Consumer Energy Meter Technician

(Job Role)

Qualification Pack: Ref. Id. PSS/Q0107

Sector: Power

Textbook for Class IX

17957

विद्यया ऽमृतमश्नुते

एन सी ई आर टी
NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
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Foreword

The National Curriculum Framework–2005 (NCF–2005) recommends bringing work and education into the domain of the curricular, infusing it in all areas of learning while giving it an identity of its own at relevant stages. It explains that work transforms knowledge into experience and generates important personal and social values such as self-reliance, creativity and cooperation. Through work one learns to find one's place in the society. It is an educational activity with an inherent potential for inclusion. Therefore, an experience of involvement in productive work in an educational setting will make one appreciate the worth of social life and what is valued and appreciated in society. Work involves interaction with material or other people (mostly both), thus creating a deeper comprehension and increased practical knowledge of natural substances and social relationships.

Through work and education, school knowledge can be easily linked to learners' life outside the school. This also makes a departure from the legacy of bookish learning and bridges the gap between the school, home, community and the workplace. The NCF–2005 also emphasises on Vocational Education and Training (VET) for all those children who wish to acquire additional skills and/or seek livelihood through vocational education after either discontinuing or completing their school education. VET is expected to provide a 'preferred and dignified' choice rather than a terminal or 'last-resort' option.

As a follow-up of this, NCERT has attempted to infuse work across the subject areas and also contributed in the development of the National Skill Qualification Framework (NSQF) for the country, which was notified on 27 December 2013. It is a quality assurance framework that organises all qualifications according to levels of knowledge, skills and attitude. These levels, graded from one to ten, are defined in terms of learning outcomes, which the learner must possess regardless of whether they are obtained through formal, non-formal or informal learning. The NSQF sets common principles and guidelines for a nationally recognised qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities.

It is under this backdrop that Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Bhopal, a constituent of NCERT has developed learning outcomes based modular curricula for the vocational subjects from Classes IX to XII. This has been developed under the Centrally Sponsored Scheme of Vocationalisation of Secondary and Higher Secondary Education of the Ministry of Human Resource Development.

This textbook has been developed as per the learning outcomes based curriculum, keeping in view the National Occupational Standards (NOS) for the job role and to promote experiential learning related to the vocation. This will enable the students to acquire necessary skills, knowledge and attitude.

I acknowledge the contribution of the development team, reviewers and all the institutions and organisations, which have supported in the development of this textbook.

NCERT would welcome suggestions from students, teachers and parents, which would help us to further improve the quality of the material in subsequent editions.

HRUSHIKESH SENAPATY
Director
National Council of Educational
Research and Training

New Delhi
June 2018

About the Textbook

Power is one of the most critical components of infrastructure and crucial for the welfare of the nation. The power sector plays a vital role in the economic growth and human development of any country. Electricity consumption is one of the most important indices for measuring the development level of a nation.

India has the fifth largest power generation capacity in the world. The country ranks third globally in terms of electricity production. As per the 13th Five Year Plan, India is targeting a total of 100GW of power capacity addition by 2022. In order to meet the increasing demand for electricity in the country, massive addition to the installed generating capacity is required for efficient and effective production of goods and services along with skilled manpower.

A Consumer Energy Meter Technician manages the installation, repair and maintenance of electrical fittings and fixtures. The textbook for the job role of 'Consumer Energy Meter Technician' has been developed to impart knowledge and skills through hands-on-learning experience, which forms a part of the experiential learning. Experiential learning focusses on the learning process for the individual. Therefore, the learning activities are student-centred rather than teacher-centred.

This textbook has been developed with the contribution of the expertise from the subject and industry experts and academicians for making it a useful and inspiring teaching-learning resource material for the students of vocational education. Adequate care has been taken to align the content of the textbook with the National Occupational Standards (NOSs) for the job role so that the students acquire necessary knowledge and skills as per the performance criteria mentioned in the respective NOSs of the Qualification Pack (QP). The textbook has been reviewed by experts so as to make sure that the content is not only aligned with the NOSs, but is also of good quality.

The NOSs for the job role of Consumer Energy Meter Technician covered through this textbook are as follows:

1. PSS/N0114/N0301 Manually remove, change and install low voltage, single- and 3-phase meters
2. PSS/N2001 Use basic health and safety practices at workplace
3. CSC/N1336 Work effectively with others

Unit 1 of the textbook talks about electricity and its uses. Unit 2 focusses on handling tools and equipment used by a Consumer Energy Meter Technician. Unit 3 deals with the electrical wiring components and accessories and Unit 4 discusses the energy meter, its types and uses.

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The Council acknowledges the contribution of the Review Committee members — K.L. Bhatia, *Professor* (Retd.), NCERT; Kanihya Lal, *Professor* (Retd), NCERT, and V.P. Srivastava, *Professor* (Retd), NCERT for sharing their expertise and time. The Council would also like to thank Rajesh Khambayat, *Joint Director*, PSS Central Institute of Vocational Education (PSSCIVE), Bhopal for providing support and guidance in the development of this textbook.

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CONTENTS

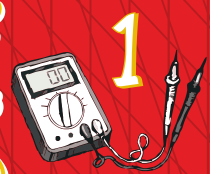
Do You Know?

According to the 86th Constitutional Amendment Act, 2002, free and compulsory education for all children in 6-14 year age group is now a Fundamental Right under Article 21-A of the Constitution.

EDUCATION IS NEITHER A PRIVILEGE NOR FAVOUR BUT A BASIC HUMAN RIGHT TO WHICH ALL GIRLS AND WOMEN ARE ENTITLED

Give Girls Their Chance !

Unit 1



Electricity

INTRODUCTION

We are surrounded by technology and innovation. Electricity is one of the greatest innovations of mankind. It has now become a part of our daily life and one cannot think of a world without electricity. Almost all the devices at home, businesses and industries are running because of electricity (Fig. 1.1). The primary use of electricity depends on the place where it is used and the nature of the facility. You must have seen bulbs, tubelights, refrigerators, TVs and other electronic gadgets at your home and you must have also felt cool because of a rotating fan at your home. All this is possible due to electricity. Electricity plays a vital role in our day-to-day life and it also plays a vital role in the country's economy.

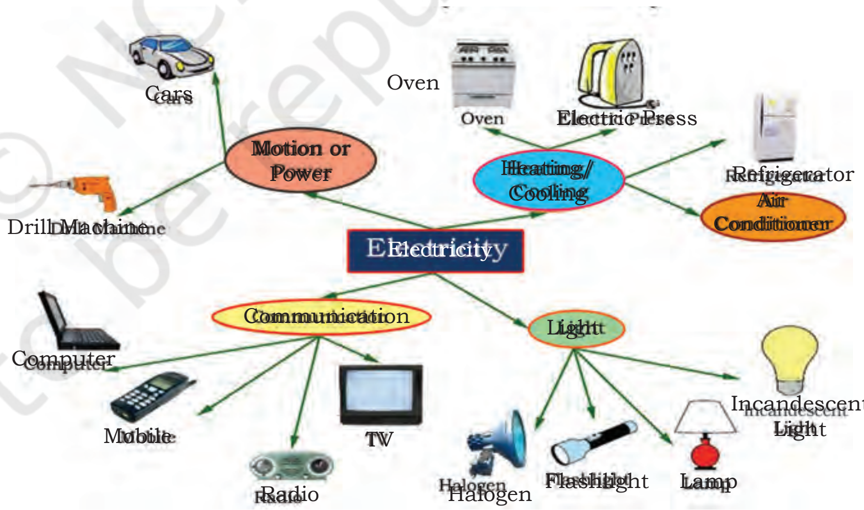


Fig. 1.1 Use of Electricity

The country's development is measured in terms of per person consumption of electricity. At present everything in human life is dependent on electricity whether it is in the health, transport, agriculture or industrial sector.

Session 1: Electricity Generation Concept

Origin of Electricity

Electricity is one of the most commonly used forms of energy. The word electricity comes from Greek word *elektron* which means amber. It is converted from mechanical (turbine) to electrical energy (generator). Many people give credit to Benjamin Franklin for discovering electricity, but his experiments only helped to establish the connection between lightning and electricity.

Basic Concept of Electricity

Electricity is a type of energy which involves the flow of electrons. All elements are made up of atoms. The centre of an atom is called nucleus. The nucleus has positively charged particles known as protons and electrically neutral particles called neutrons. The nucleus of an atom is surrounded by negatively charged particles known as electrons (Fig. 1.2). The negative charge of an electron is the same as the positive charge of a proton, and the number of electrons in an atom is equal to the number of protons.

Distribution of Electrons in the Orbits of Copper Atom (Good Conductor of Electricity)

From the generating station, electricity arrives at homes through wires. Electric lamps, electric heaters, fans, computers, etc., use electricity to work. Many appliances, such as washing machines and electric cookers use electricity. In factories, electricity is used to run machines. People who deal with electricity and electrical devices are called electricians.

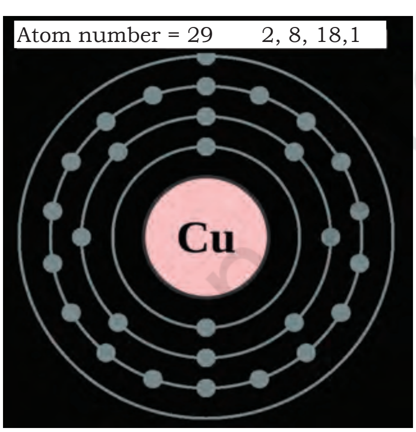


Fig. 1.2 Electrons

There are two types of electric charges — positive and negative charges. Similar charges repel each other and opposite charges attract. This means that if you put two negative charges close together, they will move apart. This is also true for two positive charges. But if you put a positive charge and a negative charge close together, they will attract each other.

Importance of Electricity

Electricity makes it possible to light our homes, roads, offices, markets and factories. This helps us to continue work during night hours. A power station provides us electricity. If the supply of electricity fails, electrical torches are used for providing light. We use electricity to operate the pump that lifts water from wells or ground level to roof-top water tank. Other electrical equipment like AC, geyser, electrical iron, television, refrigerator, induction cooker, oven, etc., also require electricity to run (Figs. 1.3, 1.4 and 1.5).

Fig. 1.3 Electricity used for Lighting

Fig. 1.4 Electricity used for Heating

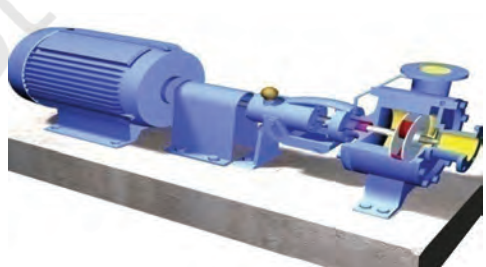


Fig. 1.5 Electricity Pump

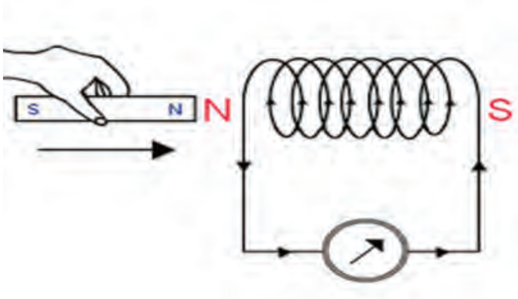


Fig. 1.6 Experiment of Michael Faraday

Generation of Electricity

The basic principle of electrical generator is Faraday's Law of Electromagnetic Induction (Fig. 1.6). An electrical generator (Fig. 1.7) is used to convert mechanical energy into electrical energy. Generation of electrical energy is just conversion of kinetic energy into electrical energy.

Experiment of Michael Faraday

Electromagnetic induction is the production of an electromotive force across a conductor, when it is exposed to a varying magnetic field. It is described by Faraday's Law of Electromagnetic Induction.

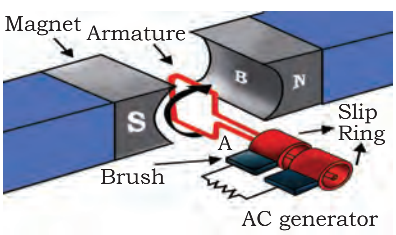


Fig. 1.7 Diagram of D.C. Generator

Electricity Generated by Electrochemical Cell

An electrochemical cell is a device which is capable of generating electrical energy through chemical reactions. A common example of an electrochemical cell (Fig. 1.8) is a standard 1.5 V cell meant for consumer use.

Fig. 1.8 Electrochemical Battery

Electricity Generated by Solar Cell

A solar cell (Fig. 1.9) is a device that converts light energy into electrical energy. This conversion is called the photovoltaic effect. Solar cells have many applications. They are used in situations where electrical power is unavailable, such as in remote areas, earth-orbiting satellites and space probes, consumer systems like handheld calculators or wrist watches.

Fig. 1.9 Electricity Generated by a Solar Panel made of Several Solar Cells

Electricity Generated by Thermal Power Station

A thermal power station (Fig. 1.10) is a power station in which heat energy is converted to electrical energy. In most parts of the world, the turbine is steam-driven. Water is heated, which then turns into steam and spins the steam turbine which drives the electrical generator. In a thermal power station fuel, such as coal, oil or gas, is burned in a furnace to convert chemical to heat energy. This heat is used to change water into steam in the boiler and this drives the generator to produce electricity—mechanical to electrical energy.

Primary Source of energy → Turbine (Prime mover) → Electrical Generator → Electrical Transformer → Transmission and Distribution Line → End User (House/ Factory)

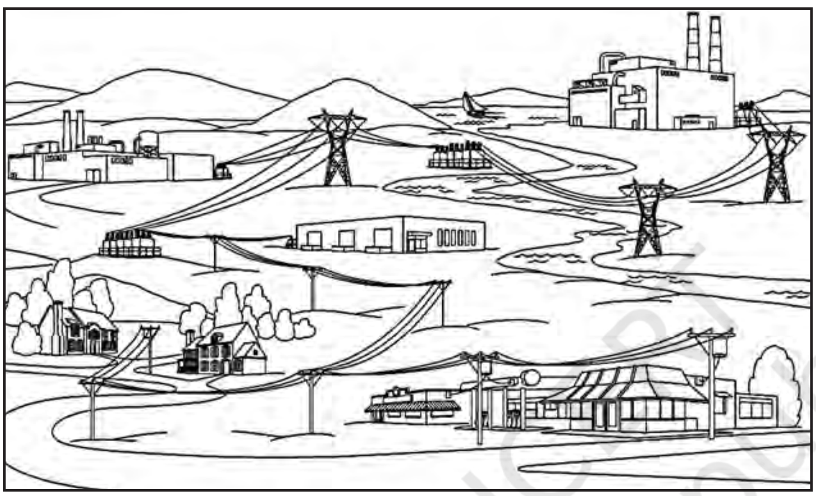


Fig. 1.10 Thermal Power Plant

Status of Electricity Production in India

1. Total Installed Capacity (as on 30.06.2017)

Fuel	MW	% of Total
Total Thermal	2,20,576	67.0%
Coal	1,94,553	59.1%
Gas	25,185	7.6%
Oil	838	0.3%
Hydro	44,614	13.6%
Nuclear	6,780	2.1%
Renewable Energy Sources*	57,260	17.4%
Total	**3,29,231**	**100%**

Source: *Central Electricity Authority (CEA)*

** Installed capacity, in respect, Renewable Energy Sources as on 31.03.2017.*

Renewable Energy Sources include Small Hydro Project, Biomass Gasified, Biomass Power, Urban and Industrial Waste Power, Solar and Wind Energy

NOTES

Practical Exercise

Activity 1

Making an electrical quiz board for listing sources of electricity and their sharing percentage (%) in India

Objective

Students will be able to

1. identify the sources of electrical energy in India,
2. define their sharing percentage (%) and
3. make basic circuit connection.

