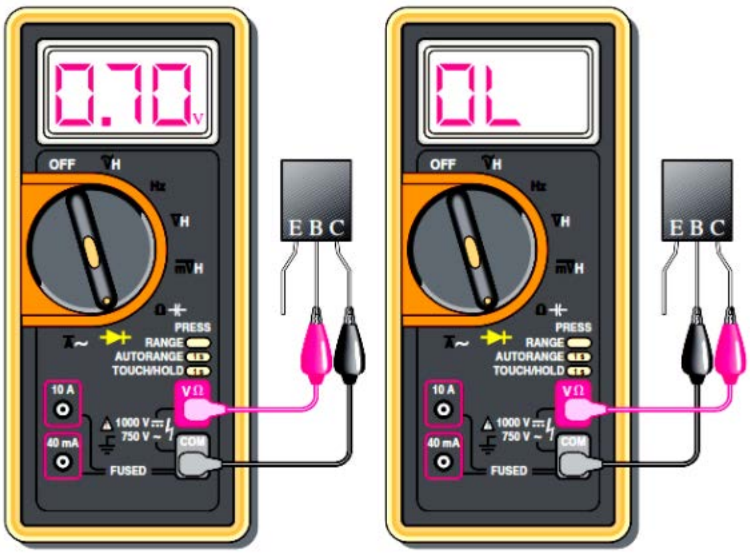


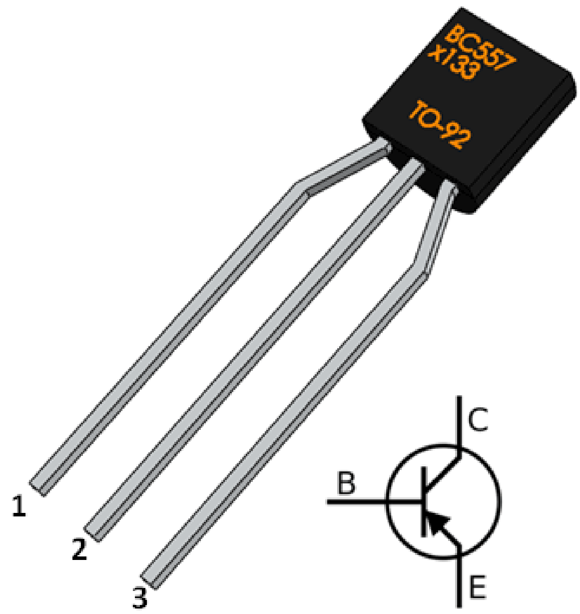
Table 2:

	Multi meter leads			
S.No	Red (Positive)	Black (Negative)	Mode of operation	Multi meter reading
1	Base	Emitter	Forward bias	0.7
2	Emitter	Base	Reverse bias	OL (Open Loop)
3	Base	Collector	Forward bias	0.7
4	Collector	Base	Reverse bias	OL (Open Loop)

Step 7: If the measured reading does not match with Table – 2, then the transistor is defective.

Task 3: Testing the PNP transistor

Step 1: Identify the terminals of PNP transistor (BC 557) Emitter, Base and Collector from the data sheet.



BC-557	
1	Collector
2	Base
3	Emitter

Step 2: Set the multi meter in diode testing position.

Step 3: Place the multi meter leads between the terminal of PNP transistor as shown in table 3 and verify the reading.

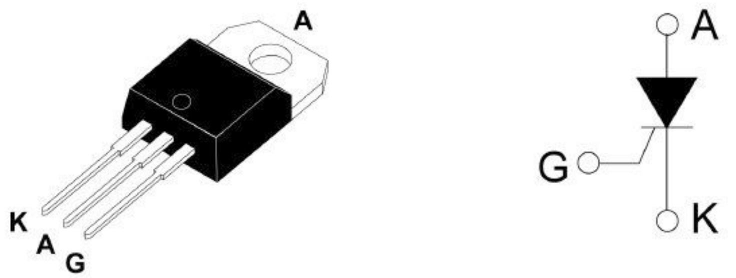
Table 3:

	Multi meter leads			
S.No	**Red (Positive)**	**Black (Negative)**	**Mode of operation**	**Multi meter reading**
1	Collector	Base	Forward bias	0.7
2	Base	Collector	Reverse bias	OL (Open Loop)
3	Emitter	Base	Forward bias	0.7
4	Base	Emitter	Reverse bias	OL (Open Loop)

Step 4: If the readings does not match with the table, then the transistor is defective.

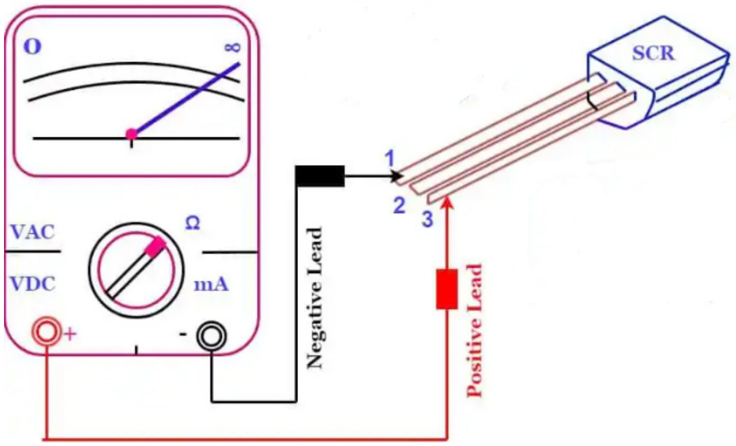
Task 4: Testing the SCR

Step 1: Identify the SCR (TYN 616) terminals Anode, Cathode and Gate from the data sheet.



Step 2: Set the multi meter in resistance mode by using selector switch.

Step 3: Place the red and black lead of multi meter at anode and cathode terminals of SCR respectively (forward blocking mode). Note and verify the readings with table 4.



Step 4: Place the red and black lead of multi meter at anode and cathode terminal with a short between anode and gate terminal (with small wire) of SCR (forward conducting mode). Note and verify the reading with Table 4.

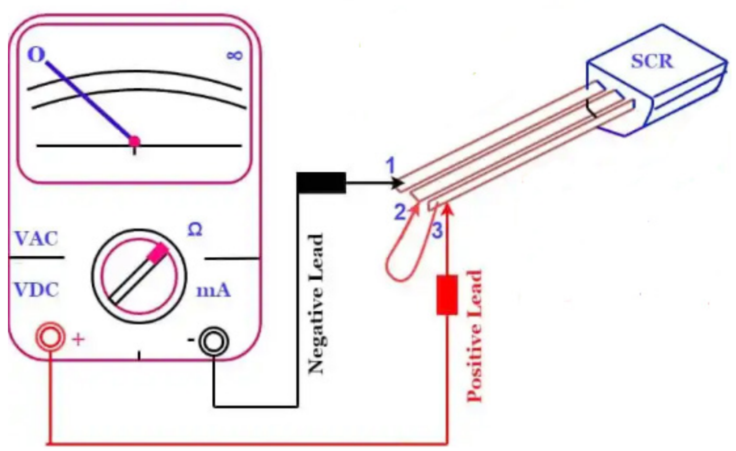


Table 4:

	Multi meter leads			
S.No	Red (Positive)	Black (Negative)	Mode of operation	Multi meter reading
1	Anode	Cathode	Forward blocking mode	infinity
2	Anode, Gate	Cathode	Forward conducting mode	0

Step 5: If the measured reading does not match with table 4, then the SCR is defective.

Procedure 2: Testing of passive components:

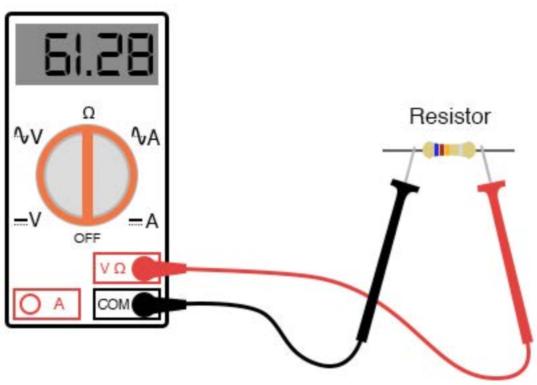
Task 1: Testing the resistors

Step 1: Take a metal film resistor and calculate its value by using colour code.

Step 2: Set the multi meter in ohms range that is equal to or higher than the value of the resistor to be tested.

Step 3: Place the red and black leads of multi meter at the two end of resistor (since resistors don't have polarity).

Step 4: Note and verify the reading from the multi meter with calculated one. If both the values are same, then the resistor is in good condition.

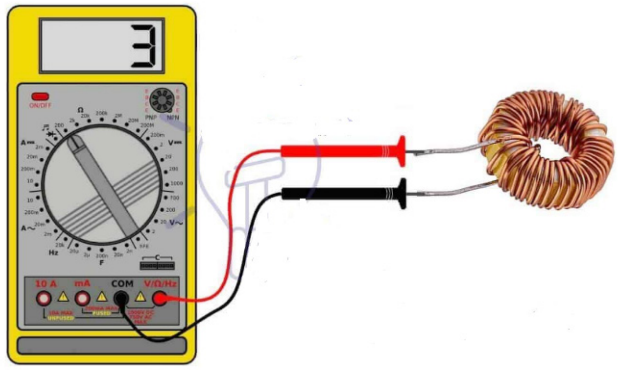


Step 5: If not displayed on the multi meter, then the resistor is defective.

Task 2: Testing the inductor

Step 1: Set the multi meter in resistance mode at least range.

Step 2: Place the multi meter leads across the inductor leads. (since we are measuring the resistance) Note the reading and ensure the resistance value not more than 10 Ω.



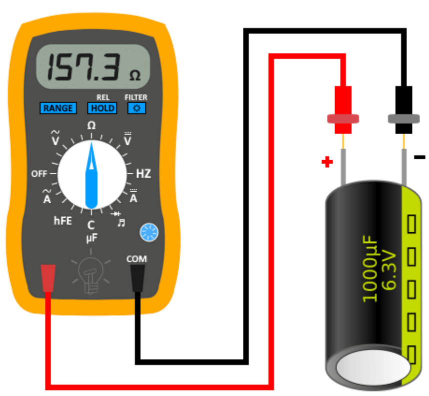
Step 3: If the multi meter does not shows any value on the resistance value lies more than 10 Ω, then the inductor is defective.