Material required

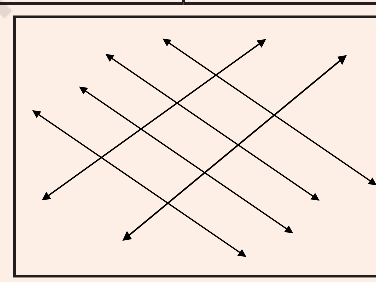
One cardboard (45cm × 15cm), insulated copper wire, one 9-volt bulb with holder, one 9-volt battery, 10 nos, connectors with socket

Tools and Equipment

S.No.	Particular	Specification	Quantity
1.	Screw Driver	6"	01
2.	Combination Plier	6"	01
3.	Wire Stripper	--	01
4.	Phase Tester	--	01

Coal	13.6
Gas	17.4
Oil	59.1
Hydro	7.6
Nuclear	0.3
Renewable	2.1

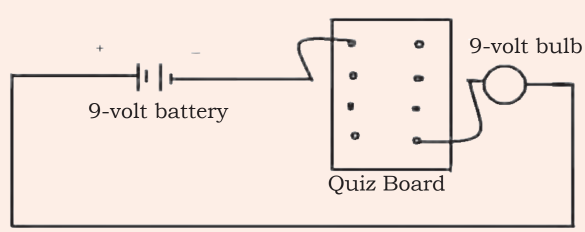
Front view of cardboard



Back view of cardboard

Fig. 1 Electrical Cardboard

Electrical Circuit Diagram of Electrical Quiz Board



Procedure

1. Take one cardboard (45cm × 15cm) and fix pieces of insulated wire with two metal connectors at the end of each wire.
2. Paste the name of energy source and percentage as shown in the figure.
3. Connect each question to the correct answer by a wire at the back of the cardboard.
4. Connect 9-volt battery and 9-volt bulb as shown in the figure.
5. Clip one lead of connector to a question and clip the other lead to what you think is the correct answer.
6. If the answer selected by you is correct the bulb will glow because the connection wire on the back side of the cardboard will complete the circuit.
7. If the answer is wrong, the bulb will not glow.

Precautions

1. All the connections should be correctly fastened.
2. No wire should be left naked.
3. 'Questions' and 'Answers' should be connected correctly at the back side of the cardboard.

Check Your Progress

A. Fill in the Blanks

1. Electricity is a form of ____________________.
2. In a generator ________________ energy is converted to electrical energy.
3. Electricity is also generated by _______________ and _______________ energy other than thermal energy.
4. The commonly used machine for generating electricity is called _______________.
5. Law of electromagnetic induction was discovered by _____________.

B. Match the Columns

1. Thermal Power Plant	(a) Renewable
2. Wind Power Plant	(b) Coal
3. Nuclear Power Plant	(c) Water
4. Hydro Power Plant	(d) Uranium

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C. Multiple Choice Questions

1. Electricity was discovered by ________________.
   (a) Isaac Newton
   (b) Benjamin Franklin
   (c) Max Plank
   (d) D. Rutherford
2. Most of the electricity generated in India is by using ______________.
   (a) wind
   (b) coal
   (c) solar
   (d) hydro
3. Which of the following forms of energy is converted by a solar cell into electrical energy?
   (a) Wind
   (b) Thermal
   (c) Nuclear
   (d) Light
4. Electricity is a type of energy which involves the flow of ________________.
   (a) protons
   (b) neutrons
   (c) electrons
   (d) atoms
5. If you put two negative charges close together, they will ______________.
   (a) attract
   (b) repel
   (c) not interact
   (d) attract some time and repel some time

SESSION 2: BASIC UNITS AND EFFECTS OF ELECTRIC CURRENT

Electricity is a form of energy which though cannot be seen, but its effects can still be felt (Fig. 1.11).

Fig. 1.11: Electricity as form energy

Various Effects of Electric Current

Fig. 1.12 Heating effect of electric current

(a) Heating effect: Heat is produced in a conductor, like nichrome, due to the flow of current through it. It is called the heating effect of electric current or Joule's law of heating. When electricity flows through a conductor like tungsten, light is emitted (Fig. 1.12) from the surface of conductor due to heating, such as in an electric bulb.

(b) Chemical effect: When current is passed through an electrolyte, it breaks up in its ions. This is known as chemical effect of electric current.

(c) Magnetic effect: It was discovered by Faraday. A magnetic field (Fig. 1.13) is produced around the conductor through which the current flows. This is called the magnetic effect of electric current.

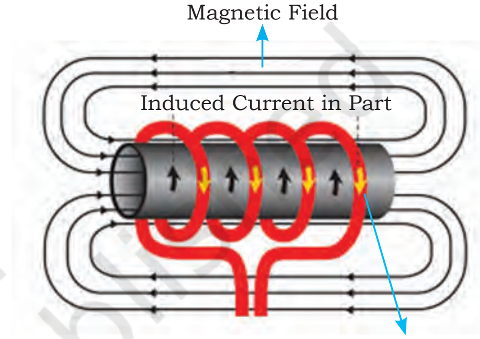

Fig. 1.14 Magnetic effect of electric current

(d) Physical effect: When electricity flows through the human body, contraction of nerves takes place, which may be dangerous for a person's life. This is the physical effect of electric current.

Voltage, Current, Resistance, Capacitance and Inductance

If we place two objects, charged to different potential, side by side, charges will not move from one to the other. Now, if the two are connected using a conductor the flow of charges will take place. The charge will flow as long as there is a difference of potential between the two objects. The flow will stop as soon as their potential becomes equal. This flow of electric charge is called electric current.

The potential difference (PD) between two points is one volt when the work done in moving one coulomb of charge between these points is one joule.

Air current (air flow) and water current (water flow) can be easily understood. The flowing water in rivers constitutes water current. Similarly, if electric charge flows through a conductor it means there is an electric current in the conductor. In a torch, the cells provide

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necessary potential difference for the flow of charges or an electric current through the torch bulb to glow. It can also be observed that the torch gives light only when its switch is on. A continuous and closed path of an electric current is called electric circuit. Now, if the circuit is broken anywhere the current stops flowing. Electric current is expressed by the amount of charge flowing through a particular area in unit time. In other words, it is the rate of flow of electric charges.

Let us understand water flow and current. Water will not flow by itself in a perfectly horizontal tube. If one end of the tube is connected to a tank of water kept at a higher level, such that there is a pressure difference between the two ends of the tube, water will flow out of the other end of the tube. For the flow of charges in a conducting wire, the voltage plays an important role. The electrons move only if there is a difference of electric pressure called the potential difference or voltage. This difference of potential may be produced by a cell or a battery, consisting more than one electric cell. The chemical action within a cell generates the potential difference across the terminals of the cell. When the cell is connected to a conducting circuit element, the charge flows from one end to another.

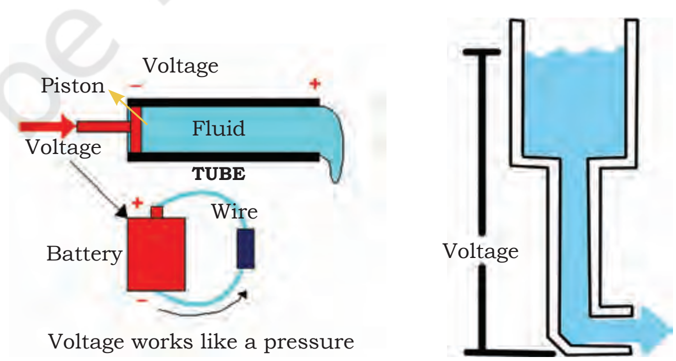

Fig. 1.14 Voltage

(a) Voltage

What makes the electric charge flow? It is voltage (Fig. 1.14). It refers to the pressure or tendency to drive the electrons in a circuit. Its unit is volt.

(b) Current

Flow of electrons in any conductor is called current (Fig. 1.15).

If electrons flow through a conducting wire, it is said that there is an electric current in the wire. Unit of current is ampere.

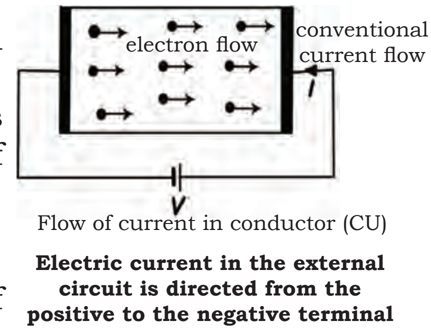

Fig. 1.15 Flow of current in conductor

(c) Resistance

It is the property of a conductor to resist the flow of charge through it. The ratio of the voltage and current is called electric resistance of the conductor. Unit of resistance is Ohm (Ω) 1 ohm = 1 volt/1 ampere.

(d) Capacitance

Capacitance is the capability of a device for storing electric charge. Capacitance is expressed as the ratio of stored charge in coulombs to the impressed potential difference in volts. Its unit is farad.

In an electric circuit the device which stores charge is called capacitor (Fig 1.16). The ratio of the charge Q on one of the plates of a capacitor and the potential difference V between the plates is the capacitance, that is, Q/V=C.

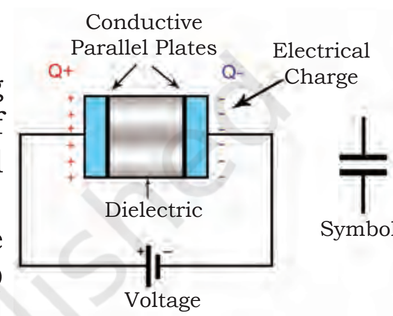

Fig. 1.16 Circuit diagram of a capacitor

(e) Inductance

If a changing magnetic field (flux) is linked with a coil of a conductor there is an electromotive force induced in it. The property of the coil of inducing electromotive force due to the changing flux linked with it is known as inductance (Fig. 1.17) of the coil. Due to this property an electrical coil is referred as inductor. An inductor can be defined as an energy storage device which stores energy in the form of magnetic field. Unit of inductance is henry.

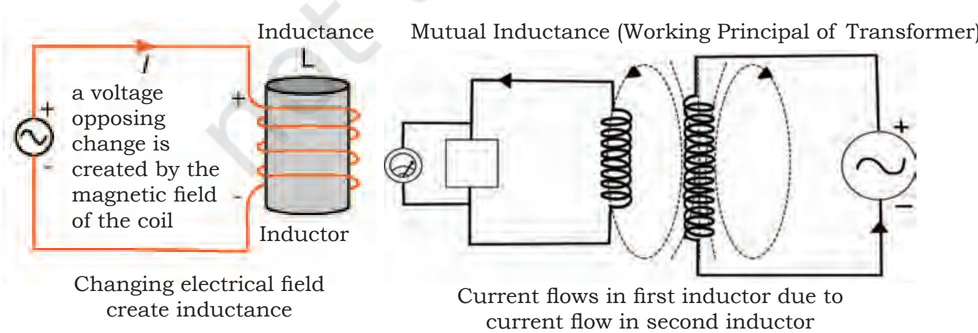

Fig. 1.17 Inductance

Understanding Series and Parallel Circuits

Series Circuit

If two or more resistors (loads) are connected in such a way that they form a chain, one after the other, then each carries the same current when the combination is connected with the supply source. They are said to be connected in series (Fig.1.18).

This circuit is called a series circuit.

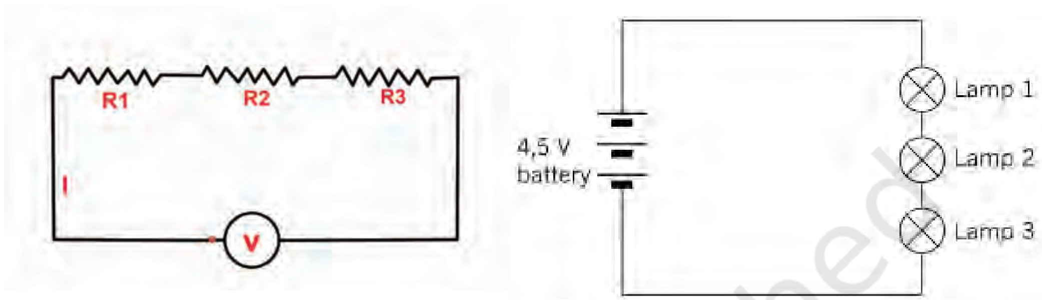

Fig. 1.18 Series circuit

In-series Circuit

Resultant Resistance

R=R1+R2+R3

Parallel Circuit

When two or more resistors (loads) are connected in such a way that each forms a separate path and carries a part of total current, they are said to be arranged in parallel and the circuit is called parallel circuit (Fig. 1.19).

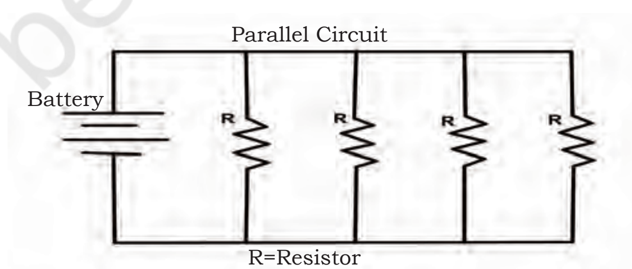

Fig. 1.19 Parallel circuit

In Parallel Circuit

Resultant Resistance

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

(i) Ohm's Law

In any electrical circuit when physical conditions (temperature diameter and length) of a conductor are constant, voltage is directly proportional to the current (Fig. 1.20).

Mathematically: $V \alpha I$

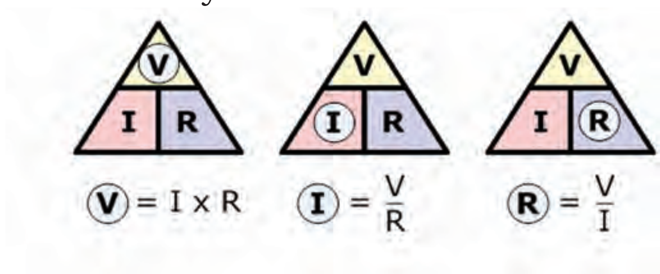

Fig. 1.20 Diagram of Ohm's Law

(ii) Kirchhoff's Current Law

It states that the total current or charge entering a junction or node is exactly equal to the charge leaving the node, as no charge is lost within the node. In other words, the algebraic sum of all the currents entering and leaving a node must be equal to zero, (Fig. 1.21), that is, I (current entering in the node) + I (current leaving the node) = 0.

This idea by Kirchhoff is commonly known as the Conservation of Charge or Kirchhoff's Current Law (KCL)

Here, the three currents entering in the node, I1, I2, I3 are all positive in value and the two currents leaving the node, I4 and I5 are negative in value.

This means we can also rewrite the equation as: I1 + I2 + I3 – I4 – I5 = 0

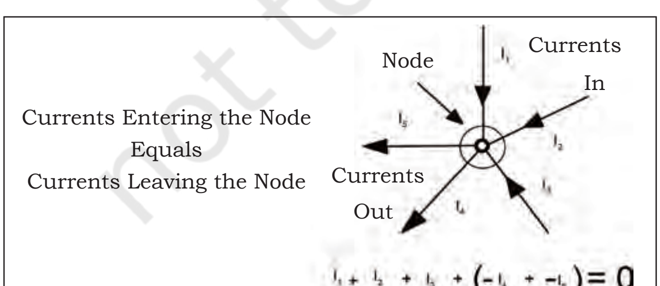

Fig. 1.21 Diagram of Kirchhoff's Current Law

Notes

Notes

(iii) Kirchhoff's Voltage Law (KVL)

Kirchhoff's Voltage Law or KVL, states that in any closed-loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop. In other words the algebraic sum of all voltages within the loop must be equal to zero (Fig. 1.22). This is called Kirchhoff's Second Law or law of Conservation of Energy.

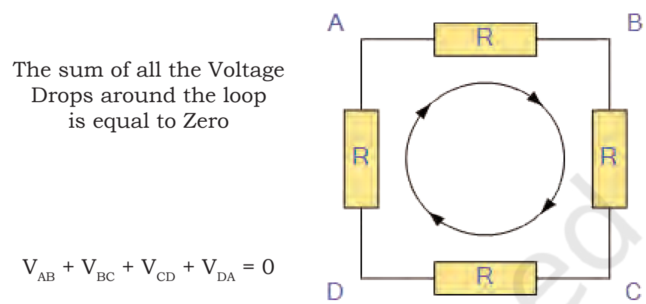

Fig. 1.22: Diagram of Kirchhoff's Second Law

Starting at any point in the loop continue in the same direction noting the direction of all the voltage drops, either positive or negative, and come back to the same starting point. It is important to maintain the same direction either clockwise or anti-clockwise or else the final voltage sum will not be equal to zero. Kirchhoff's voltage law can be used when analysing circuits.

When analysing either DC circuits or AC circuits using Kirchhoff's Circuit Laws, the following terminologies are used to describe the parts of the circuit being analysed:

(a) Nodes: when any resistance is connected in the circuit the two terminals of resistance are called nodes.

(b) Loop: when multiple resistances are connected and create a circle, it is called loop.

(c) Path: when multiple resistances are connected with an electrical circuit, the direction of the current flow is called path.

(d) Meshes: hundreds of resistances connected in a circuit in parallel and in series are called meshes.

Check Your Progress

NOTES

A. Fill in the Blanks

1. Light emitted from the surface of conductor is due to ______________ of electric current.
2. The unit of current is ______________.
3. The unit of resistance is ______________.
4. The unit of capacitance is ______________.
5. The unit of inductance is ______________.

B. Match the Columns

1. Voltage Storing	A. Charge
2. Current	B. Obstruction in flow of charge
3. Resistance	C. Flow of charge
4. Capacitance	D. Pressure

C. Multiple Choice Questions

1. Voltage is like ______________.
   (a) energy
   (b) volume
   (c) pressure
   (d) temperature
2. If an electric circuit could be compared to a water circuit, then the current would be analogous to the ______________.
   (a) water
   (b) water flow
   (c) water pressure
   (d) water pump
3. Kirchhoff's Current Law or KCL says that the algebraic sum of all currents leaving a node should be __________.
   (a) one
   (b) two
   (c) three
   (d) zero
4. In any electrical circuit when physical condition (temperature, diameter and length) of a conductor are constant, the voltage is directly proportional to ______________.
   (a) current
   (b) resistance
   (c) power
   (d) energy
5. If two or more resistors (loads) are connected in such a way that they form a chain, it is called ____________.
   (a) parallel circuit
   (b) series circuit
   (c) closed circuit
   (d) open circuit

Notes

D. Short Answer Questions

1. Describe Ohm's Law.
2. What is electricity?
3. Write any one type of effect of electric current.
4. What is a parallel circuit? Explain with diagram.
5. What do you understand by the terms voltage, current and resistance?

Session 3: Concept of electrical Power and Energy

Difference between Power and Energy

Power is the measurement of energy transfer by an electrical circuit in unit time. Electrical power and energy play a vital role in today's society. Electrical power and energy involve generation, transmission and distribution of electrical energy reliably and efficiently to meet consumer demands. Electrical appliances at home transfer energy from the mains to supply heat and light in our homes. Electric energy also operates appliances, such as TV, microwave, computers, etc. The units measured by an electricity meter and used to calculate the consumption (electricity bill), are called kilowatt hours. The cost of each unit of electricity varies. The electricity bill is calculated by working out the number of units used and multiplying it with the cost of per unit.

Electrical Power

It is the rate at which electrical energy is consumed by an electrical appliance. Unit of electrical power is watt.

1000 watt = 1 kilowatt

Electrical Power in DC and AC Circuit

Electrical Power in DC Circuit

$$P = V \times I$$

$$P = I^2R$$

$$P = V^2/R$$

where V = voltage, I = current and R = resistance

Electrical Power in AC Circuit

$$P = VI \cos ø,$$

where $\cos ø$ = power factor and P = power

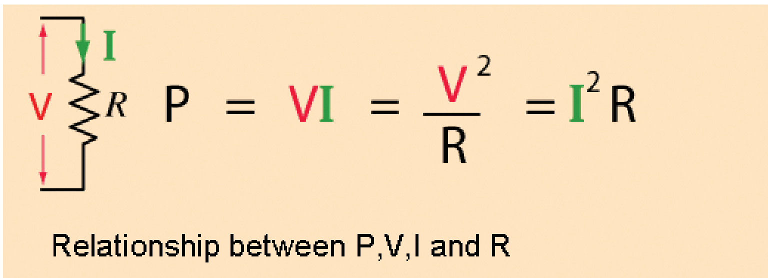

Fig. 1.23 Diagram shows relationship between P, V, I and R

Electrical Energy

Electrical energy is the capacity for doing electrical work.

Energy in watt hour is the multiplication of power in watt and time in hour. This is the basic unit of energy. The commercial unit of energy is kilowatt-hour (Fig. 1.24).

Electrical Energy = power × time

Electrical Energy = watt × hour

Electrical Energy = 1000 watt × 1 hour

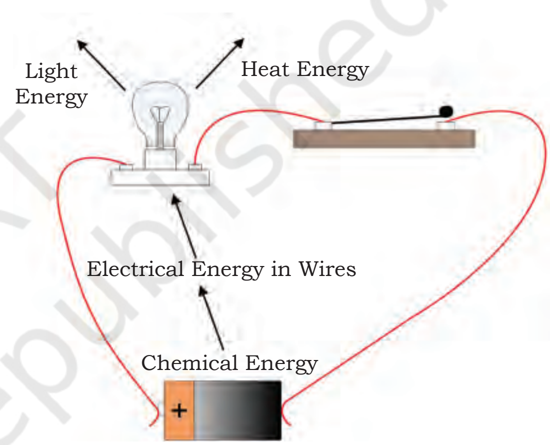

Fig. 1.24 Diagram shows conversion of chemical energy into electrical energy

Electrical power in a circuit is the rate at which energy is used or generated within a circuit. A source of energy, such as a battery, will deliver power while the connected load uses it. Light bulbs and heaters are examples of usage of electrical power and its conversion into either heat, or light, or both. The higher the value or rating in watts, the more the electrical power they are likely to consume.

Electric Power Calculation

Electrical power (Fig. 1.25) is also expressed as the rate by which energy is transferred in the circuit. If one joule of work is either absorbed or delivered at a constant rate of one second, then the corresponding power will be one watt. So power can be defined as '1Joule/sec = 1Watt'. Then we can say that one watt is equal to one joule per second and electrical power can be defined as the rate of doing work or the rate of transferring of electrical energy.

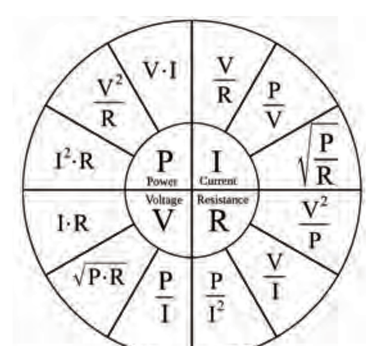

Fig. 1.25 Diagram shows electric power circulation

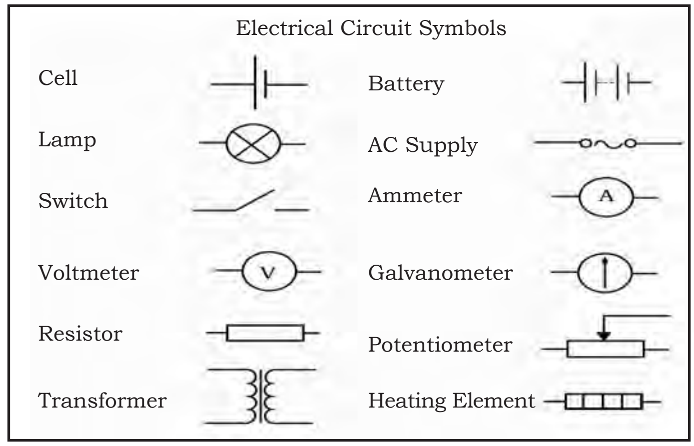

Fig. 1.26 Electrical circuit symbols

Use of Voltmeters and Ammeters

(a) Voltmeters

(i) A voltmeter is always connected across the device or in parallel.

(ii) A voltmeter has a very high internal resistance, so as to not draw a large current from the circuit.

(b) Ammeters

(i) An ammeter is always connected in series.

(ii) An ammeter has a very low internal resistance, so as to not generate a drop in potential.

Power and Energy Calculation in DC and AC System

(a) Watts

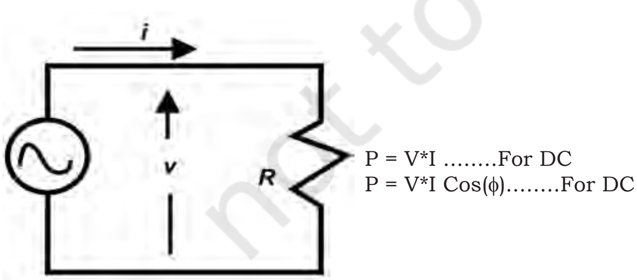

Fig. 1.27 Diagram of electric power measurement

This is a unit of power. It is the rate at which electricity is used at a specific moment (Fig. 1.27).

1 kilowatt = 1,000 watt,

1 megawatt = 10,00,000 watt.

Example: 09-watt LED light bulb consumes 09 watts of electricity at any moment when turned on.

(b) Watt-hour

One watt-hour is the energy consumed when one watt of power is used for one hour.

watt= hour = watt × hour

The commercial unit of energy is kilowatt-hour (kWh).

Example

09-watt LED bulb, which draws 09 watts at any one moment, uses 09 watt-hours of electricity within a span of one hour.

Here's the general rule for calculating power dissipation:

Power: P = V × I

where V = voltage applied across the circuit and I = current flowing in the circuit

Example

We begin with one of the simplest circuits: A battery hooked up to a single resistor.

Here, we have a single 9V battery, and a single 100Ω (100 Ohm) resistor, hooked up with wires to form a complete circuit. Calculate power and energy in 10 hours (Figs A and B).

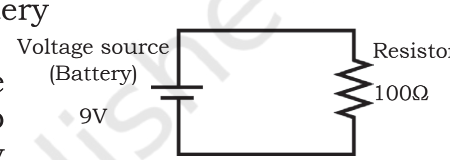

Fig. A

Calculation of Power

As per the formula of power in DC circuit

Electrical Power = Voltage × Current, i.e.,

$$P = V \times I$$

As per Ohm's Law,

V = IR (where R = resistance of the circuit)

$$I = V/R$$

Then, $P = V \times V/R$

$P = V^2/R$

$P = 9^2/100 = 81/100 = 0.81$ watt

Solution: Power dissipated in the electrical circuit is 0.81 Watt.

Calculation of Electrical Energy

As per the formula of electrical energy in DC circuit

Electrical energy = Power (in watt) × Time (in hours)

Therefore, electrical energy consumed for 10 hours = 0.81 × 10 = 8.1 watt-hours

Solution: Energy consumed by the above electrical circuit is 8.1 Unit.

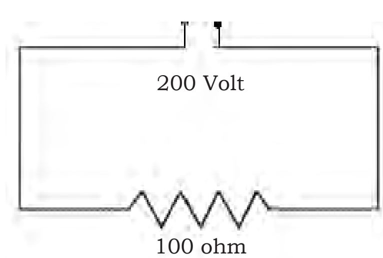

Fig. B

Notes

Check Your Progress

A. Fill in the Blanks

1. Ammeter is always connected in ______________ in a circuit.
2. Voltmeter is always connected ______________ across a circuit.
3. The unit of power is ______________.
4. The unit of electrical energy is ______________.
5. 1000 watt × 01 Hour Electrical Energy is called __________ energy.

B. Match the Columns

1.	Battery	(a)	Current indicating device
2.	Galvanometer	(b)	Resists the flow of current
3.	Resistor	(c)	A resistance which generates heat
4.	Heating element	(d)	Combination of two or more cells

C. Multiple Choice Questions

1. AC stands for ___________.
   (a) Alternating Current
   (b) Accumulated Current
   (c) Air Current
   (d) None of the above
2. The internal resistance of an ammeter is ___________.
   (a) very high
   (b) very low
   (c) zero
   (d) infinite
3. Rate of doing electrical work is called electric ___________.
   (a) energy
   (b) current
   (c) potential
   (d) power
4. Potentiometer is an electric device that gives variable ______________.
   (a) power
   (b) resistance
   (c) voltage
   (d) current
5. One commercial unit electrical energy is equal to ____________.
   (a) 1 watt × 1 hour
   (b) 10 watt × 1 hour
   (c) 100 watt × 1 hour
   (d) 1000 watt × 1 hour

D. Short Answer Questions

1. What do you understand by the term electrical power?
2. What is electrical energy?
3. What do you mean by one commercial unit of electrical energy? Explain briefly.
4. An electric iron is connected across 220 volt power supply. If the resistance of the iron is 50 ohm, then calculate
   (a) the current flowing through the iron.
   (b) electrical power of the iron.
   (c) energy used in commercial units (kWh) if the iron is connected for 2 hours.
5. One LED bulb is labeled 220 volt and 11 watt. If the bulb is connected to 220 volt power supply, then calculate
   (a) the current flowing through the LED bulb.
   (b) the amount of electrical energy used by the LED bulb in 08 hours.