Task 3: Testing the capacitor

Step 1: Set the multi meter in resistance mode (at least for 1000 Ω).

Step 2: Place red and black leads of multi meter to the positive and negative terminal of capacitor respectively without changing the polarity.

Step 3: If the multi meter shows some readings and immediately it will return to OL (Open Loop) or infinity, then the capacitor is in good condition.



Step 4: If the multi meter reading remains constant, then the capacitor is defective.

Result:

The active and passive components were identified and tested.

EXPERIMENT 10

Series and Parallel connections of batteries

Aim:

Calculate the Voltage and current rating of batteries in series and parallel connections.

Practical procedure:

Batteries in series connection

↓

Batteries in parallel connection

↓

Measuring the voltage and current of batteries

Tools and materials required:

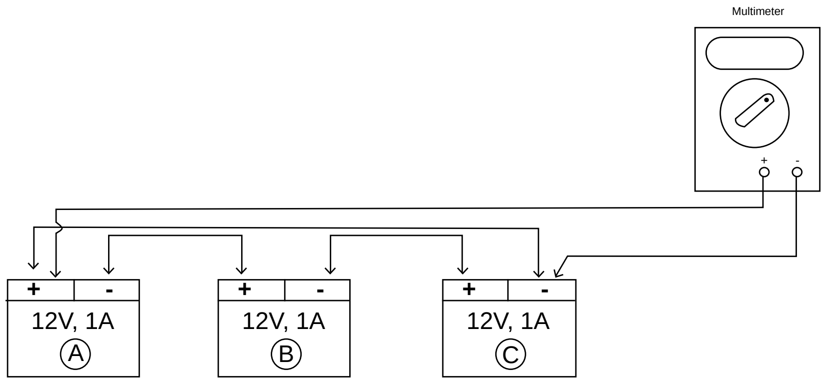
S.No	Name of the tools/Equipment	Range/Value	Quantity
1	Rechargeable lead acid battery	12 V, 7 AH	3 Nos
2	Voltmeter	(0 – 50V) MC	1 No
3	Multimeter	(0 – 100V)	1 No
4	Connecting leads (or) Cables with crocodile clips	1.5 Sq.mm.	As required

Task 1: Connecting batteries in series

Step 1: Check all the batteries are having the same ampere hour rating.

Step 2: Name the battery as A, B and C.

Step 3: Connect the negative terminal of battery (A) to the positive terminal of another (B) and so on until all the three batteries are connected as shown Measure the voltage and current using voltmeter/multimeter.



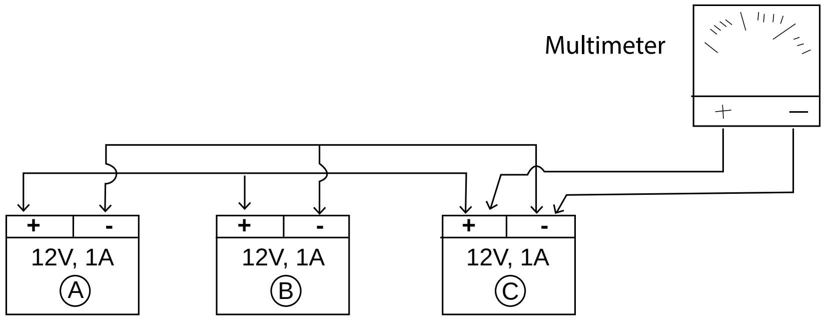
Step 4: Measure the voltage by applying positive and negative terminals of voltmeter to (any of the) positive and negative terminals of series connected batteries with same polarity as shown below.

Step 5: Note down the readings in below table.

S.No	Model of connection	Voltage	Current
1	Series		

Task 2: Connecting batteries in parallel

Step 1: Measure the voltage with voltmeter by connecting positive and negative terminal to any of the positive and negative terminal of parallel connected batteries as shown below.



Step 2: Note down the readings in below table.

S.No	Model of connection	Voltage	Current
1	Parallel		

Result:

The batteries are connected in series and in parallel, voltage and current values are measured and calculated.

EXPERIMENT 11

Three phase star connection

Aim:

To connect and verify the load in star connection.

To verify the relationship between Line and Phase values in star connection.

Practical procedure:

Circuit connection diagram

↓

Measuring the voltage values

Tools and materials required:

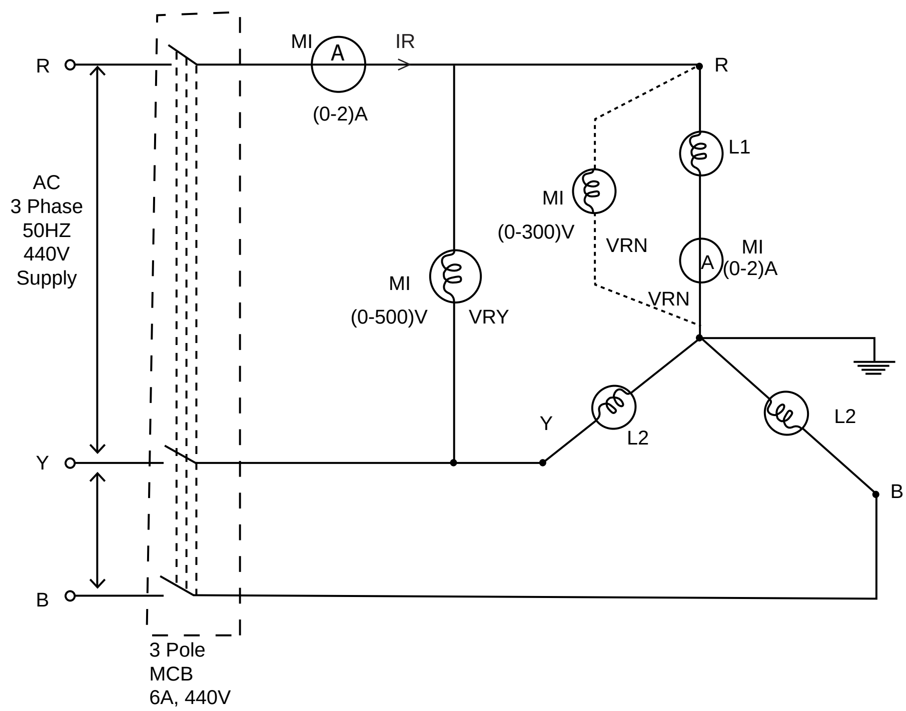
S.No	Name of the tools/Equipment	Range/Value	Quantity
1	Screwdriver	150mm	1 No
2	Combination plier	150 mm	1 No
3	Ammeter	Amp MI	2 Nos
4	Voltmeter	(0 – 500) Volts MI	2 Nos
5	3 Pole MCB	6A,440 volts	1 No
6	BC lamp	100W, 230V	3 Nos
7	BC lamp	200W, 230V	3 Nos
8	Copper wire	1.5 Sq.mm	As Req

Procedure:

Task 1: Circuit diagram

Step 1: Connect the circuit as per the diagram. with one lamp each connected to all the 3 phase (100/200W).

STAR CONNECTED NETWORK



Step 2: Identify the 3-phase and neutral of the supply terminals.

Task 2: Measuring the voltage values

Step 1: Switch ON the 3-phase supply.

Step 2: Measure the line voltage V_{RY} by placing the voltmeter leads between the two lines R and Y. Note the readings in table 1.

Step 3: Repeat the step 4 to measure other line voltages V_{YB} and V_{BR}.

Step 4: Measure the phase voltage by placing the voltmeter leads between one line and star point N and note the readings in table 1.

Step 5: Measure the phase and line current from the ammeters and note the reading in table 1.

Step 6: Repeat the steps from 3 to 7 for various loads (100w, 200w).

Table 1:

S.No	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{RY}	V_{YB}	V_{BR}	V_{RN}	V_{YN}	V_{BN}	I_R	I_Y	I_B	I_{RN}	I_{YB}	I_{BN}
1	100W												
2	200W												

Step 7: Calculate the ratio between line and phase voltage and ensure the values are around 1.732 V.

Step 8: Verify the line current and phase current and ensure the values are unity.

Result:

From the calucations it was observed that the line and phase currents are same ($I_L = I_{ph}$) and line voltage is 1.732 times that of the phase voltage ($V_L = 1.732 V_{ph}$).

EXPERIMENT 12

Three phase delta connection

Aim:

To connect the loads in delta connection.

To verify the relationship between line and phase values in delta connection.

Practical procedure:

Circuit connection diagram

↓

Measuring the voltage values

Tools and materials required:

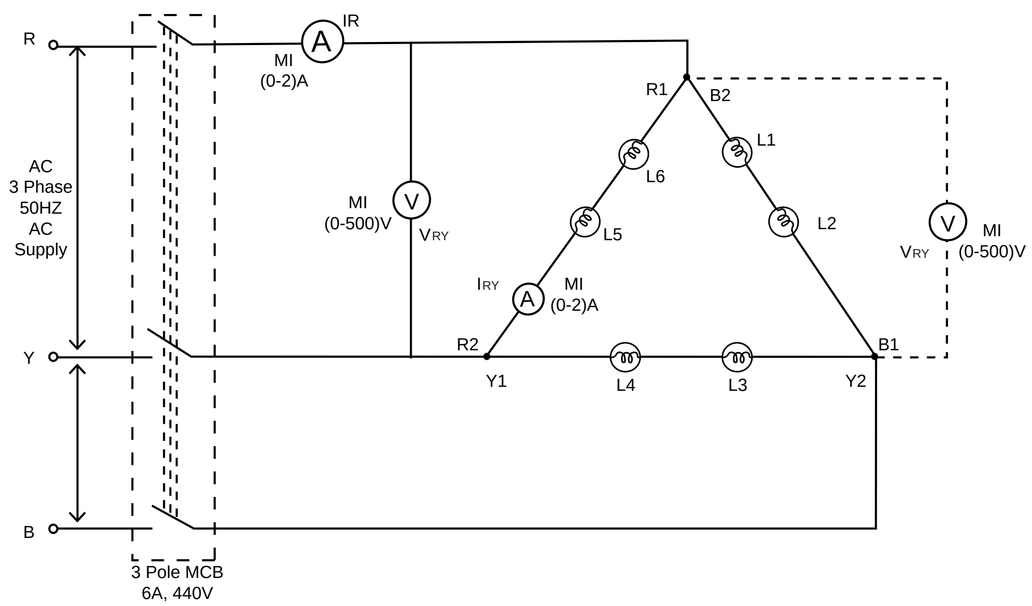
S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Screw driver	150 mm	1 No
2	Combination plier	150 mm	1 No
3	Ammeter	(0-2A) MI	2 Nos
4	MI Voltmeter	(0 – 500V) MI	2 Nos
5	3 Pole MCB	6A,440 volts	1 No
6	BC lamp	100W, 230V	6 Nos
7	BC lamp	200W, 230V	6 Nos
8	Copper wire	1.5 Sq.mm	As Req

Procedure:

Task 1: Circuit diagram

Step 1: Connect the circuit as per the diagram given below. Two lamps in series to be connected between two phases of the same voltage.