E. Draw the Electrical Symbol of the following

1. Cell
2. Battery
3. Bulb
4. Resistance
5. Switch

Session 4: Importance of Earthing System

Importance of Earthing and its Types

Earthing system in an electrical circuit is for safety purpose. The earthing system provides an alternative path for high and dangerous current to flow to the earth so that the problem of electric shock and damage to equipments does not occur.

The metallic connection between electrical machines and devices with the earth plate, commonly known as earth electrode, through a thick wire of low resistance to provide safety is known as earthing.

Metallic parts of an equipment are earthed and if the equipment's insulation fails there will be dangerous current present on the surface of the equipment. This may cause a short circuit and the fuse will blow off immediately.

Notes

Notes

Earthing

Earthing means connection of non-current carrying parts (metallic parts) of electrical apparatus to the earth to discharge electrical energy without any danger.

Earthing is done by connecting the appliance or machinery to earth by a good conductor known as earth electrode. Earthing is done to save human life from the danger of electrical shock, in case a human body comes in contact with a live wire.

If earthing is done correctly and the metallic part comes in contact with a live wire, it will be discharged in to the earth. In this condition, due to zero potential of earth a large amount of the current flows to the earth. If the current exceeds the limiting value of the fuse, it blows off or the MCB trips and cuts off the supply from appliance.

Different Terms used in Electrical Earthing

(a) **Earthing:** The proper electrical contact between electrical installation and the earth is known as earthing.

(b) **Earthed:** When an electrical machine, appliance or wiring is connected to the earth through earth electrode, it is known as earthed.

(c) **Earth electrode:** A pipe or plate buried in the earth for discharge of electricity is known as earth electrode.

(d) **Earthing lead:** The conducting wire or conductive strip connected between earth electrode and electrical installation and machine is called earthing lead.

(e) **Earthing resistance:** This is the resistance between earth electrode and the earth in ohms.

Specification for Earthing

S.No.	Details	Specification
1.	Distance of earth from building	More than 1.5 meter from the building
2.	Size of earth electrode	Not be less then 2.9mm^2 or 14 SWG
3.	Resistance of earth	Not greater than 8 ohm

NOTES

The earth electrode and earth wire should be of the same material.

Points to be earthed

1. Earth pin of 3 pin and 5 pin plug and socket
2. All metal parts of the electrical machine, e.g., motor, heater geyser and mixer
3. Metallic frame of electrical machines
4. The neutral conductor of 3-phase 4-wire system
5. Pole, tower, armouring of cable
6. Stray wire of overhead lines

Importance of electrical earthing

Electrical earthing is important to

1. save human life from the danger of shock from leaking current.
2. maintain the line voltage constant.
3. protect large machines and buildings from atmosphere lighting.
4. avoid the risk of accident in an electrical sub-station and other installation.

Earth resistance of different electrical installations

Large power station	0.5 Ohm
Major power station	1.0 Ohm
Small sub-station	2.0 Ohm
In-house wiring and such other case	5.0 to 8.0 Ohm

Types of Earthing

(a) Strip earthing: In this type of earthing galvanised iron strip of 25mm × 4mm or copper strip of 25mm × 1.6mm are laid in horizontal trenches of minimum depth of 0.5 meter and covered with charcoal and salt.

(b) Rod earthing: In this type of earthing system 12.5 mm diameter of solid rod of copper or 16 mm diameter of solid rod of galvanised iron are fitted vertically into the earth not less than 2.5 meter on earth surface.

(c) Pipe earthing: It is cheaper and the best form of earthing. In this type of earthing a hollow pipe of 38 mm diameter and 2.5 meter

NOTES

long GI is placed underground and covered with charcoal and salt.

(d) Plate earthing: In this type of earthing system, a plate of either copper with dimensions $60cm \times 60cm \times 3.18mm$ or galvanised iron (GI) of dimensions $60cm \times 60cm \times 6.35mm$ is buried vertical in the earth pit which should not be less than 3 metre from the surface of ground.

Atmospheric Lightning

Atmospheric lightning is a form of visible discharge of electricity between a rain cloud and the earth. The electric discharge is seen in the form of a arc between cloud and earth surface.

When the electrical potential between two clouds, or a cloud and the earth reaches a sufficiently high value the air becomes ionised along a narrow path and results in lightning flash.

The possibility of lightning is more on tall trees and buildings rather than the ground. Buildings are protected from lightning by metallic lightning rods. These lightning rods are known as lightning arresters. This lightning arrester is fitted at the highest part of the roof and it is extended to the ground through a conductor. The conductor has a pointed edge on one side and the other side is connected to a long thick copper strip which runs down the building. The lower end of the strip is properly connected to the earth. When lightning strikes on the rod the current flows down through the copper strip. These rods provide a low-resistance path for the lightning discharge and prevent it from travelling through the structure of a building itself.

Lightning Arrester

The principle of the lightning arrester was first discovered by Benjamin Franklin in 1749, who in the subsequent years developed his invention for household application.

Lightning arresters (Fig. 1.28) are devices which prevent damage of apparatus due to high lightning voltages. The lightning arrester provides a low resistance path to ground for the current from a lightning strike.

When a high voltage or greater than normal line voltage exists in the circuit, the lightning arrester immediately provides a path to earth and thus limits and drains off the excess voltage.

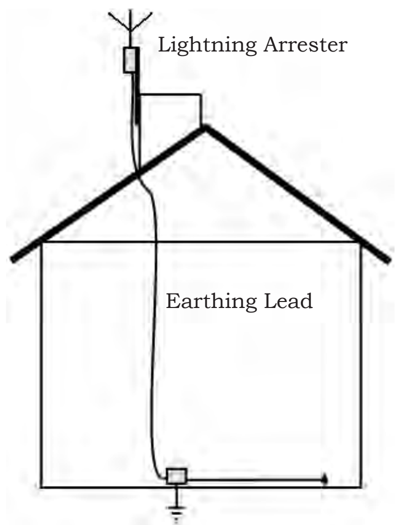

Fig. 1.28 Lightning arresters

Working of Lightning Arrester

A lightning arrester

1. does not absorb any charge caused by lightning.
2. diverts the charge towards the ground.
3. limits the voltage produced by atmospheric lightning.
4. works at the time of lightning because lightning produces very high voltages.
5. provides protection against lightning surges during rainy session.

Pipe Earthing

This type of earthing is used widely in industries and house wiring system. In this system of earthing, a GI pipe of 30 mm diameter and 2.5 m length is buried vertically into the ground to work as an earth electrode, but the depth depends upon the soil conditions (there are no hard and fast rules for this). The earth electrodes are connected to the top section of the pipe with a nut and bolt. The pit area around the GI pipe is filled with

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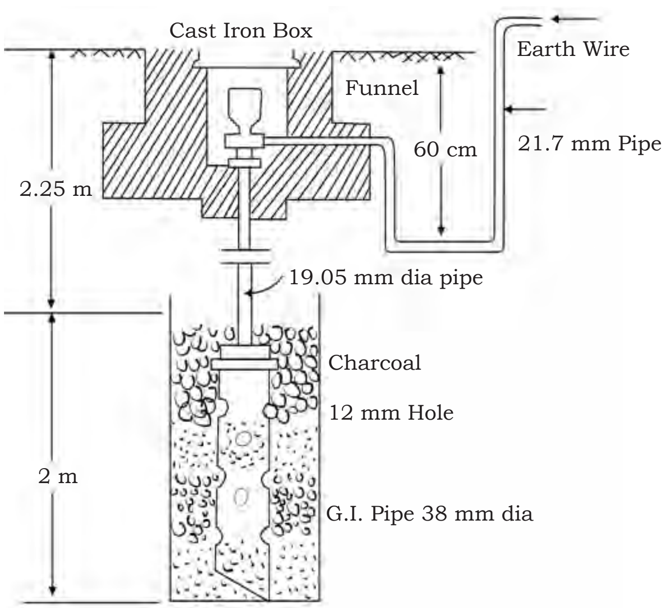


Fig. 1.29 Pipe earthing

an alternate layer of salt and charcoal for reducing the earth's resistance. It can take heavy leakage current for the same electrode size in comparison to plate earthing. Water is filled through pipe to maintain the resistance of earth electrode. Pipe earthing (Fig. 1.29) is the best form of earthing and it is also a cheap method of earthing.

Earthing pipes are also known as earthing electrode pipes, these can be used in houses, office as well as power stations. Earthing pipes are used in electrical installation, transmission line and other installation. Copper pipe is generally used in an earthing system. The pipe size depends upon the current to be carried and on the soil type. Pipe earthing is reliable, durable, easy to handle and highly secure. Connectivity of the pipe earthing is up to the chamber or earth terminal. The connection of earth wire from machine to Galvanised Iron (GI) pipe, being above the ground level makes it easy to check for any discontinuity.

Pipe earthing gives us the freedom to put 23 buckets of water through the funnel, which helps in achieving effective earthing. It is one of the most widely used method of earthing.

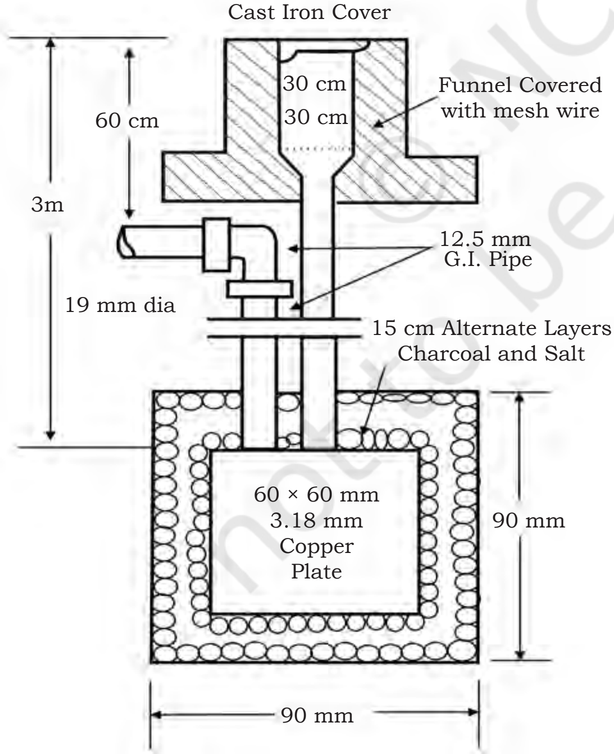


Fig. 1.30 Plate earthing

Plate Earthing

In this type of earthing, a plate of copper or GI, is buried into the ground at a depth of greater than 3 m (Fig. 1.30).

Earthing plate is filled with alternate layers of salt and coke not less than 46 cm (1.5 feet) so as to provide lesser resistance due to absorption of moisture. The earth conductor is properly bolted to an earth plate with the help of nut and bolt and washer made of copper, in case of copper plate earthing and of G.I., in case of G.I., plate earthing (Fig. 1.30).

For G.I., the earthing plate size should be 600 mm × 600 mm × 8.30 mm and for copper earthing the plate size should be 600 mm × 600 mm × 3.15 mm and the pit size made for maintenance should be 30 cm × 30 cm so as to provide ease of accessibility of maintenance of these earthing pits and for testing of earthing pits.

Advantages of Earthing

One of the major objectives of earthing is to ensure safety of persons during leakage fault conditions. Earthing creates the path of least resistance from machine to the earth so that the fault current dissipates quickly. It allows the lightning electrical energy to be safely dissipated thereby minimising the danger caused by the lightning. Earthing is the key to safety, i.e., protection of personnel, equipment, wiring, machines and instruments (Fig. 1.31). Another advantage of earthing is in communication tower where it is used to reduce electromagnetic interference.

Both type of earthing processes can be used. But plate earthing is preferred in small buildings and pipe earthing is used for multistorey buildings as well as electrical sub-station. All metallic parts of electric machines must be earthed for safety of equipment.

Earth Resistance

1. Earth resistance depends on the following factors:
   - (a) Type of earth soil
   - (b) Temperature of earth
   - (c) Humidity on earth
   - (d) Minerals on earth
   - (e) Length of electrode
   - (f) Distance between two electrodes
   - (g) Number of electrodes
2. Maximum earth resistance allowed is as follows:
   - (a) Major power station—0.5 ohm
   - (b) Major sub-stations—1.0 ohm
   - (c) Minor sub-station—2 ohm
   - (d) Neutral bushing—0.2 ohm
   - (e) Service connection—4 ohm

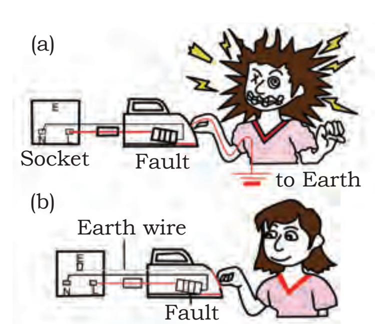


Fig. 1.31 Proper earthing

(f) L.T. Lightning arrestor—4 ohm
(g) L.T. Pole—5 ohm
(h) H.T. Pole—10 ohm
(i) Tower—20–30 ohm

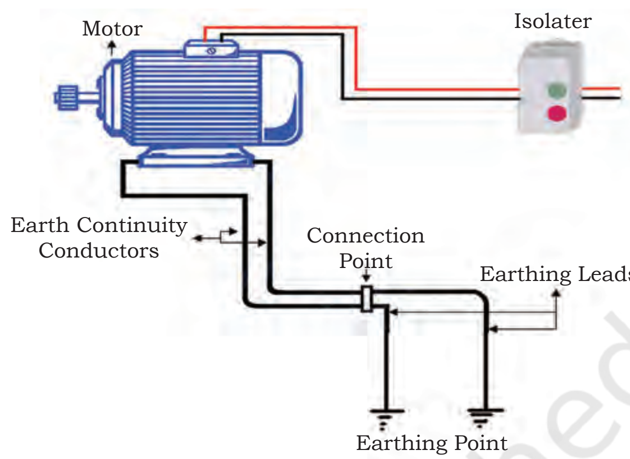


Fig. 1.32 Earthing to the electrical motor

Earth Tester and Resistance

Use of earth tester

Earth tester is used for measuring earth's resistance. If earth's resistance is high, certain processes need to be adopted for controlling it.