DELTA CONNECTED NETWORK



Step 2: Identify the 3-phase and neutral with the supply terminals.

Task 2: Measuring the voltage values

Step 1: Switch ON the 3-phase supply.

Step 2: Measure the line voltage by connecting the voltmeter leads between the two lines R_1, Y_1, B_1.

Step 3: Measure the phase voltage in the voltmeter across R_1 and R_2 or Y_1 and Y_2 or B_1 and B_2.

Step 4: Measure the line current from ammeter connected between supply and load.

Step 5: Measure the phase and line current from the ammeter connected in single load terminal (Two lamps connected in series) Note the readings in Table 1. .

Step 6: Repeat the steps from 3 to 7 for various loads (100w, 200w).

Table 1:

S.No	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{RY}	V_{YB}	V_{BR}	V_{RN}	V_{YN}	V_{BN}	I_R	I_Y	I_B	I_{RN}	I_{YB}	I_{BN}
1	100W												
2	200W												

Step 7: Calculate the ratio between line and phase voltage and ensure the ratios are unity.

Step 8: Verify the line current and phase current and ensure the values are around 1.732 A.

Result:

The relationship between line and phase values in delta connections are verified. The line voltage and phase voltages are same. Line current (I_L) is 1.732 times greater than the phase current (I_{PH}) in the delta connection.

EXPERIMENT 13

Automatic iron box

Aim:

To dismantle, identifying the parts, testing and reassembling of an iron box.

Practical procedure:

Dismantling the iron box

↓

Checking the power cord

↓

Conducting earth fault in iron box

↓

Testing the thermostat

↓

Reassembling the iron box

Tools and materials required:

S.No	Particulars	Range	Quantity
1	Combination Plier	200 mm	1 No
2	Screw driver	3 to 6 mm	1 Set
3	Automatic iron box	750W	1 No
4	Test lamp	230V, 60W	1 No
5	Appliance test board	230V, 6A	1 No
6	Copper wire	1.5 sq.mm	as req.

Procedure:

Task 1: Dismantling the iron box

Step1: Unscrew the housing of iron box with appropriate tool.

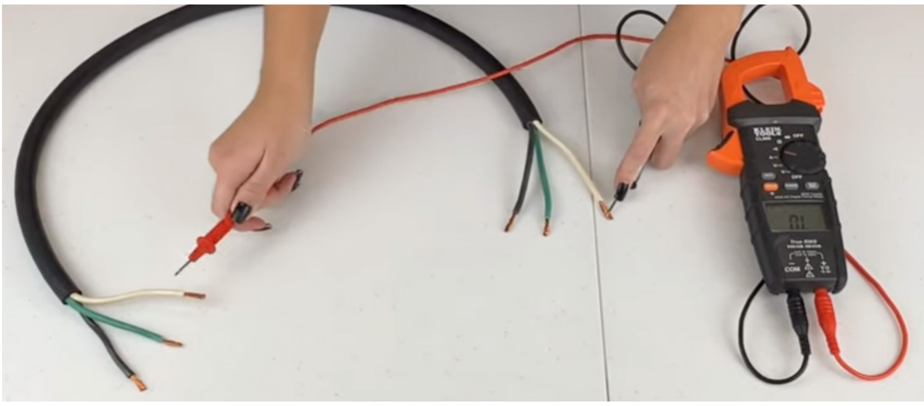
Step 2: Remove the 3 core power cable connected to the heating element via thermostat. Note down the terminals where phase, neutral and earth (body) wires are connected.

Task 2: Testing the power cord

Step 1: Conduct the continuity and short circuit test in the power cord.

Step 2: Place the test lamp between each terminal in 3 pin top and ensure that no short circuit occurs between phase, neutral and earth.

Step 3: Place the test lamp between one terminal in three pin top and other end of power cord at same wire to ensure the continuity.(Check with all three wires).



Step 4: you can also use multimeter in continuity mode to check continuity and short circuit in power cord

Task 3: Conducting Earth fault test in the iron box

Step 1: Isolate the power supply from the iron box.

Step 2: Place a test lamp between metal body of iron box and each terminal (phase, neutral and earth) one by one in 3 pin top as shown below.

Step 3: If lamps glows, then earth fault exists in the circuit, Replace the power cord with good one.

Task 4: Testing the thermostat

Step 1: Remove the indicator connected across the thermostat. Test the indicator lamp with test lamp. If it not glow, replace it.

Step 2: Manually test the thermostat, heating element and sole plate.

Step 3: Dismantle the thermostat from the heating element.

Step 4: Check the thermostat manually whether any moving contact is connected with bimetallic strip.

Step 5: Check the knob by rotating with free hand and ensure it is working smoothly.

Step 6: Connect the thermostat and indicator lamp in series with the heating element.

Step 7: Connect the supply to the heating element. Adjust the knob and ensure that the thermostat is working properly.

Task 5: Reassembling the iron box

Reassembling the parts in reverse process as done in dismantling. Ensure that now parts were left out.

Result:

The Iron box was dismantled, reassembled and tested. Now it is working in good condition.

EXPERIMENT

14

Induction stove

Aim:

To dismantle, test and reassemble the induction stove.

Practical procedure:

Dismantling of induction stove

↓

Testing the various components of induction stove

↓

Reassembling of induction stove

Tools and materials required:

S.No	Name of the Tool/Equipment	Range/Value	Quantity
1	Screw driver	300 mm	1 No
2	Combination plier	200 mm	1 No
3	Long nose plier	150 mm	1 No
4	Cotton waste		As required
5	Induction stove	1800W	1 No
6	Digital multi meter	AC/DC	1 No
7	Emery sheet	500	1 No

Procedure:

Task 1: Dismantling procedure of an induction stove

Step 1: Note down the specifications in name plate details and separate it.

Step 2: Disconnect the power supply of the Induction stove and ensure that it has no power.

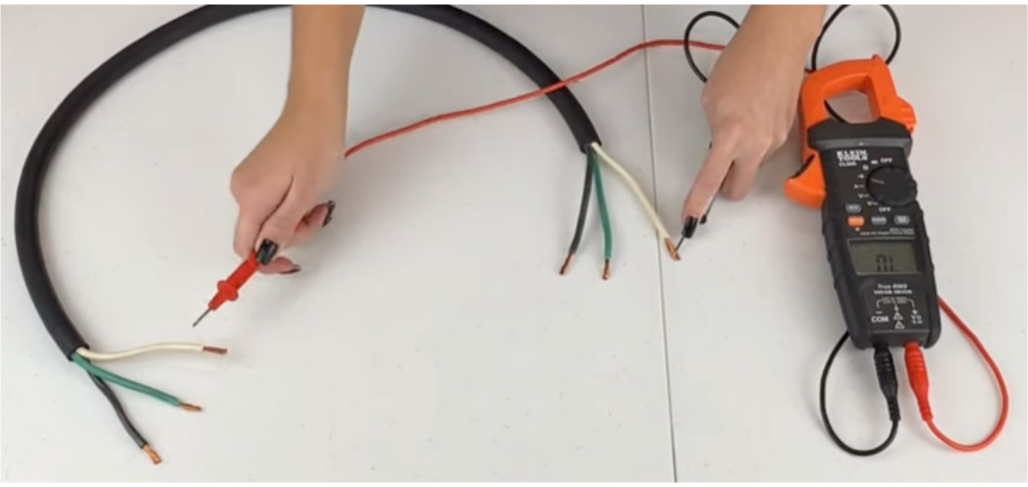
Step 3: Unscrew the power supply in the induction stove and remove the power cord.

Step 4: Remove the induction stove top separately with the body.

Task 2: Testing the components

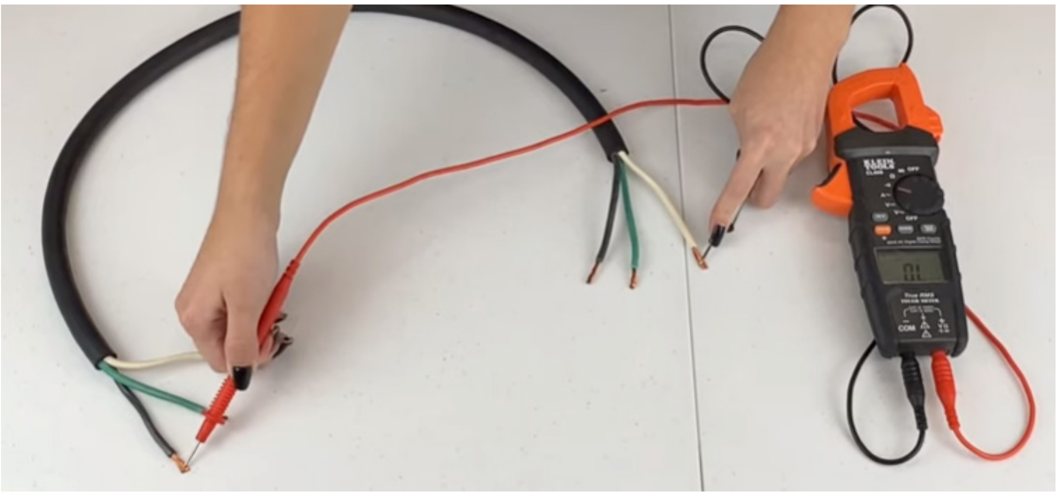
Step 1: Continuity test.

Test the power cord with multi meter and ensure it is in continuity. If the continuity of the cord is not correct, replace a new one.



Step 2: Open and Short circuit test.

While connecting the power cord terminal with multi meter, if the value is displayed in the meter, it indicates the appliance is in good condition. If there is no value it indicates the open circuit.



When we connect the two leads of the multi meter with the induction stove, if beep sound occurs, that indicates the short circuit in the appliance. Then remedial measure has to be taken to clear the fault.

Step 3: Check the fuse with multi meter by setting it in continuity mode, if beep occurs then fuse is ok or otherwise replace it.

Step 4: Check the Bridge rectifier IC by setting the multi meter in continuity mode and know whether it is in good condition. If any defects in IC, replace it.

Step 5: Check the IGBT terminal with the help of multi meter. If any defect in it, replace it.

Step 6: Check the induction coil terminal visually, and if any defects in it be replaced.

Step 7: Ensure all the defective components in the stove are replace it with specific rating.

Step 8: Assemble the parts in reverse process as dismantled.

Step 9: Now test the appliance induction stove with supply.

Result:

The method of dismantling, reassembling and testing of an induction stove was done systematically and now the appliance is working in good condition.

EXPERIMENT 15

Geyser

Aim:

To know the method of dismantling, testing and reassembling of a geyser

Dismantling the geyser

↓

Testing the various components

↓

Reassembling the geyser

Tools, materials and instruments:

S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Insulated screw driver	300 mm	1 No
2	Insulated combination plier	200 mm	1 No
3	Insulated long nose plier	150 mm	1 No
4	Cotton waste		as required
5	Geyser	2000W	1 No
6	Series test lamp board with test probe	230V	1 No
7	Incandescent lamp	230V, 100W	1 No
8	Multi meter		1 No
9	Emery sheet	500	1 No

Procedure:

Task 1: Dismantling the geyser

1. Disconnect the water inlet from the tank or close the inlet valve.
2. Switch off the power supply before dismantling and remove power cord.
3. Remove thermostat and heating element.

Task 2: Testing the components of a geyser

Step 1: Check the power cord of the geyser with Multimeter. (set the Multimeter to the beep continuity mode).

Continuity test: Place the multimeter red probe to the power cord line terminal one end and place the other end of multimeter black color probe to the other end of the line terminal. Hear the sound whether beep occurs or not, if beep occurs, continuity is in good otherwise fault may be in the line terminal. Repeat the step in the power cord, neutral and earth terminal.

Short circuit test: Place the multimeter red probe in line terminal and Multimeter black probe to the neutral terminal. If beep sound occurs, line and neutral terminal are in short circuit. Similarly carry the test with the earth terminal.

Step 2: Check Auto cut off accomplishing the thermostat. If it is not working in selected temperature value change the auto cut off switch to new one.

Step 3: Check the Thermostat with the series lamp test board.

Condition:

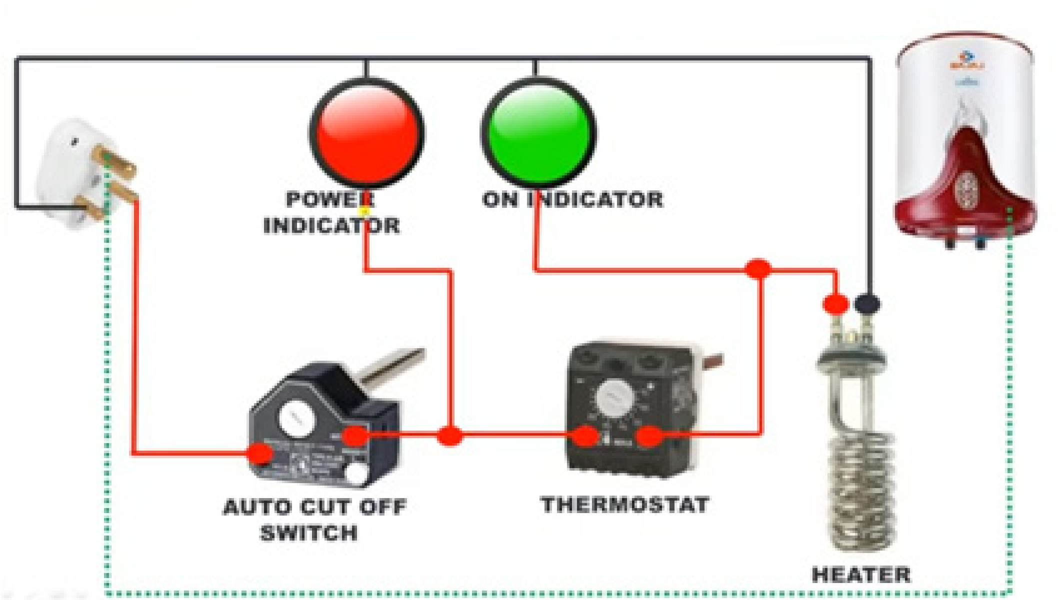
NC terminals always close – test lamp start glow else fault. Change the thermostat.

Step 4: Check the filament with the test board, if lamp glow then filament is ok or change the filament. Similarly check the filament terminal to the insulated cover of the filament. If the lamp glows, it indicates short circuit. Then change the filament with the new one.

Step 5: Ensure all the fault component are replaced with name plate of the geyser.

Task 3: Re assembling the geyser

Step 1: Assemble the geyser by reversing the process did in dismantling.



Step 2: Check the working condition by giving power source.

Result:

The dismantling, testing and reassembling were properly conducted. The appliance geyser is in good condition.

EXPERIMENT 16

Microwave oven

Aim:

To know the method of dismantling, testing and reassembling of a micro wave oven.

Practical procedure:

Dismantling the micro wave oven

↓

Testing of micro wave oven

↓

Reassembling of micro wave oven

Tools and materials required:

S.No	Name of the apparatus/component	Range/Value	Quantity
1	Insulated screw driver	300 mm	1no
2	Insulated long nose plier	150 mm	1 no
3	Micro wave oven	2000W	1 No.
4	Digital multi meter		1no
5	Soldering iron	50W	1no
6	Soldering paste		As required
7	Solder lead	60/40	As required

Procedure:

Task 1: Dismantling the micro wave oven

Step 1: Remove the power cord of the microwave oven from the power supply.

Step 2: Unscrew the cabinet screw of the microwave oven.

Step 3: Identify the high voltage power capacitor without touching any of the components.

Step 4: Discharge the capacitor by using long insulated nose plier by shorting the terminals of high voltage capacitor.

Task 2: Testing of micro wave oven

Step 1: Ensure the high voltage capacitor is discharged.

Step 2: Test the power cord and electrical components of the micro wave oven with multi meter and know its continuity.

Step 3: Test the high voltage capacitor with the multi meter. If the capacitor is defective, replace it.

Step 4: With the help of multi meter or test lamp, test the continuity of heating element. If the heating element is not in good condition, replace it.

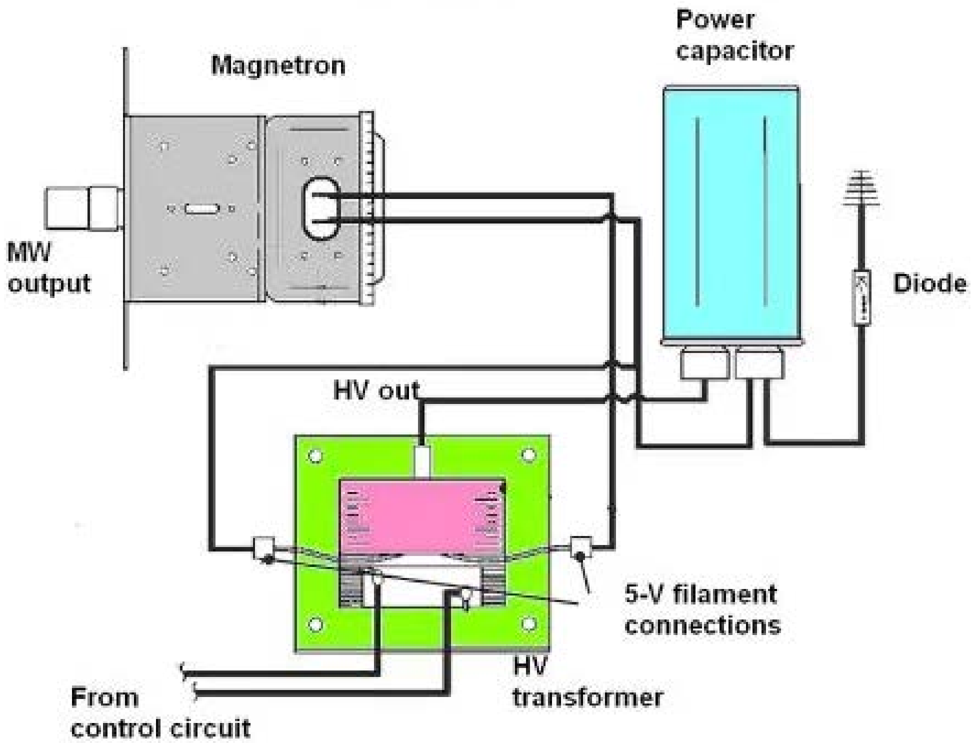
Step 5: Test the power transformer with multi meter and know its continuity. If any defects in coil side, replace it with a new one.

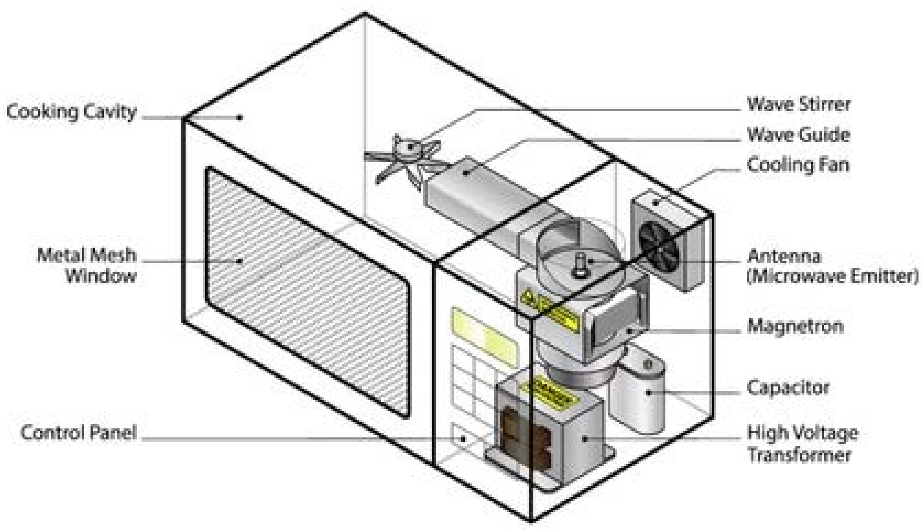
Step 6: Test the magnetron with the help of multi meter and know whether it is working or not. If it is not works, replace it to a new one.