Working of earth tester

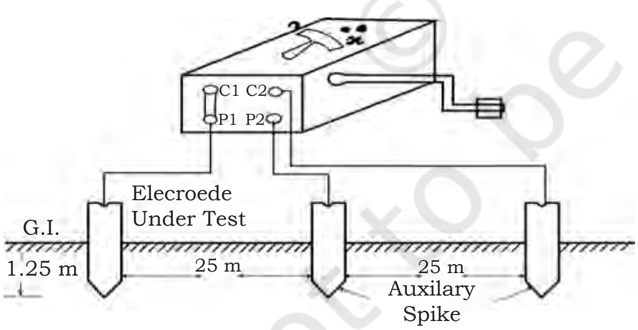


Fig. 1.33 Measurement of Earthing Resistance—Three-Point Method

Earth tester consists of a hand-operated D.C. generator, 4 spikes and a connecting wire. These spikes are connected through wire to terminals of the earth tester. Spikes are inserted in the ground to check the earth's resistance. Current is feeded to the spikes through the D.C. generator. The D.C. is converted into A.C. by the converter and the A.C. received from the spike is again converted to D.C. with the help of a rectifier. While moving towards the generator, the A.C. is fed to the spike driven in the earth as there should be no electrolytic effect.

Three-point method

In this method, earth tester terminals C1 and P1 are joined to each other and connected to the earth electrode (pipe) under test. Terminals P2 and C2 are connected to the two separate spikes driven in earth (Fig. 1.33). These two spikes are kept in the same line at a distance of 25 metres and 50 metres each due to which, there will not be mutual interference in the field of individual spikes. If we rotate the generator handle at a specific speed, we will directly get the earth's resistance on scale. This method of testing is known as the three-point method.

***Note*:** Spike length in the earth should not be more than 1/20th distance between two spikes.

Four-point method

In this method, four spikes are driven in the earth in the same line at an equal distance. Outer two spikes are connected to C1 and C2 terminals of earth tester. Similarly, inner two spikes are connected to P1 and P2 terminals. Now, if the generator handle is rotated at a specific speed, earth's resistance value of that place can be obtained.

In this method, error due to polarisation effect is eliminated and earth tester can be operated directly on A.C.

If earth's resistance is higher, the following treatments can be done to minimise the resistance.

(a) Oxidation on joints should be removed and joints should be tightened.
(b) Sufficient water should be poured into earth's electrode.
(c) Earth electrode of bigger size as far as possible should be used.
(d) Electrodes should be connected in parallel.
(e) Earth pit of more depth and width-breadth should be made.

NOTES

Check Your Progress

A. Fill in the Blanks

1. The metallic connection between electrical machines and devices with the earth plate, through a thick wire is known as ____________.
2. ______________ earthing is a cheap and best form of earthing.
3. The resistance between earth electrode and earth in Ohms is called ____________.
4. Earthing saves human lives from ________________.
5. The unit of earth resistance is ________________.

B. Match the Columns

1. Major sub-station	A. 20–30 ohm
2. Major power staton	B. 2 ohm
3. Minor sub-station	C. 0.5 ohm
4. Tower	D. 1 ohm

C. Multiple Choice Questions

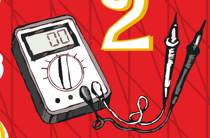
1. Earth resistance value of house wiring is _________.
   (a) 5 ohm
   (b) 2 ohm
   (c) 1 ohm
   (d) 8 ohm
2. The most commonly used type of earthing is ________.
   (a) plate earthing
   (b) pipe earthing
   (c) rod earthing
   (d) strip earthing
3. Ideal value for earth's resistance in ohm is __________.
   (a) 1
   (b) 2
   (c) 3
   (d) 0
4. For maintaining moisture around the earthing we use __________.
   (a) salt and charcoal
   (b) sugar
   (c) oil
   (d) None of the above
5. Every metallic electrical pole must be ______
   (a) grounded
   (b) earthed
   (c) phase
   (d) neutral

D. Short Answer Questions

1. What do you understand by electrical earthing? Why is it done?
2. Which electrical points should be earthed?
3. Write down the earth's resistance of different electrical installations.
4. What are the different types of earthing?
5. Draw a simple diagram of pipe earthing.

NOTES

Unit 2



Handling of Tools and Equipment

17957CH02

Introduction

When repairing an appliance, one needs to be familiar with the working of the tools. You may already be familiar with the typical wrenches and screwdrivers, but you will need to know more, such as about voltage meters and even single and multiphase compressor testers (Fig. 2.1).


Fig. 2.1 Tools used in repairing electric appliances

Various tools and equipment are required for maintainance as well as erection of various electrical components. Therefore, it is necessary to know about these tools and equipment to operate them safely.

Session 1: Tools and Equipment

The various tools and equipment used by an electrical or electronic technician while working with electrical circuits are as explained below:

(a) Screw driver: It is used to turn, tighten or remove screws (Figs. 2.2 and 2.3).

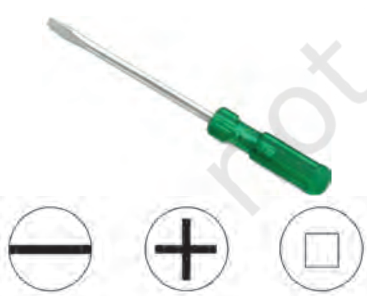


Fig. 2.2 and 2.3
Types of Screw drivers

(b) Ratchet: It is used to allow rotary motion in only one direction and prevent the motion in opposite direction. It is used to tighten nuts of various sizes (Fig. 2.4).

(c) Spanner: It is used to provide grip to apply torque for turning objects, such as a nut or a bolt. A spanner is available in variable diameter to tighten nuts and bolts of various sizes (Fig. 2.5).

(d) Wrench: It is a hand tool used for tightening and loosening of the nuts and bolts (Fig 2.6). These tools hold slippery or small nuts and bolts for loosening or tightening them.

(e) Wire cutter and plier: A wire cutter is used for striping and cutting wires where as a plier is used to hold objects like nuts and bolts firmly. It is also used for cutting metal wires (Fig. 2.7).

(f) Tester: It is used to verify the presence of electric voltage in an electrical equipment (Fig. 2.8).

(g) Hammer: It is used to fix nails in walls and wood, fit parts, or forge metal and for breaking different materials (Fig. 2.9).

(h) Ladder: It is used to climb upwards to reach higher places (6 to 7 feet) in tall units of a control panel (Fig. 2.10).

(i) Utility knife: It is used to cut various objects, such as wires, cords, tapes and so on (Fig. 2.11).

(j) Soldering or desoldering iron: It is used to embed or remove the components on or from the panel (Fig. 2.12).

(k) Soldering or desoldering station: It is used to hold the hot iron when it is not in use and adjust the temperature of the tip (Fig. 2.13).

Fig. 2.8 Tester

Fig. 2.9 Hammer

Fig. 2.10 Ladder

Fig. 2.11 Utility knife

Fig. 2.12 Soldering or desoldering iron

Fig. 2.4 Ratchets

Fig. 2.5 Spanner

Fig. 2.6 Wrench

Fig. 2.7 Wire cutter and pliers

Fig. 2.13: Soldering or desoldering station

Fig. 2.14 Crimping tool

Fig. 2.15 Voltmeter

(l) **Crimping tool:** It is used to cut various objects, such as wires, cords, tapes and so on. It is also used to join wires with metal or plastic objects (Fig. 2.14).

(m) **Voltmeter:** It is used to measure the potential difference between two points in an electric circuit (Fig. 2.15).

(n) **Ammeter:** It is used to measure the current flow in a circuit (Fig. 2.16).

(o) **Watt meter:** It is used to measure the electrical ower of any given circuit (in watts) (Fig. 2.17).

(p) **Megger:** It is used to measure leakage in wires and earth resistance (Fig. 2.18).

(q) **Multimeter:** It is used to measure various electrical quantities like resistance, voltage and current, etc. (Fig. 2.19).

Fig. 2.16 Ammeter

Fig. 2.17 Watt meter

Fig. 2.18 Megger

Fig. 2.19 Multimeter

Check Your Progress

A. Fill in the Blanks

1. ______________ is used for measuring the current.
2. Wire cutter is used for ________________ made of metal or plastic objects.
3. Crimping tool is used for ______________.
4. In an electric tester _____________ bulb is used.

B. State whether the following Statements are True or False

1. One should always examine the tool for damages before use.
2. One can wear loose clothing, dangling objects and jewellery while using hand tools.
3. A watt meter is used to measure the current flow in a citcuit.

4. Only those tools and equipment should be used which are in good condition.
5. Safety glasses should always be worn while using power hand tool.

C. Short Answer Questions

1. List the tools and equipment required for electrical work.
2. Explain the purpose of multimeter and voltmeter.

Session 2: Tools and Equipment used for Cable Laying

Preparation of Cables and Equipment for Cable Laying Activities

Tools and equipment are used for various electrical activities. One should take proper care while handling electrical wire laying. While laying the cables necessary precautions, and health and safety practices for power-related work should be observed as per standard rules. Important tools and equipment used for laying electrical wire (laying works) have been discussed in this session.

Many tools are used for cable laying. These include cable pulling winch, cable guiding device, cable pulling grip, etc.

Fig. 2.20 Cable drum with cable

Fig. 2.21 Cable drum without cable

Fig. 2.22 Angle rollers

Cable Drums

Cables get twisted during the laying process. Drums are used to check or avoid twisting of cable. Cable drums (Figs. 2.20 and 2.21) help the technicans with the laying. Similiarly angle rollers are also used for laying the cable (Fig. 2.22).

Pulling Methods and Calculations

The correct method should be used while laying the cable in the field. Adequate equipment and tools must be used in this process. The cable drum should be mounted on jacks and the cable should be rolled off the drum gently avoiding kinks and twists. The free end in the case of heavy cables may be pulled with the help of a winch. Laying of cable in open trench presents no serious difficulty. The cable is first placed on rollers

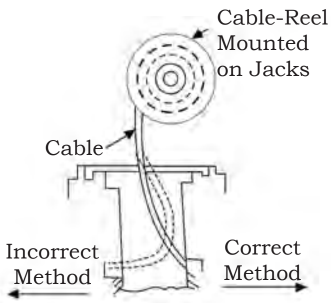


Fig. 2.23 Pulling Methods

laid in the trench or on the ground above, which is then transferred to the bed of the trench. When laying cables in pipes and ducts, care should be exercised so as to not damage them during installation. The correct method of laying out cable for installation in a duct is shown in the below given figure (Fig. 2.23)

Testing of Underground Cables

After laying of cables underground or above the ground, proper testing is done to check the faults caused due to laying, if any. The cables are tested for short-circuit faults, discontinuity faults and earth fault. Murray and Varley loop tests are done to check these faults.

Tools used for Erection and Maintenance


Fig. 2.24 Tools for Erection and Maintenance

A lineman who is doing erection and maintenance work, cannot do the job without proper hand tools, which they have carry around on a daily basis. Unlike tools used by any other worker, a lineman's tools require proper insulation, because these tools are used with electrical installations. The handles of these tools are coated with rubber to prevent the worker from getting electrocuted (Fig. 2.24).

Tools are important to carry out a job. The entire job being carried out by a technician is with the help of tools. The following tools are commonly used for working in a distribution system:


Fig. 2.25 Combination Plier

(a) Combination pliers: It is used for cutting, removing insulation, joining and twisting the electric wires and cables even on a live-line. A lineman's pliers have a special design, which multiplies force through leverage. These pliers usually have grips for better handling than bare metal handles. The grips also provide with insulation for protection against electric shock when working with live circuits.A lineman's pliers are typically machined from forged steel. The two handles are precisely joined with a heavy-duty rivet that maintains the pliers' accuracy even after repeated use under extreme force on heavy-gauge wire (Fig. 2.25).


Fig. 2.26 Adjustable Wrench

(b) Adjustable wrench: An adjustable wrench is used to open and close nuts and bolts in case of proper size spanner not being available. Common sizes are 8” (inch) to 12” (inch). Adjustable wrenches are designed to provide a wide range of capacity in a single tool and are a convenient service wrench for distribution linemen. They are not intended to replace fixed opening wrenches for production or general service work. High dielectric insulated handle types are widely used by linemen and other electrical workers (see Fig. 2.26).

Fig. 2.27 Pipe wrench

(c) Pipe wrench: It is used to open, close conduit, GI pipes and valves. The common size is 10” (inch). The design of the adjustable jaw allows it to lock in the frame, such that any forward pressure on the handle tends to pull the jaws tighter together. They are usually made of cast steel. Nowadays, aluminium is also used to construct the body of the wrench, while the teeth and jaw remain of steel (Fig. 2.27).

Fig. 2.28 Measuring tape

(d) Measuring tape: It is used to measure the length of wires, cable and space. Use of measuring tape makes cable savings efficient for cleaning and reduces wastage. These are made of cotton or metal strips bearing size of 10' (feet) to 100' (feet) (Fig. 2.28).

Fig. 2.29 Hammer

(e) Hammer: It is used to pierce nails, centre punch, rawl plug fix and chisel. Common sizes are 1, 2.5, 3 and 5 lbs (Pounds). A lineman’s hammer is best suited to drive in big lag screws and hammering bolts in utility-pole work. They are also used by electricians to drive nails in hard places (Fig. 2.29).

Fig. 2.30 Ratchet with drill bit (hand drill)

(f) Ratchet with drill bit (hand drill): It is used to make holes on wooden cross arms and wooden cleats for tight fitting HT and LT cables emanating from DP structures, or LT transformer bushings (Fig. 2.30).

Fig. 2.31 Electric drill

(g) Electric drill machine: It is a portable electric-powered tool used for drilling the surface (Fig. 2.31). It has a high speed motor to revolve the chuck. It is used to make holes smoothly and easily.

(h) Bench vice: A vice is a mechanical apparatus used to secure an object to allow work to be performed on it. In electrical works, cutting does play an important role. Cutting an electrical conduit has to be secure enough for a smart cut to be made. A bench vice (Fig. 2.32) is a perfect way to do this.

Fig. 2.32 Bench Vice

Fig. 2.33 Chain Pulley

Fig. 2.34 Tripod

Fig. 2.35 Come along clamp

Fig. 2.36 Ratchet device

It is used to grip the job (object) which has the following features:

(i) Base plate (permanently fixed on the working table sides)

(ii) Fixed jaw (fixed with base plate)

(iii) Moving jaw (could be moved according to the thickness of the job)

(i) Chain pulley: It is a pulley with depressions in the periphery of its wheel, or projections from it, made to fit the links of a chain. Desired capacity chain pulley is hooked at the centre to lift heavy load for loading and unloading at site (Fig. 2.33).

(j) Tripod: It is a combination of three to four metre long 40 mm GI pipes hinged at upper end for making tripod formation. Tripods are perfect for utility workers as they are portable and lightweight with high-strength anchor (Fig. 2.34).

(k) Come along clamp: It is used while laying overhead lines. These are mainly used for holding conductors and ground wires in overhead transmission lines and various other industrial maintenance operations. These clamps are available in multiple diameter, weight and design that are ideal to use in electrical works. They are ideal to pull conductors as they are lightweight and compact in structure (Fig. 2.35).

(l) Ratchet device: It is a device consisting of a bar or wheel with a set of angled teeth in which a pawl, cog or tooth engages, allowing motion in one direction only. Ratchets are widely used in machinery and tools as well as maintenance works (Fig. 2.36).

A lineman normally works in a distribution sub-division of a Power Company (Discom). The recommended norms for tools and equipment for a distribution sub-division is almost same for all states.