Step 7: To know the earth leakage in magnetron, the multi meter leads are connected with magnetron and body. If the magnetron is under earth fault, then replace it with a new one.

Step 8: Test the continuity of the diode with multi meter and used accordingly.

Task 3: Assemble the appliance of micro wave oven with a reverse process as did in dismantling.





Step 1: After testing of all the components reassemble it, and test the appliance with supply, It is working in good condition.

Result:

The dismantling, testing and reassembling of micro wave oven appliance was conducted practically and now the appliance is working with good condition.

EXPERIMENT 17

Ceiling fan

Aim:

To know the method of dismantling, testing and reassembling of a ceiling fan.

Practical procedure:

Dismantling of ceiling fan

↓

Earth fault test

↓

Continuity test between the windings

↓

Identification of starting and running winding.

↓

Testing of capacitor

↓

Changing of polarity

↓

Reassmbling of fan

Tools and materials required:

S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Appliance test board	6A, 230V	1
2	Test lamp	60W, 230V	1
3	Combination plier	200 mm	1
4	Multi meter	(0 - 100V)	1
5	Ceiling fan	100 W, 230V	1
6	Screw driver	2 mm, 3 mm, 4 mm	Each 1
7	Spanner set	6 mm to 22 mm	1 set
8	Copper wire	1.5 Sq.mm.	As required
9	Insulation tape	-	1

Procedure:

Task 1: Dismantling the ceiling fan

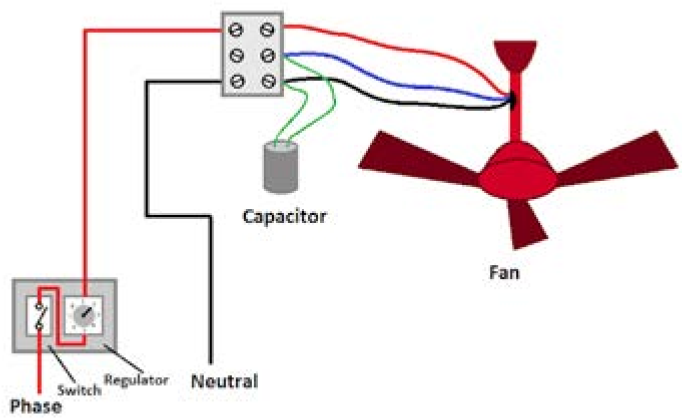
Step 1: Disconnect the power supply from the fan.

Step 2: Remove the fan from the ceiling.

Step 3: Keep the ceiling fan on the work bench.

Step 4: Remove the fan rod and blade from the body.

Step 5: Before removing the capacitor from the terminals, note (or) mark the points where the capacitor is connected.



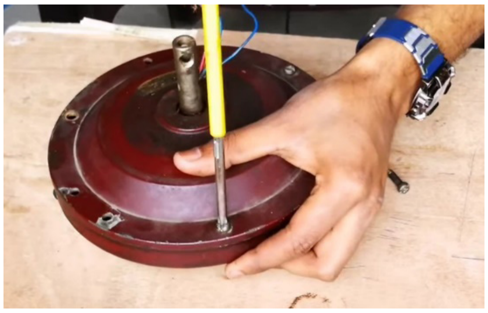
Ceiling fan Wiring Diagram

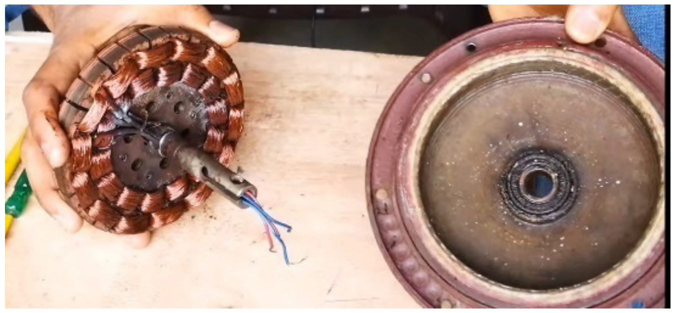
Task_2: Testing the earth fault

Step 1: Connect the test lamp between the each terminals (3) and the body of fan to know any insulation failure occurs as shown below.

Task 3: Checking continuity between the windings

Step 1: Remove the housing of the fan with appropriate tools.



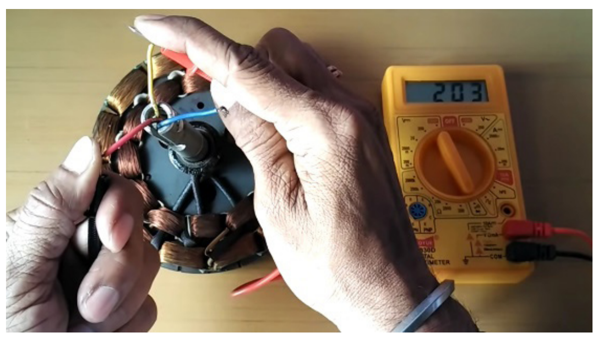


Step 2: Connect the test lamp between the terminals and check the continuity in the windings are correct.

Step 3: If the test lamp does not glow, it indicates that the windings are not in good and replace it with new winding.

Task 4: Identifying starting winding and running winding

Step 1: Connect the low value of resistance range in the multimeter using the selector switch.



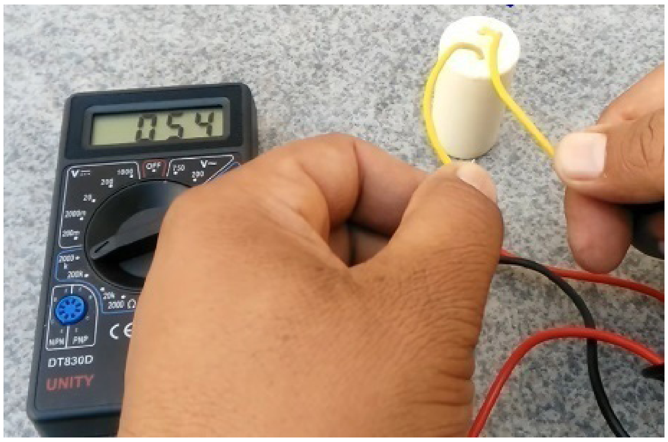
Step 2: Note the readings in the below table and identify the starting and running winding.

S.No	Resistance in ohms	Starting or running winding
1		
2		

Note:

Low resistance and high resistance ensure running and starting winding respectively.

Task 5: Testing of capacitor.

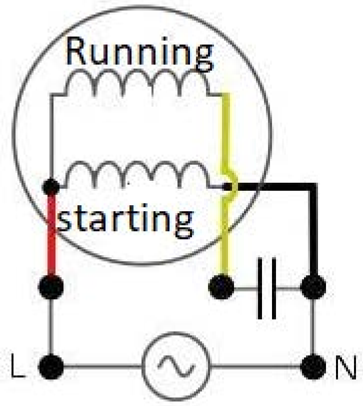


Step 1: The multi meter shows specific value of resistance on display it indicates the capacitor is good. If the value shows infinity, it indicates open circuit.

Step 2: If the values on the multi meter displays remains same with no change, then the capacitor is defective, and replace another.

Task 6: changing of polarity

Step 1: To reverse the direction in ceiling fan, remove the capacitor from starting winding and reconnect in series with the running winding as shown below.



Task 7: Assembling the fan

Step 1: Connect the capacitor back to its original position. i.e. series with starting winding.

Step 2: Close the housing and tighter the screw.

Step 3: Now hold the rotor, and rotate the stator with free hand and ensure the fan rotates with no noise and vibration. Else replace the bearings.

Step 4: Connect the power supply to the fan, check its working before mounting on ceiling.

Result:

The ceiling fan was dismantled, conducted various tests and finally reassembled. Now the ceiling fan is running in good condition.

EXPERIMENT 18

Table Fan

Aim:

To know the method of dismantling, testing and reassembling of a table fan.

Practical procedure:

Dismantling of table fan

↓

Conduction of OC, SC and EF tests

↓

Reassmbling of table fan

Tools and materials required:

S.No	Name of the apparatus/ components	Range/Value	Quantity
1	Table fan	230V, 60W	1
2	Combinational plier	150 mm	1
3	Screw driver	150 mm	1
4	Test lamp	230V, 100W	1
5	Multi meter	Digital	1
6	Connecting wires		As required
7	Grease		1 pocket
8	Waste cloth		As required

Procedure:

Task 1: Dismantling of a table fan

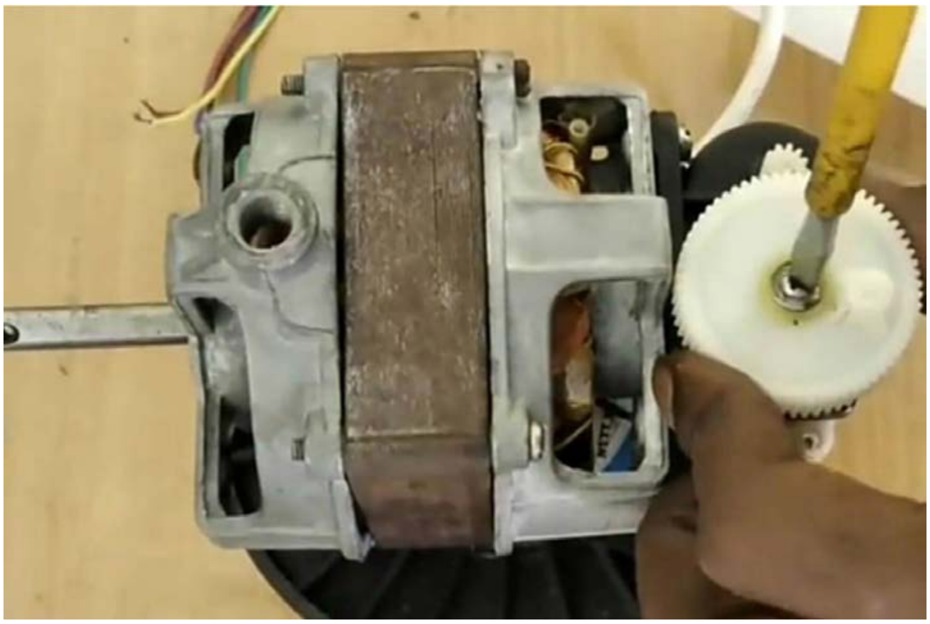
Step 1: Keep the table fan in smoothed surface area.

Step 2: Open the clips of the front cage and keep separately.

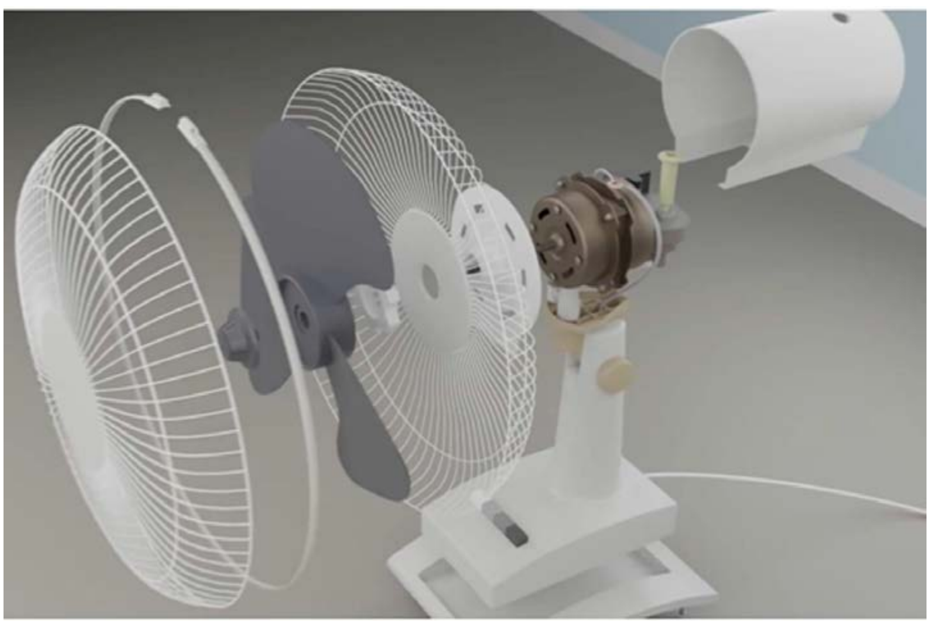
Step 3: Remove the screws in the blades by using screw driver, and separate it from the shaft.

Step 4: Unscrew the back cover and remove it.

Step 5: Take out the gear box by removing the mounted screws.



Step 6: Finally remove the rotor with combinational plier and keep separately.



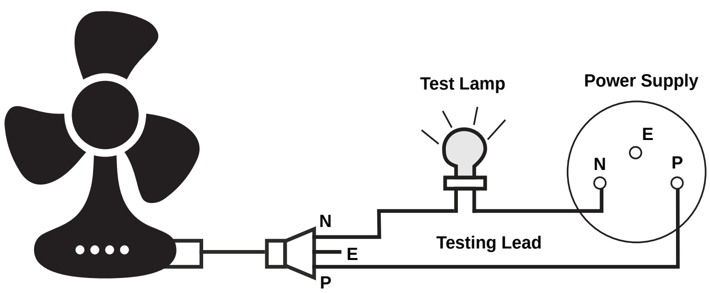
Task 2: Identification of parts of a table fan

1. Front cage
2. Regulator/ON-OFF switch
3. Back cage
4. Blades
5. Power cord
6. Gear box (Oscillating mechanism)
7. Motor

Task 3: Testing of a table fan

Open circuit and Short circuit test

Step 1: Connect the testing procedure as per diagram. When the supply is ON, if the lamp glows with dim brightness, it represents the table fan is in good condition. If the lamp glows with the specified watts, then it indicates short circuit. If the lamp does not glow, it indicates the open circuit.



Earth fault Test

Step 1: In test lamp method, connect one terminal with supply and another terminal with the body of the table fan. If the test lamp glows, it indicates the table fan is under earth fault.

Capacitor Test

1. By using 230V AC supply

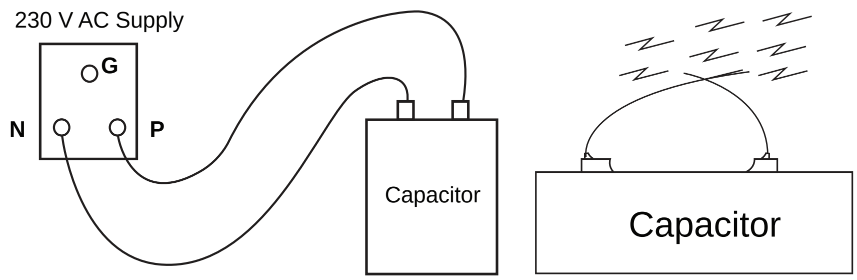
Step 1: Make sure that the capacitor is fully discharged.

Step 2: Short the two ends of the capacitor to discharge (or) short it with the help of a screw driver.

Step 3: Connect the capacitor terminals with AC supply for few seconds to make it charge and disconnect it from the supply.

Step 4: Following safety precautions, make the terminals to get short circuited.

Step 5: If it gets strong spark, it indicates the capacitor is in good condition. If the spark is weak (or) gets no spark, it indicates that the capacitor is defaulted and new capacitor has to be replaced.

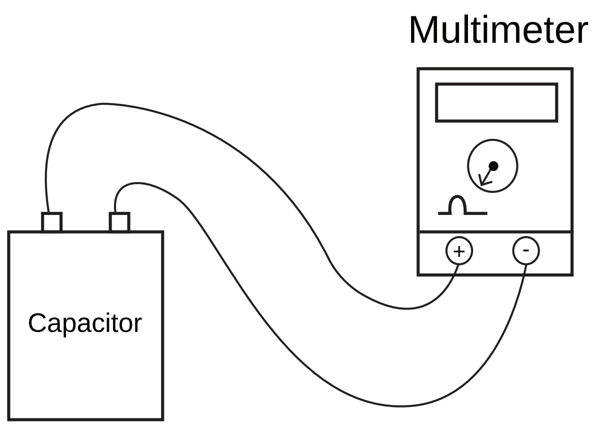


2. By using multi meter

Step 1: Make sure that the capacitor is fully discharged.

Step 2: Short the two ends of the capacitor to discharge (or) short it with the help of a screw driver.

Step 3: Connect the multi-meter leads with the capacitor terminals.



Step 4: Keep the multi meter knob in high resistive value.

Step 5: If the value of multi-meter increases from zero towards high, it indicates that the capacitor is charging and in good condition.

Step 6: If the value of the multimeter will decreases and reach towards zero, It indicates that the capacitor is discharging, and have to replace new one.

Task 5: Reassembling of table fan

Step 1: After completing the tests of table fan, assembling has to be done. For this we have to follow the reverse process as what was done during dismantling the table fan.

Step 2: Fix the gear box on the motor and tight the screws by using screw driver.

Step 3: Fix the back cover of the table fan and screw it.

Step 4: Then fix the blades and then tight the screws.

Step 5: Finally, fix the front cage of the table fan and close it with clips.

Result

The given table fan was practically dismantled, its parts were identified and tested and finally it was reassembled. Now the table fan is running with good condition.

19 Mixer/Juicer

Aim:

To know the method of dismantling, testing and reassembling Mixer/Juicer.

Operations to be covered under this experiment:

Dismantling of the mixer

↓

Testing of parts

↓

Reassmbling of mixer

List of tools and equipments:

S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Appliance test board	6A, 230V	1
2	Test lamp	230V	1
3	Combination plier	200 mm	1
4	Multi-meter	AC/DC	1
5	Mixer	230V, 750W	1
6	Screw driver	3 mm, 4 mm	Each 1
7	Wire stripper	150 mm	1
8	PVC copper wire	2 Sq mm	As required
9	Insulation tape	-	1

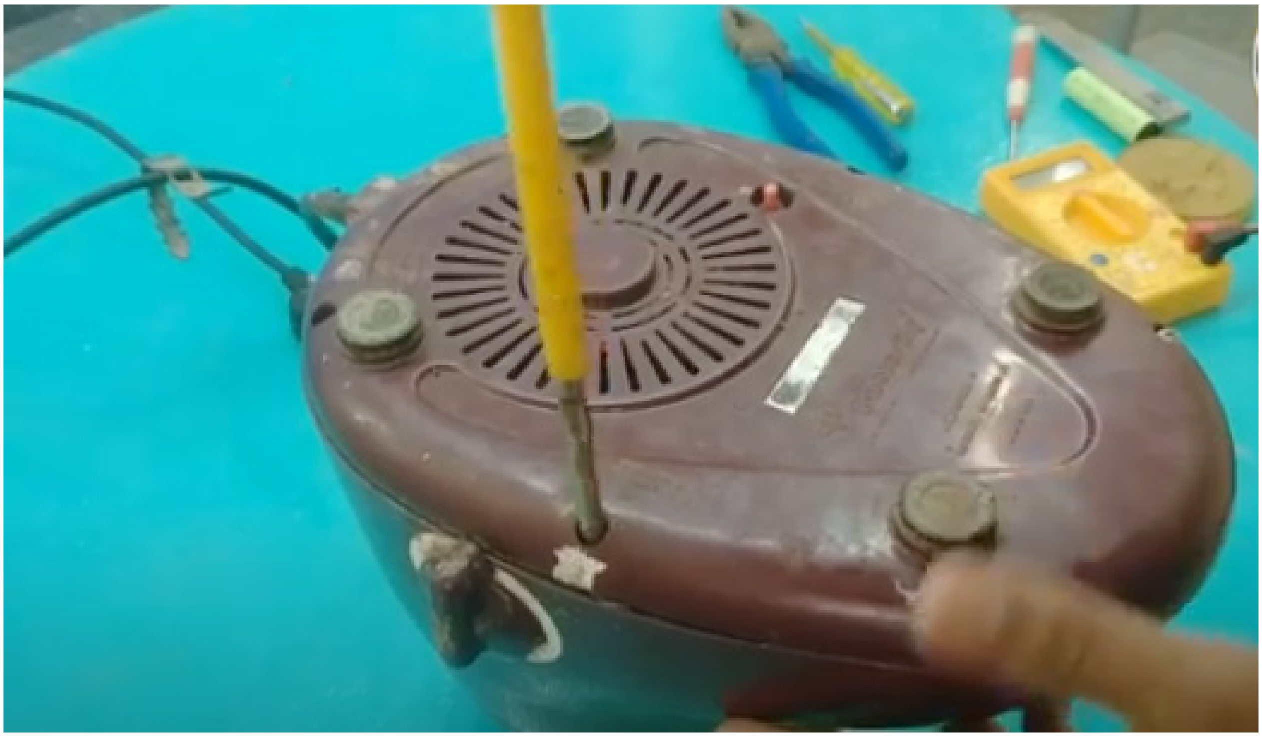
Procedure:

Task 1: Dismantling method of Mixer

Step 1: Remove the power supply from the mixer.