An electrician working in the field must have the following tools with them as per the given list below in Table 2.1.

Table 2.1 List of Standard Tools for an Electrician

S.No.	Particulars	Quantity
1.	Chain pulley block 5 MT	1
2.	Megger 1000 volts	1

3.	Earth tester	1
4.	Portable drilling machine	1
5.	Bamboo ladder	2
6.	Steel measuring tape	1
7.	Pulling and lifting machine (3 tonnes)	1
8.	Pipe wrench 3” (7.6 cm)	2
9.	Spirit level	4
10.	Socket spanner set	2
11.	Ring spanner set	2
12.	Hammer	2

Fault Indicators and Protective Equipment

The flow of current towards an undesired path or abnormal stoppage of current is termed as a fault. A fault indicator (Fig. 2.37) is a device which indicates the passage of fault current. When properly applied, fault indicators can reduce the operating costs and reduce service interruptions by identifying the section of cable that has failed.

Fig. 2.37 Fault indicator

Dos and Don’ts while Working

1. Never touch a current carrying wire or conductor.
2. Never pull out a flexible cable while removing the plug from the mains.
3. Switch off the supply while checking any electrical appliance.
4. Never play with tools.
5. Handle tools carefully and be alert while working.
6. Never switch on supply unless you are sure about the working of an appliance.
7. Ensure that proper earthing is provided for the appliance.
8. Seek guidance of your teacher in case of any doubt and do not try to experiment yourself.
9. Report damage or breakdown to your teacher immediately.
10. When working on a circuit, use approved tools with an IE rating.

Precautions

1. In DC measurements check polarities.
2. Select higher range for measurement initially and later select the required range for accuracy.

Notes

Check Your Progress

A. Multiple Choice Questions

1. If a worker on live-line gets electrocuted, what is the first thing to be done?
   (a) Call the doctor
   (b) Switch off supply
   (c) Remove the person from electrical contact
   (d) Provide artificial respiration
2. _______________ are portable and ligtweight with high strength anchor.
   (a) Tripods
   (b) Chain pulley
   (c) Rachet device
   (d) None of the above
3. See the picture given on the right. This tool is known as a ______________.
   (a) screw driver
   (b) combination plier
   (c) bench vice
   (d) crimping tool

4. Fault indicators are devices which indicate the passage of ______________ current.
   (a) altemating
   (b) direct
   (c) fault
   (d) None of the above
5. When working on a circuit, use approved tools with ______________.
   (a) rubber gloves
   (b) an IE rating safety grounds
   (c) insulated handles
   (d) All of the above
6. If an equipment has been repaired, make sure that it has been ______________ as safe before using it.
   (a) demonstrated
   (b) listed
   (c) tested and certified
   (d) None of the above
7. Damaged tools must be removed from service and properly ______________.
   (a) repaired
   (b) destroyed
   (c) tagged
   (d) carried

8. An example of properly matching the tool to the job is ______________.
   (a) using the right size slothead screwdriver on a slothead screw
   (b) using a wrench to hammer in a nail
   (c) using a hard metal hammer head on hardened steel
   (d) None of the above
9. The safest way to take tools up and down ladders is in ______________.
   (a) a bag or bucket
   (b) a tool belt
   (c) pocket
   (d) None of the above
10. One safety risk of not keeping track of your tools is ______________.
   (a) having the tool fall on another person
   (b) getting cut by a hidden pointed or sharp tool
   (c) Both (a) and (b)
   (d) None of the above
11. At the end of a task where you used hand tools, you should ______________.
   (a) leave them where they are so they can be used later
   (b) turn them to your supervisor for inspection
   (c) put them away in their proper storage place
   (d) None of the above

B. State whether the following Statements are True or False

1. Never use electric tools in wet conditions.
2. You cannot be injured by a hand tool.
3. You do not need any personal protective equipment to work safely with hand tools.
4. If a tool does not work for a particular job, you should alter it to make it work.

Notes

Unit 3

Electrical Wiring Components and Accessories

17957CH03

Introduction

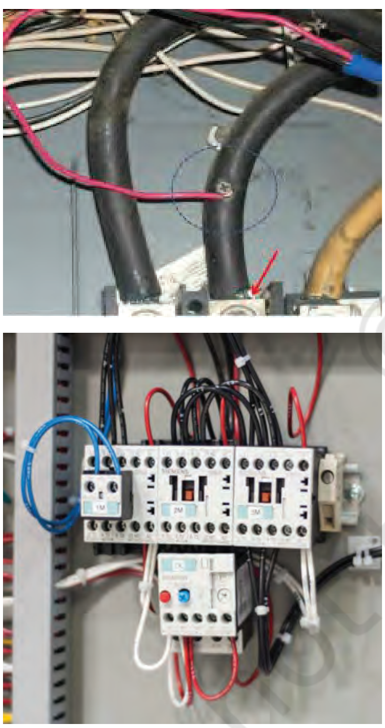


Fig. 3.1 Wiring components

Electricity requires an electric path to flow and there are many conducting materials used for this purpose. There are many semi-conductor materials which are used to reduce the voltage and also drop the current flow. There are non-conducting materials which are used as insulation during working on live-lines. In this unit we will study how the household or industrial wiring is done and what materials are essential for household or industrial wiring. We will also study about the various types of wiring (Fig. 3.1).

Session 1: Identifying and Selecting the Wiring Material and Components

Wiring Material

Electrical wire is made of material like copper, aluminium and silver. Silver is very costly; and therefore, mostly copper and aluminium are used in wiring.

Material is of three types:

1. Conducting material
2. Insulating material
3. Semiconductor material

Conducting Material

(a) Copper: It is a good conductor of electricity. It is used in wiring material in cables. Its resistance is low and used for conduction of electricity at high, medium and low voltage (Fig. 3.2).

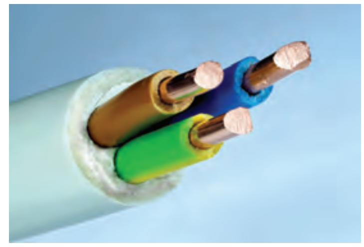


Fig. 3.2 Copper wire

(b) Aluminium: It is light weight in comparison to copper. Aluminium is cheaper than copper and is therefore mostly used in electrical wiring and cable making. Its colour is silvery-white and it is soft (Fig. 3.3).

Fig. 3.3 Aluminium wire

Insulating Material

Insulating material are used for insulating purpose. This type of material does not carry current, for example, rubber, paper, mica, wood, glass and cotton.

Wiring Accessories

Wiring accessories are used for connecting appliances (Fig. 3.4).

Fig. 3.4 Switches

(a) Switch: A switch is used to make or break an electrical circuit. It is used to switch 'on' or 'off' the electrical supply.

There are various switches, such as

- surface switch
- flush switch
- ceiling switch
- pull switch
- push button switch
- bed switch

(i) Surface switch: It is mounted on a wooden board fixed over the surface of a wall. It is of three types.

1. One-way switch
2. Two-way switch
3. Intermediate switch

- **One-way switch:** It is used to control a single circuit and lamp (Fig. 3.5).

Fig. 3.5 One-way switch

Fig. 3.6 Two-way switch

- **Two-way switch:** It is used to divert the flow of current to either of the two directions. The two-way switch can also be used to control one lamp from two different places as in case of staircase wiring (Fig. 3.6).
- **Intermediate switch:** This switch is used to control a lamp from more than two locations (Fig. 3.7).

Fig 3.7 Intermediate switch

(i) Flush switches: These are used where good appearance is required (Fig. 3.8).

(ii) Bed switch: As the name indicates it is used to switch 'on' or 'off' the light from the place, other than switch-board or from near the bed. This switch is connected through a flexible wire (Fig. 3.9).

Fig. 3.8 Flush Switch

Fig. 3.9 Bed switch

(b) Holder*:* A holder is of two types.

1. Pendant holder (Fig. 3.10)
2. Batten holder (Fig. 3.11)

Fig. 3.10 Pendant holder

(c) Ceiling rose*:* These are used to provide a tapping to the pendant lamp holder through the flexible wire or a connection to a fluorescent tube (Fig. 3.12).

(d) Socket outlet or plug: The socket outlet have all insulated base with molded or socket base having three terminal sleeves (Fig. 3.13).

(e) Main switch: To control the electrical circuit a main switch is used. Through main switches, complete control of power in a building is done (Fig. 3.14).

(f) PVC casing capping wiring: For covering the wires, PVC capping is done. It includes casing also. This casing capping wiring is also known as open wiring, as it is done outside the wall.

Fig. 3.11 Batten holder

Fig. 3.12 Ceiling rose

Fig. 3.13 Socket

Fig. 3.14 Main switch/ Main MCB

Material for PVC casing capping wiring (Figs. 3.15 and 3.16) includes

- wire
- casing enclosures made up of plastic
- capping made up of plastic
- T. Joints VIR or PVC insulated wire
- junction box
- elbow
- casing and capping joints

Wooden casing capping wiring is very old fashioned. Now PVC or VIR insulated wires are carried through a PVC casing enclosure and PVC capping is used to cover the casing.

Fig. 3.15 PVC casing, capping accessories

Fig. 3.16 PVC casing capping bend

Advantages of PVC casing capping wiring

- Easy to install
- Strong and durable wiring
- Customisation can be done easily
- Safe from smoke, dust, rain and steam, etc.
- Due to casing and capping, no risk of shock

Disadvantages of PVC casing capping wiring

- Costly
- Not suitable for weather with high humidity
- High risk of fire

MCB (Miniature Circuit Breaker)

An MCB is used in new construction in place of the old fuses. Circuit breakers are small devices used to control and protect the electrical panel and the other devices from overflowing of electrical power (Fig. 3.17).

Fig. 3.17 MCB Distribution Box

Uses of MCB

Home electrical panels

As with all breakers, the MCB is designed to protect the house from circuit overload. An MCB is much safer than the typical fuse, because it can be reset manually and it handles much larger amounts of power. The breaker can manage the flow of energy, distributing the voltage evenly even when many devices run off the same power circuit.

Notes

Lights

MCBs are used in the lighting system of the house, because they can deal with the amount of power needed for lightning a house, especially if specific types of lamps, such as fluorescent lights are used. MCBs overcome the need of additional power required when switching on the lights, especially when lights are used extensively in the entire house.

Industrial applications

There are many small scale industrial buildings where MCBs are used instead of the old fuses. Miniature circuit breakers are largely used in restaurants, bakeries and commercial stores.

Heaters

When heaters are used at home or in the office, the MCB can be beneficial. It is known that heaters can be problematic sometimes, especially with distribution of electrical power. The MCB prevents from possible problems, cutting off electricity in the case of overload or fault. In this case, though, you need to choose an MCB of required capacity as per the appliance, enabling it to handle the power load when needed.

Conduit Wiring

Electrical conduits are used to protect and provide the route of electrical wiring in an electrical system. Electrical conduits are made of metal, plastic or fibre and can be rigid or flexible. Conduits (see Figs 3.18 and 3.19) must be installed by electricians as per standard regulations. For workshops and public buildings, conduit wiring is the one of best and most desirable systems of wiring. It provides protection and safety against fire.

Types of Conduits

1. Class A conduit: Thin layer steel sheet low-gauge conduit
2. Class B conduit: Thick sheet of steel high-gauge conduit

Components used in Conduit Wiring

Fig. 3.18 Conduit wiring

- GI (Galvanised Iron) wire (Fig. 3.18)
- Elbow
- Coupling
- VIR (Vulcanised Indian Rubber) or PVC (Polyvinyl Chloride) insulated cables
- Lock nut
- Clip
- Junction box (Fig. 3.19)

Fig. 3.19 Conduit wiring components

Advantages of conduit wiring

- Safe
- Appearance is better
- No risk of fire
- No risk of damage to cable insulation
- Immune to humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

Disadvantages of conduit wiring

- Expensive
- Installation is not easy
- Not easy to customise for future
- Hard to detect faults

Concealed Wiring

It is laborious to install this type of wiring. The layout of this wiring is done under the plaster of the wall, of the building.

Advantages of concealed wiring

- Safe wiring
- Appearance is better
- No risk of fire
- No risk of damage to cable insulation
- Immune to humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

NOTES

Disadvantages of concealed wiring

- Expensive
- Installation is not easy
- Not easy to customise for future
- Hard to detect faults

Colour Code

Wiring for AC and DC circuit are colour coded for identification of individual wires. Refer to Table 3.1 for details.

Table 3.1 AC power circuit wiring colour codes

Function	Label	Colour	Old Colour
Protective ground	P G	Green or green-yellow	Green
Neutral	N	White	Gray
Line, single phase	L	Black or red	_
Line, three phase	L1	Black	Brown
Line, three phase	L2	Red	Orange
Line, three phase	L3	Blue	Yellow

Check Your Progress

A. Write short notes on

(a) Advantages of Conduit Wiring
(b) Use of MCB
(c) Use of Insulating Material
(d) Wiring Material

B. Fill in the Blanks

1. For wiring _________ and ___________ metals are used.
2. Switches are made from ____________ material.
3. Most common insulating materials are ______________, ______________ and ____________.

C. State whether the following Statements are True or False

1. Silver is a bad conductor of electricity.
2. Switches are made of conducting material.
3. VIR wires are used for wiring.

D. Multiple Choice Questions

1. Concealed wiring is done (on) ______________.
   (a) open wiring
   (b) under the plaster
   (c) flexible wiring
   (d) casing wiring

2. Pendant holder is used for ______________.
   (a) fixing a bulb
   (b) fixing a fan
   (c) hanging a bulb
   (d) hanging a fan
3. Two-way switch is used for ________________.
   (a) controlling one bulb from 2 points
   (b) controlling two bulbs from 2 points
   (c) controlling multiple bulbs from 2 points
   (d) controlling one bulb from one point

Session 2: ICTP Switch and Distribution Board

ICTP (Iron Clad Triple Pole) Switch

These switches are used in an energy meter to isolate the supply automatically or manually (Fig. 3.20).

Fig. 3.20 ICTP switch

Distribution Board

A distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. A distribution board is also known as a panelboard, breaker panel or electric panel (Fig. 3.21).

Fig. 3.21 MCB distribution board

Electrical Circuit

In an electric circuit, the positive side of wire is connected to the negative side to start the power supply. The circuit is like an electrical house.

Types of Circuit

1. Series
2. Parallel

- **Series Circuit:** Series circuit is like a staircase. In this type of circuit, resistances r1, r2, r3 are connected in series. When many resistances are connected in series, it is called a series circuit. In this,

  $$R = r1+r2+r3$$

  where R is equivalent to resistance.

NOTES

- **Parallel circuit:** When various resistances are connected in parallel, it is called a parallel circuit. Like if r1, r2 and r3 are connected in parallel, then

$$R = 1/r1+1/r2+1/r3$$

In this, all resistances which have a positive side are connected to one end and all that have a negative side are connected to another end. All branch voltages are same in this type of circuit.

Fixing Wiring Accessories on Board

Now you should be able to know the tools required for fixing the accessories on the board. You should also know the purpose of fixing the accessories.