Step 2: Invert the mixer to down position.

Step 3: Unscrew the housing from the bottom as shown below.



Step 4: Unplug the wires from the overload switch and speed regulator.

Task 2: Testing the power cord

Step 1: Remove the power cord from the mixer. Visually, If any damage can be seen replace it.

Step 2: Test the continuity of the power cord with multi meter and ensures it is good.

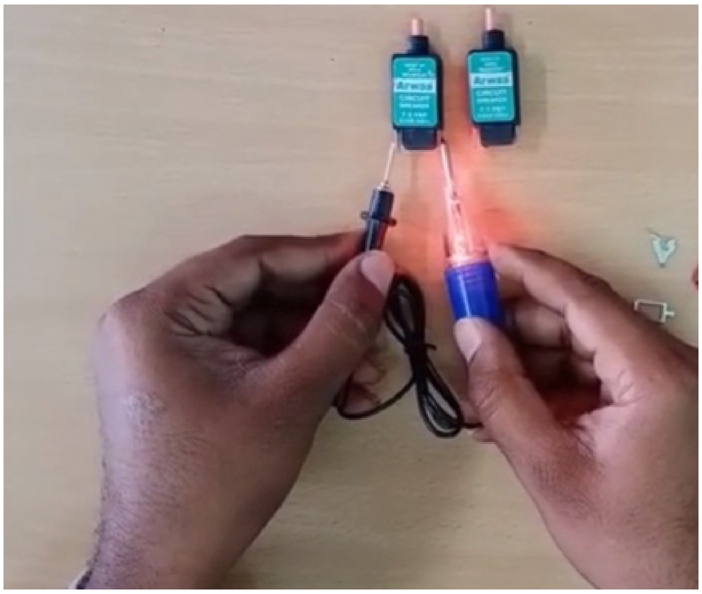
Step 3: Test lamp can also be used for knowing the continuity of power cord.

Task 3: Testing of the over load switch

Step 1: Remove the overload switch from the housing.

Step 2: Check the working of overload switch by pressing the reset knob

Step 3: Connect the test lamp between the two terminals of overload switch as shown below.



Step 4: If lamp does not glow, switch is defective. Replace the switch with a new one.

Task 4: Testing of the speed regulator

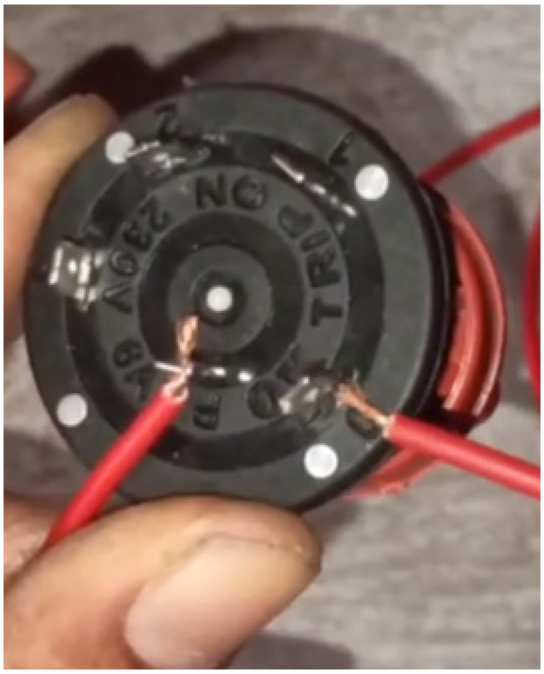
Step 1: Fix the multi meter in continuity mode.

Step 2: Set the knob in zero position in the speed regulator.

Step 3: Check the continuity by selecting Point 1, 2, 3 in the rotary switch.

Step 4: If there is no continuity, replace the switch with new one.

Step 5: Use the test lamp between the point 'p' and other terminals 0, 1, 2 and 3 in rotary switch.

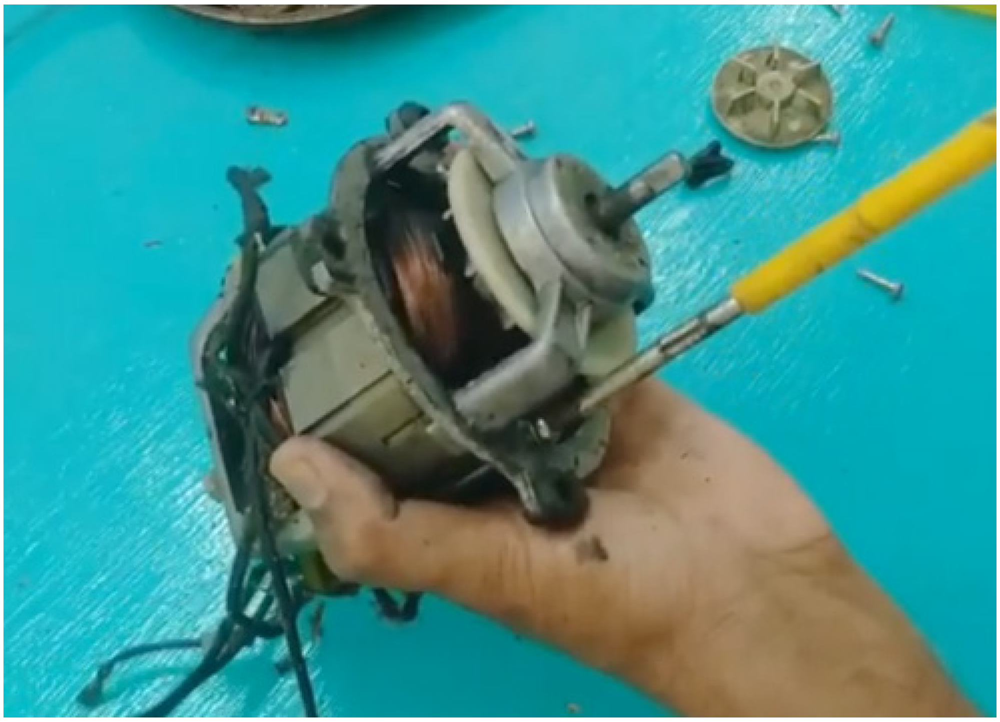


Caution:

Most care is needed while checking the continuity in rotor winding by using test lamp.

Task 5: Dismantling the motor

Step 1: Remove the motor from the housing.

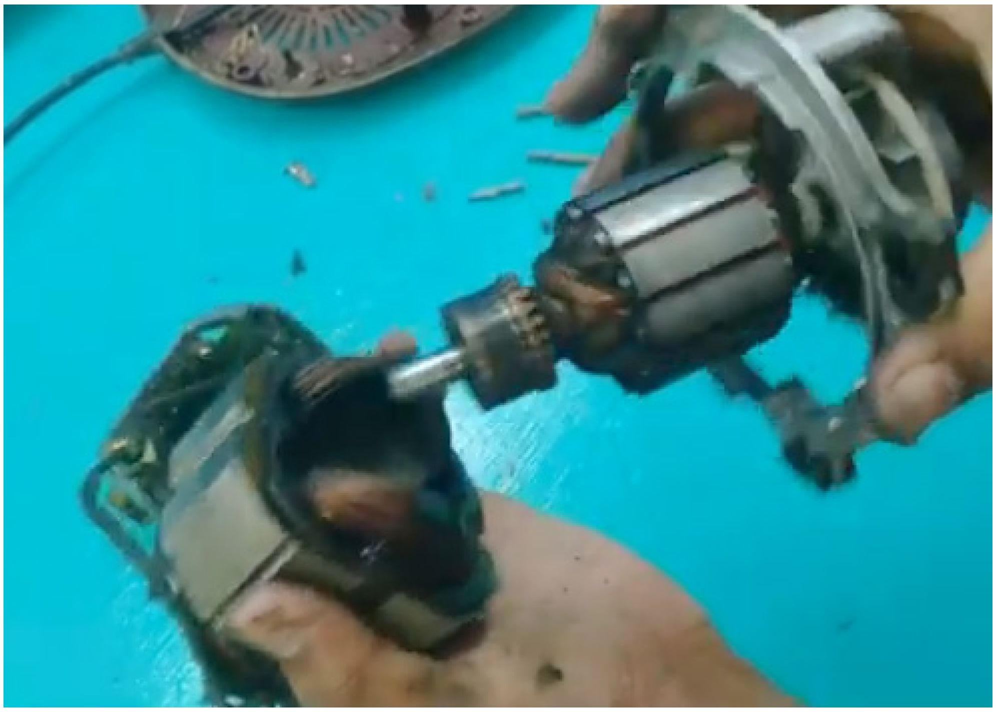


Step 2: Dismantle the motor parts as shown below.

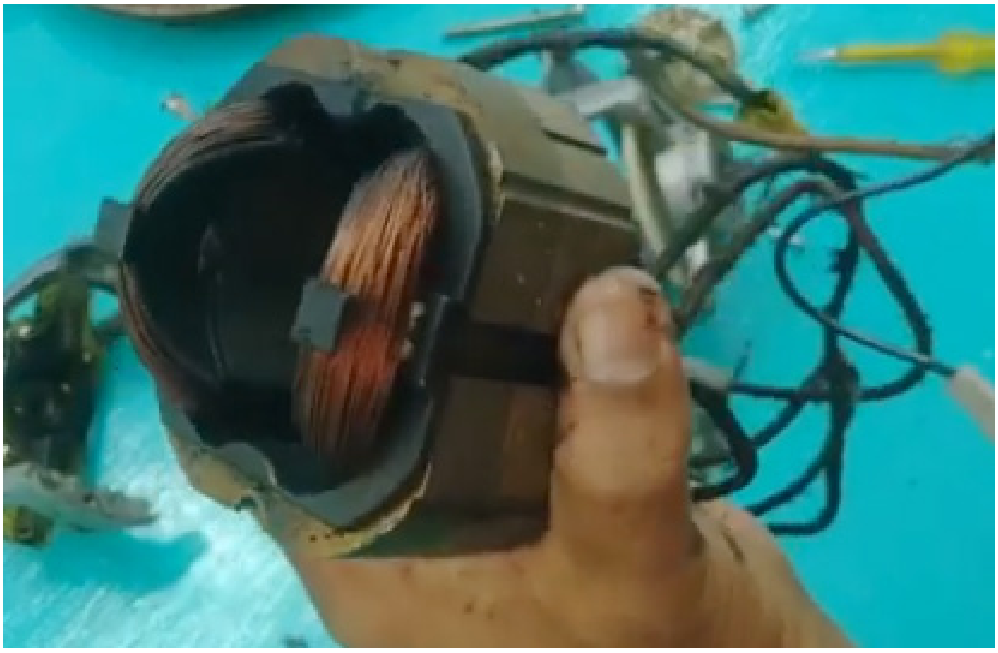
Step 3: Remove the carbon brushes from the housing, check visually, If any depreciation occurs, replace with good one.

Note: Depreciation in the carbon brush can lead to occur sparking at commutator & motor may stop.

Step 4: Separate the stator from rotor.



Step 5: Check the continuity in the stator winding using the multi-meter between the tapping as shown below.

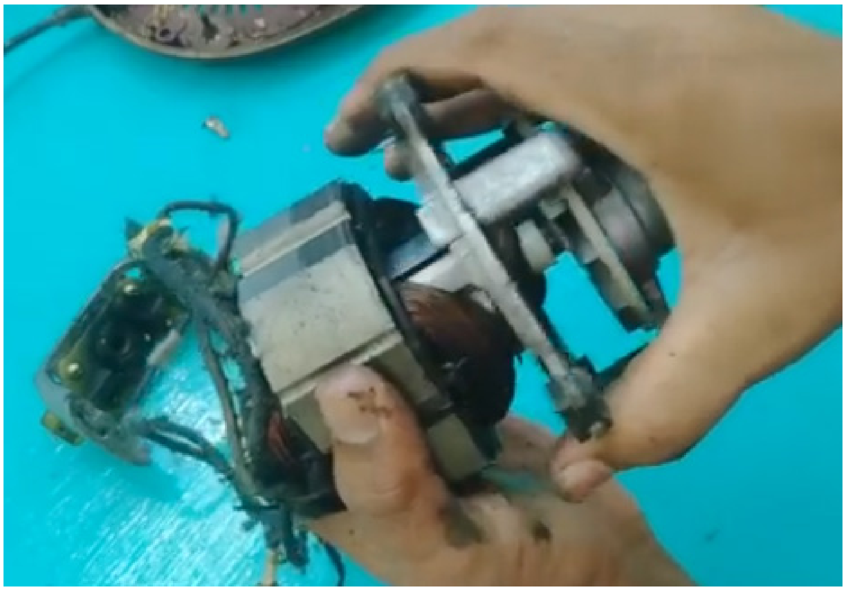


Step 6: Check the continuity in the rotor winding using multi-meter by placing one end of the probe on the commutator segment & other probe on the slots one by one as shown below.

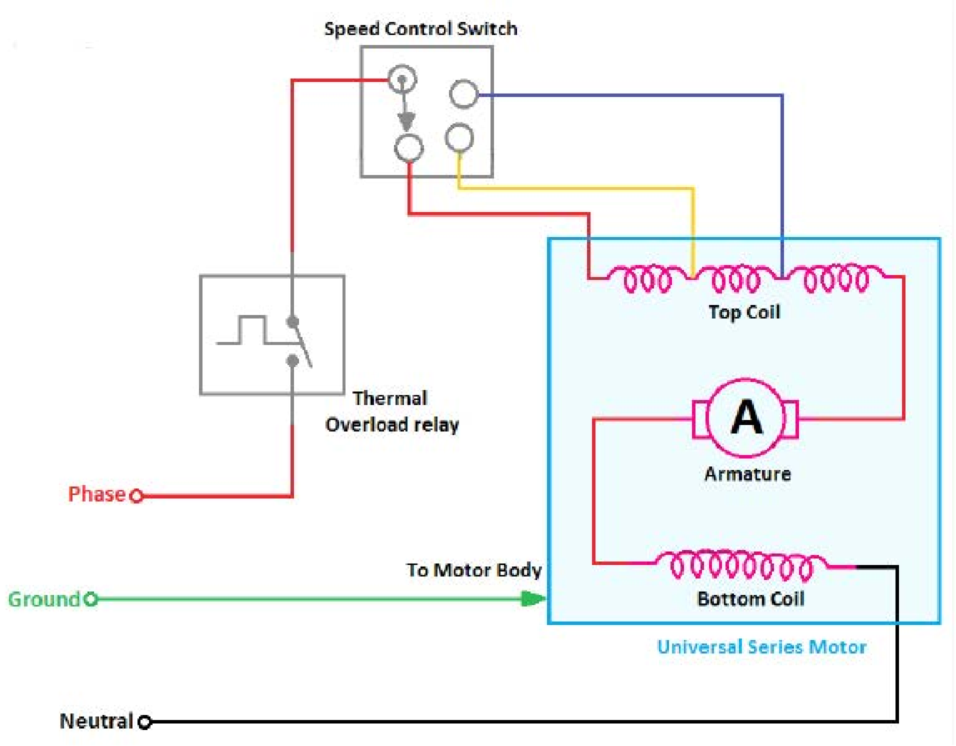
Task 6: Reassembling the parts

Step 1: Reassemble the stator, rotor & carbon brush to its position.

Step 2: Mount the motor on the housing.



Step 3: Connections are made as per the diagram



Step 4: Connect the power supply to the mixer & check for its working

Result:

The mixer is dismantled, tested and reassembled with proper way and it is in good condition.

EXPERIMENT 20

Wet Grinder

Aim:

To know the method of dismantling, testing and reassembling of wet grinder.

Practical procedure:

Dismantling the wet grinder

↓

To conduct tests

↓

Reassmbling the wet grinder

Tools and materials required:

S.No	Name of the Tools/Equipment	Range/Value	Quantity
1	Appliance test board	6A, 230V	1
2	Test lamp	60W, 230V	1
3	Wet grinder	230V, 0.5 HP	
4	Combination plier	200 mm	1
5	Screw driver	3 mm, 4 mm	Each 1
6	Wire stripper	150 mm	1
7	Spanner set	6 – 24 mm	1 set
8	Copper wire	1.5 Sq.mm.	As required
9	Insulation tape	-	1

Procedure:

Task 1: Dismantling the wet grinder

Step 1: Disconnect the plug and stop the supply of the wet grinder.

Step 2: Remove the housing of the wet grinder with appropriate tools.

Task 2: Check the belt and wheel

Step 1: Check whether the belt is having enough tension to drive motor as shown below. If not, replace the belt and fit it thghtly.

Step 2: Rotate the wheel by free hand and ensure that the wheel rotates without any sound or vibration. If anything occurs, replace the bearing.

Task 3: Testing of power cord and a capacitor

Step 1: Remove the motor from the housing by using appropriate tools.

Step 2: Disconnect the power cord from the motor terminal and check the continuity of the power cord. While testing the power cord in multi meter, if it shows continuity, it indicates power cord is good. If there is no continuity, then replace the power cord.

Step 3: Similarly test the power cord for short circuit between the wires by placing the multimeter leads between each terminal in 3 pin top. If any continuity occurs, it concludes that the power cords is under short circuit, and have to replace it.

Step 4: Disconnect the capacitor from the motor and test it by using multimeter.

Step 5: Set the multimeter rating in ohms by using selector switch.

Step 6: Connect the multimeter leads across the lead of the capacitor. If the multimeter shows a value of resistance on display, and soon it will move to high value of resistance. Now we can say that the capacitor is in good condition.

Step 7: If the values of the multimeter remains same with no change, then the capacitor is defective and have to replace it.

Task 4: Identifying and testing of motor windings

Step 1: Now you could see four terminals on the motor.

Step 2: Place the test lamp on four terminals between each other and identify the 2 set of winding and also the continuity between the windings.

Step 3: If there is no continuity, then the windings are defective and have to replace it.

Step 4: To identify the starting and running winding, set the multimeter in low value of resistance range using selector switch.

Step 5: Place the multimeter probes between the set of windings and note down the resistance value in the given table.

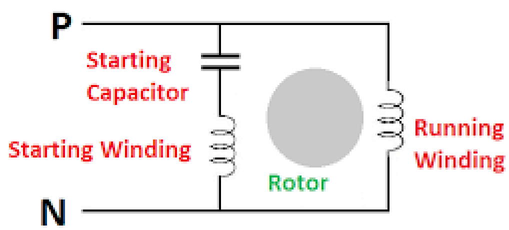
S.No	Resistance (Ohms)	Starting/Running winding
1		
2		

Note:

Low resistance and high resistance ensure running and starting winding.

Task 5: Assembling of the wet grinder

Step1: Connect the capacitor in series with the starting winding. i.e. high resistance winding as shown below.



Step 2: Connect the power cord and mount the motor on the housing.

Step 3: Connect the belt between the pulley and wheel.

Step 4: Connect the power supply to the wet grinder and verify its working.

Result:

The dismantling, testing and reassembling method of wet-grinder was practically done. Now the wet grinder is working in good condition.

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