In-house wiring of the switches, holders and sockets are mostly fixed on wooden or sun mica boards and blocks. Therefore, it is necessary to learn how to fix these accessories. The ways to fix these accessories have been discussed in the following practical activity.

Let's Practise 1

1. Adjust the electrical accessories like, switch, holder, socket, etc., on the given board or round block.
2. Then mark their positions by a pencil.
3. Remove the covers of the accessories and loosen the screws of terminals.
4. Make a powder of chalk and pour it in the holes of the terminal. Mark the point on them with a poker.
5. Now make the holes on the round block or board with a drilling machine where the points have been marked.
6. Insert the wires in the terminal, after removing the insulation. Then fix all the accessories on the board or round block by wooden screws after making holes on them with the poker.
7. Then fix all covers on the accessories.

Tools and material required

Tools

1. Hand drilling machine with a drift bit of 5 cm
2. Poker
3. Screwdriver
4. Connector screwdriver (8 cms)
5. Combination plier (15 cm)
6. Try square
7. Firmer chisel (20 mm)
8. Electrician knife (10 cm)

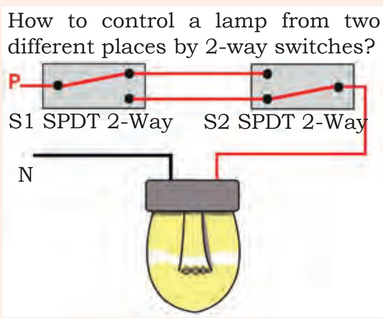
Notes

Material

1. Wooden round block or PVC round block
2. Wooden board or sunmica board
3. Single pole one-way switch 5 A, 250V
4. PVC wire
5. Pencil
6. Chalk

Precautions

All the fittings (switch, holder) should be fitted well. No naked portion of the conductor should remain visible. The screws in the accessories fitted should be tight. The tools should be used carefully.



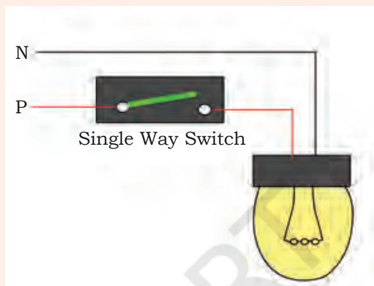


Fig. 1 Circuit diagram of simple wiring

Fig. 2 Circuit diagram of staircase wiring/ or a lamp controlled from two different places

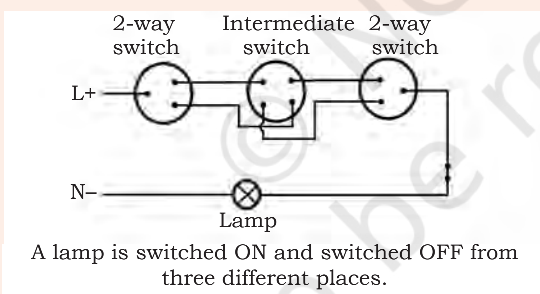


Fig. 3 A lamp controlled from three different places

Let's Practise 2

Identify and draw the figure of various wiring materials

Procedure

1. See the different types of wiring materials as shown in the figure above as well as in classroom and draw the diagram.

Notes

Let's Practise 3

Identify and connect the accessories with the wires

Tools and equipment required

1. Multimeter for measuring the current and voltage
2. Tools like plier, screwdriver

Procedure

Connect the accessories with the help of wires

Precautions

1. All connections should be tight.
2. Do not touch the terminals when supply is on.

Let's Practise 4

Connect different types of components with wires in a junction box

Tools and equipment required

1. Tools like screwdriver, plier
2. Multimeter for measuring the current and voltage

Procedure

Connect different types of components with the help of wires in a junction box

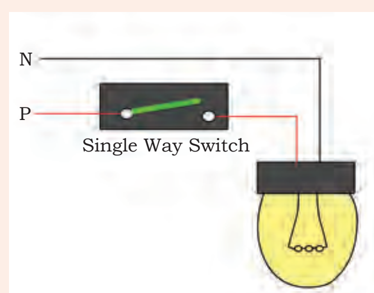
Precautions

1. All connections should be tight.
2. Do not touch the terminals when supply is on.

Let's Practise 5

Understand the electrical connection of a lamp to the supply mains and select the proper size of connecting wires and switch for a given load.

Related information



In a lamp, the electrical energy is converted into light. The function of the switch is to turn the lamp 'on' or 'off' by making and breaking the electrical circuit, respectively. The switch should be connected to the phase wire of the supply. It should be connected in series with the lamp. The function of the fuse is to protect an electrical circuit against excess current which may be caused by a fault or overloading.

Apparatus and material required

1. Lamp
2. Switch
3. Fuse
4. Wooden batten or PVC batten
5. Link clips
6. Screws
7. Nails
8. Insulation tape
9. Connecting wires
10. Lamp holder
11. Electrician's common hand tools

Procedure

1. Fix the switch and lamp holder on the board.
2. Connect the switch and lamp.
3. Connect the circuit to the supply mains, while the main switch is 'off'.
4. Put 'on' the main switch.

Precautions

1. All the connections should be tight.
2. Check the rating of the fuse.

Let's Practise 6

Check the connection of the lamp by one switch (series)

Apparatus, tools and material required

1. Lamp 100W/220V
2. Holder
3. One-way switch
4. PVC wire 1/18 SWG
5. Pliers (slide cutting and combination) (1 each)
6. Screw driver (1)
7. Phase tester 6"(1)

Procedure

1. Take a PVC 1/18 SWG wire about 1 metre in length and cut it into two pieces of equal length with side cutting plier.
2. Remove the insulation of nearly 1 cm from both the ends of each wire with the help of a combination plier.
3. Now take the holder and screw its nut with the help of screwdriver.
4. Fit each end of both the wires in the bolt and screw the nuts.
5. Now cover the holder, connect one end of the wire to the top point of the switch.

NOTES

Notes

6. Take 1 feet of another wire and connect it to the bottom of the switch.
7. Connect the switch wire to phase and another wire to neutral. Switch 'ON', if the bulb glows, the connection is right.

Precautions

1. Phase is always controlled by the switch.
2. The part of the wire without insulation should not be open.
3. Twisted wire fitted in the holder should be put in such a way that the two wires do not touch each other.
4. Carefully remove the insulation part such that the wire does not cut.
5. Do not touch any naked electrical wire unless you are sure that there is no current in the wire

Let's Practise 7

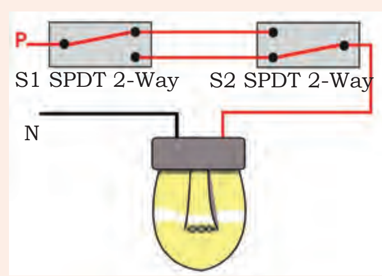
Check the connection of lamp with a two-way switch (parallel)

Related information

The circuit consists of one lamp and 2-way switches connected. The common points in switches S1 and S2 are C1 and C2, respectively. The common point C2 is connected to position 2 in switch S2. Now, if the common C1 is connected to the position 1 in switch S1, then the path of the electric circuit is not complete and, hence, the lamp will not glow. However, if C1 is connected to position 1, then the path of the current is completed through S1, S2 and the lamp. Then the lamp will not glow.

Apparatus and material required

1. Lamp holder, (pendent) 5A, 250V(1)
2. Lamp 40 Watts, 250V (1)
3. Two-way switch, 5A, 250V (2)
4. Connecting wires
5. Insulated plier
6. Electrician's knife
7. Screw driver



Procedure

1. Connect the lamp with the two switches S1 and S2.
2. Put the lamp in position in the holder.
3. Make the positions 1 and 1' on S1 and 2 and 2' on S2.
4. Operate switch S1 in position 1 and 1'.
5. For each position of S1 put switch S2 in position 2 and 2', respectively.
6. Observe the results.

Precautions

1. All connections should be firmly made.
2. Switches S1 and S2 should be connected to the phase wire.

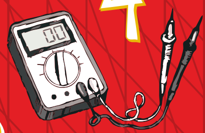
Check Your Progress

A. Short Answer Questions

1. What is wiring material?
2. Why is silver rarely used as a wiring material?
3. Write the properties and applications of copper and aluminium.
4. How will you identify copper and aluminium on the basis of colour?
5. What are the types of holder?
6. List the disadvantages of casing capping.
7. List the advantages of conduit wiring.
8. Write the necessary tools required for conduit wiring.
9. How are wiring accessories fixed in a board?
10. What do you mean by series and parallel circuit?
11. Write the apparatus required to fix wiring accessories on board.
12. Which apparatus is used in simple wiring?
13. Write the precautions for casing, capping wiring.

NOTES

Unit 4



Introduction to Energy Meter

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Introduction

Do you have an electricity connection at your home? If yes, you must have seen that an energy meter is installed at your premise and a person comes to your home to take a reading every month. The energy meter is an electrical measuring device, which is used to record electrical energy consumed over a specified period of time in terms of units. Every house, small factory, business establishment, shops, offices, etc., needs at least one energy meter to register power consumption. The supplier of electrical energy raises the bill on the basis of reading shown by this meter. The consumer needs to pay the amount against the bill raised by the supplier.

Session 1: Importance of Energy Meter

Energy Meters

Fig. 4.1 Energy meter

A meter is a device suitable for measuring, indicating and recording consumption of electricity or any other quantity related to an electrical system (Fig. 4.1). It also includes, wherever applicable, other instruments, such as current transformer (CT), voltage transformer (VT) or capacitor voltage transformer (CVT) necessary for such purpose.

Power companies or state electricity board install energy meters at every place where electricity is consumed, such as residential places, industries, commercial organisations to measure the electricity consumption.

The basic unit of power is watts. One-thousand watts is one kilowatt. If we use one kilowatt in one hour, it is considered as one unit of energy consumed. These meters measure the instantaneous voltage and currents, calculate its product and give instant power. This power is integrated over a period which gives the energy utilised over that time period.

Basic Types of Energy Meters

Energy meter or watt-hour meter is classified in accordance with several factors, such as

- type of display like analog or digital electric meter,
- type of metering point like grid, secondary transmission, primary and local distribution,
- end applications like domestic, commercial and industrial and
- technical like three-phases, single-phase, HT, LT and accuracy class meters.

Electromechanical induction-type energy meter

It is the most common type of age old watt-hour meter. It consists of a rotating aluminium disc mounted on a spindle between two electromagnets. Speed of rotation of disc is proportional to the power and this power is integrated by the use of counter mechanism and gear trains. It comprises two silicon steel laminated electromagnets, i.e., series and shunt magnets (Fig. 4.2).

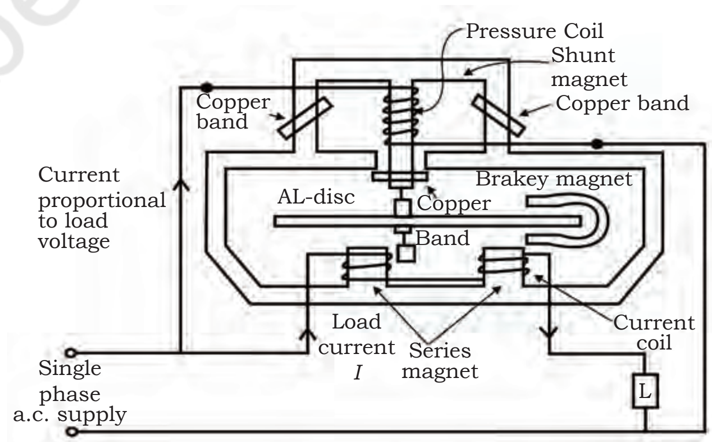


Fig. 4.2 Electromechanical meter

Series magnet carries a coil which is of few turns of thick wire connected in series with line whereas shunt magnet carries a coil with many turns of thin wire connected across the supply.

Breaking magnet is a permanent magnet which applies the force opposite to normal disc rotation to move that disc at a balanced position and to stop the disc while power is off.

Notes

Series magnet produces the flux which is proportional to the current flowing and shunt magnet produces the flux proportional to the voltage. These two fluxes lag by 90 degrees due to inductive nature. The interaction of these two fields produces eddy current in the disc, exerting a force, which is proportional to the product of instantaneous voltage, current and phase angle between them.

Vertical spindle or shaft of the aluminium disc is connected to gear arrangement which records a number, proportional to the number of revolutions of the disc. This gear arrangement sets the number in a series of dials and indicates energy consumed over a time. This type of meter is simple in construction and accuracy is somewhat less due to creeping and other external fields. A major problem with these types of meters is that they are prone to tampering easily. This has led to the requirement of an electrical energy monitoring system. These are very commonly used in domestic and industrial applications.

Electronic energy meters

These are accurate, high procession and reliable type of measuring instruments as compared to conventional mechanical meters. They consume less power and start measuring instantaneously when connected to load. These meters might be analog or digital. In analog meters, power is converted to proportional frequency or pulse rate and it is integrated by counters placed inside it. In a digital electric meter the power is directly measured by a high-end processor. The power is integrated using logic circuits to get the energy and also for testing and calibration purpose. It is then converted to frequency or pulse rate.

Analog electronic energy meters

In analog type meters, voltage and current values of each phase are obtained by voltage divider and current transformers, respectively, which are directly connected to the load as shown in Fig. 4.3.

These analog values are converted to corresponding frequency signals by frequency converter. These frequency pulses then drive a counter mechanism where these

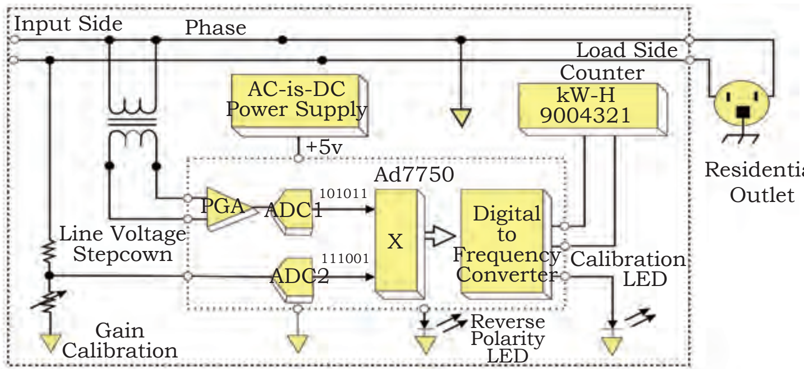


Fig. 4.3 Analog energy meter

values are integrated over a time to produce the electricity consumption.

Electromechanical meters were replaced by the analog electronic energy meters. The electromechanical meter's disc as well as counter can easily be tampered and there are chances of theft of energy as well.

Digital electronic energy meters

Digital signal processor or high performance microprocessors are used in digital electric meters. Similar to the analog meters, voltage and current transducers are connected to a high resolution ADC. Once it converts analog signals to digital samples, voltage and current samples are multiplied and integrated by digital circuits to measure the energy consumed (Fig. 4.4).

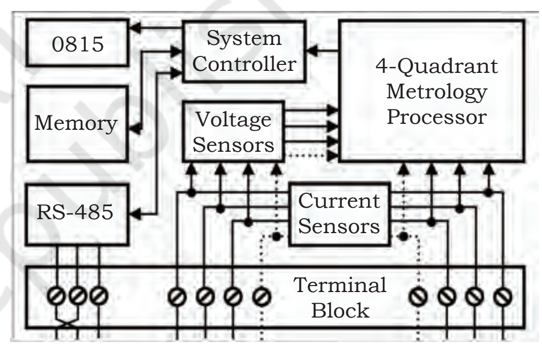


Fig. 4.4 Digital electronic energy meters

The microprocessor also calculates phase angle between voltage and current, and also measures and indicates reactive power. It is programmed in such a way that it calculates energy according to the tariff and other parameters like power factor, maximum demand, etc., and stores all these values in a non-volatile memory EEPROM (Electrically Erasable Programmable Read-only Memory).

It contains real time clock (RTC) for calculating time for power integration, maximum demand calculations and also date and time stamps for particular parameters. Furthermore, it interacts with the liquid crystal display (LCD), communication devices and other meter outputs. Battery is provided for RTC and other significant peripherals for backup power.

Today, analog electronic meters have been replaced with digital electronic energy meters, because there is least chance of energy theft due to digital display unit.

Smart energy meters

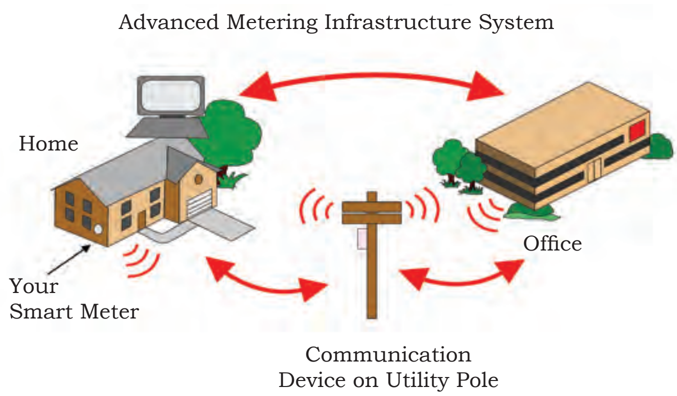


Fig. 4.5 Smart energy meters

It is an advanced metering technology involving placing intelligent meters to read, process and provide feedback to customers. It measures energy consumption, remotely switches the supply to customers and remotely control the maximum electricity consumption. Smart metering system (Fig. 4.5) uses the advanced metering infrastructure system technology for better performance.

This system is capable of communicating in both directions. It can transmit data to the utilities like energy consumption, parameter values, alarms, etc., and can also receive information from utilities, such as automatic meter reading system, reconnect or disconnect instructions, upgrading of meter softwares and other important messages. These meters reduce the need to visit for taking or reading monthly bill. Modems are used in these smart meters to facilitate communication systems, such as telephones, wireless, fiber cables, power line communications (Fig. 4.6). Another advantage of smart metering is that it can help prevent tampering of energy meter, where there is scope of using power in an illegal way.

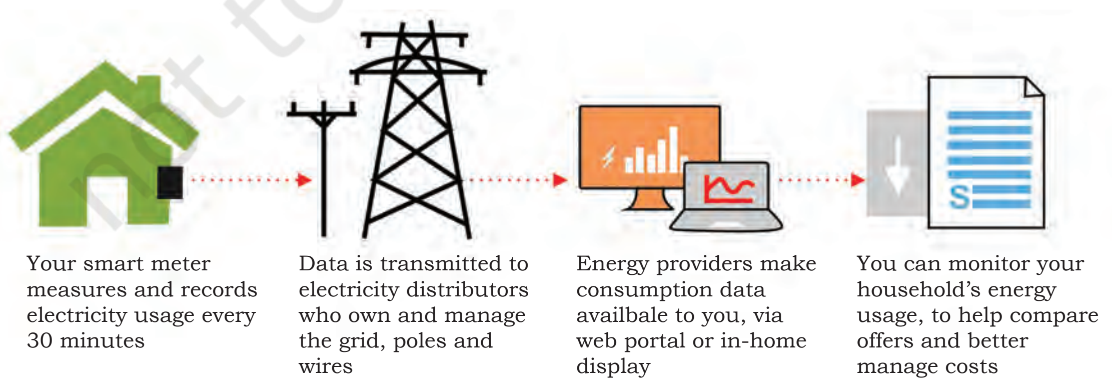


Fig. 4.6 Data transfer from smart meter

Smart meters are installed in big installations like cinema halls, showrooms, industrial plants where load is less than 100 HP.

Check Your Progress

A. Fill in the Blanks

1. Data is transfered through __________ in smart meter.
2. Electrical energy is measured by __________
3. __________ is called age old watt-hour meter.
4. 1000 watts is equal to __________

B. Multiple Choice Questions

1. If we consume 2000 watts for an hour, the total unit consumed is __________.
   (a) 2 units
   (b) 1 units
   (c) 0.5 units
   (d) 0.2 units
2. In smart meters, to facilitate communication we use __________.
   (a) telephone
   (b) mobile
   (c) modem
   (d) direct line
3. Basic form of energy meter is __________.
   (a) electronic meter
   (b) electromechanical meter
   (c) analog meter
   (d) digital meter

C. Write Short Notes on

1. Digital meter
2. Smart energy meter
3. Electronic energy meter

Session 2: Types of Meters

Various types of meter are installed for various purpose as per requirement.

Single-phase Meter

They are directly connected to the mains. These meters have a simple, compact and robust design with

Fig. 4.7 Single-phase meter


Fig. 4.8 Three-phase meter

outstanding performance and characteristics (Fig. 4.7). Single-phase meters are rated for 240V AC supply, current rating is 2.5–10A, 10–60A or 20–80A (max).

Three-phase Whole Current Meter (Polyphase Meter)

These meters are directly connected to the supply if load is up to 50A in LT system for sanctioned load up to 25 kW. Polyphase whole current meter is three-phase four wire meter which is a combination of three single-phase meters. The entire load current to be measured passes through the meter itself. They are rated for 415 volts (Fig. 4.8).

Fig. 4.9 Trivector meter

HT Meter (Trivector Meter)

The HT or Trivector meter is a measuring instrument which measures the active power, reactive power and total energy consumed of a power line (Fig. 4.9). Trivector meters are usually used in substations or for billing power drawn by industrial consumers.


Fig. 4.10 Smart meter

Smart Meter

Smart meters are the next generation of electricity meters and offer a range of intelligent functions (Fig. 4.10).

For example, these meters record how much energy you are using through a display in your home. These meters can also communicate directly with your energy supplier that means no one will need to come and read your meter at home or office premises.

Most of the smart meters that are being installed today use a SIM card to send meter readings to your supplier, and other wireless technologies to send information to the in-home display.

It measures and records how much electricity a household or business is using at 30-minute intervals. There are different smart meter models available, but the basic functions are the same.


Fig. 4.11 Prepaid meter

Prepaid Meter

A prepayment or prepaid meter lets you pay for your energy before you use it. It is an excellent way to keep track of how much you are spending and can help you budget for your energy bills (Fig. 4.11).

NOTES

In other words, you pay for your energy up front instead of by quarterly bill or monthly direct debit. And if there is no credit in the meter, there is no energy supply to the home.

A prepayment meter can help you to make a budget for your energy bills, but it can also be one of the most expensive ways to pay for electricity.

Duties and Responsibilities of Consumer Energy Meter Technician Working in a Power Distribution Company

The Consumer Energy Meter Technician installs, removes and changes low voltages, single-phase or three-phase consumer energy meters and also HT meters and supportive equipment at works site in accordance with the guidelines of Discoms (State Power Utilities and Private Distribution Companies).

In some of the Discoms, the power of recruitment for consumer energy meter technicians are delegated to the concerned Engineer In-charge of the Circle.

The Consumer Energy Meter Technician is allowed to work on a live line, however it is mandatory that they possess a competency certificate issued by the Electrical Inspector.

(a) The jurisdiction of Consumer Energy Meter Technician (CEMT) is fixed by the Assistant Engineer (AE)/Assistant Manager (AM) in writing. The Helpers coming in the area are subordinate to the Consumer Energy Meter Technician, if so specified. The Consumer Energy Meter Technician will be responsible for all the meter related works done under his jurisdiction. Any negligence and consequent losses will be treated as negligence of their duties.

(b) The CEMT shall know all the network details within their jurisdiction, such as length of HT and LT lines and telephone lines, type of conductors, spans, number of distribution transformers and number of service and their connected load, etc.

(c) The CEMT shall be responsible for proper ground clearance of all service connections in their area.

NOTES

It is their responsibility to intimate their next superior in writing about the defects noticed by them in the distribution.

(d) The Consumer Energy Meter Technician shall be responsible for maintaining continuity of supply to the consumer in their jurisdiction.

(e) They shall be responsible for upkeep of (Tools and Plant) and safety appliances supplied to them and keep them in working order.

(f) They are responsible for maintaining the proper gradation of fuses in all service connections.

(g) A certificate has to be given regarding inspection of services under their charge, stating that the connected load, tariff, meters and other properties of Board are safe.

(h) They shall maintain a register showing the details of new energy meters issued, replaced, burnt meters, meters waited for testing and meter-related complaints of slow, fast and defective meters and details of meter seals with numbers, fixation.

(i) They shall maintain diaries showing the daily work done and get the signatures of their superiors once in a fortnight.

(j) Any field complaints or defects shall be recorded in the register kept at the Section office and no other plea of the staff brought to the notice of Section Officer orally will be entertained.

(k) The CEMT should also maintain a register showing all the statistics and details of services, lines, transformers and equipment. They shall also possess maps of these lines, with location numbers, cut points and geographical features, etc., supplied by the Section Officer.

(l) They shall associate with meter testing schedules, after completing the testing of each connection and handover the report to their superiors.

(m) They shall be responsible to ensure that the code of safety rules is followed by them and their colleagues. A copy of the said code is already supplied to them.

Any instances where the staffs fail to use safety appliances as per the code shall be brought to the notice of their superiors immediately for taking disciplinary action.

The above functions are broad, general indication of a Consumer Energy Meter Technician's functions. In addition to the above, the line staff has to perform the role expected of them in the respective Distribution Companies with which they are associated.

Consumer Meters

The consumer meter shall be installed by the licensee either at consumer premises or outside the consumer premises:

(a) Provided that where the licensee installs the meter outside the premises of the consumer, the licensee shall provide real-time display unit at the consumer premises for information to indicate the electricity consumed by the consumer.

(b) Provided further that for the billing purpose, reading of consumer meter and not the display unit shall be taken into account.

In the event the appropriate Commission allows supply of electricity directly from a generating company to consumer on a dedicated transmission system, the location of the meter will be as per their mutual agreement.

Regulation of Central Electricity Authority

In exercise of the powers conferred by sub-section (1) of section 55 and clause (e) of section 73 read with sub-section (2) of the section 177 of Electricity Act, 2003, the Central Electricity Authority hereby makes the following regulations for managing the installation and operation of meters:

Short Title and Commencement

These regulations are called the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.

These regulations came into force on the date of their publication in the Gazette of India.

NOTES

Applicability of Regulation

(i) These regulations shall be applicable to meters installed and to be installed by all the generating companies and licensees who are engaged in the business of generation, transmission, trading, distribution, supply of electricity and to all categories of consumers.

(ii) After coming into force of these regulations, the provisions of the Indian Electricity Rules, 1956, related to installation and operation of meters in this regard, shall not be applicable.

These regulations provide for type, standards, ownership, location, accuracy class, installation, operation, testing and maintenance, access, sealing, safety, meter reading and recording, meter failure or discrepancies, anti-tampering features, quality assurance, calibration and periodical testing of meters, additional meters and adoption of new technologies in respect of the following meters for correct accounting, billing and audit of electricity.

Types of Meters

(i) All interface meters, consumer meters (Fig. 4.12) and energy accounting and audit meters shall be of static type.

(ii) The meters not complying with these regulations shall be replaced by the licensee on their own or

Fig. 4.12 Consumer meter

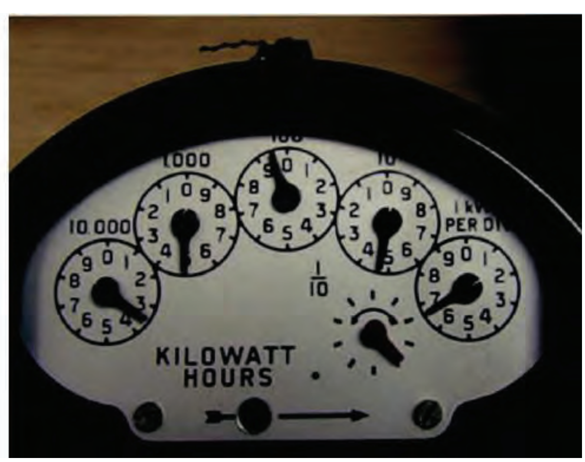


Fig. 4.13 Analog meter

on request of the consumer. The meters may also be replaced as per the regulation or direction of the appropriate commission or pursuant to the reforms programme of the appropriate government.

NOTES

Standards

All interface meters, consumer meters and energy accounting and audit meters shall

(i) comply with the relevant standards of Bureau of Indian Standards (BIS). If BIS Standards are not available for a particular equipment or material, the relevant British Standards (BS), International Electrotechnical Commission (IEC) Standards, or any other equivalent Standard shall be followed.

(ii) provide that whenever an International Standard or IEC Standard is followed, necessary corrections or modifications shall be made for nominal system frequency, nominal system voltage, ambient temperature, humidity and other conditions prevailing in India before actual adoption of the said standard.

(iii) conform to the standards on 'Installation and Operation of Meters' as specified in schedule annexed to these regulations and as amended from time to time.

All consumer meters shall bear BIS mark, meet the requirements of these regulations and have additional features as approved by the appropriate Commission or pursuant to the reforms programme of the appropriate government. To facilitate this, the licensee shall provide a list of makes and models of the meters.

Location of Meter Installation

The location of meter installation is very important to minimise the incidents of theft, malpractice and for easy approach and comfortable meter reading.

The benefits include

1. less temptation to bypass,
2. discouraged meter tampering activity and
3. easy meter reading.

NOTES

The location of an electricity meter varies with each installation. The possible locations include a utility pole serving the property, in a street-side cabinet (meter box) or inside the premises adjacent to the consumer unit or distribution board. Electricity companies may prefer external locations as the meter can be read without gaining access to the premises or the meter location should be at the door step and should be installed not more than 5 feet high.

Current transformers permit the meter to be located remotely from the current-carrying conductors. This is common in large installations. For example, a substation serving a single large customer may have metering equipment installed in a cabinet, without bringing heavy cables into the cabinet.

Check Your Progress

A. Write Short Notes on

1. Electromechanical meter
2. Consumer meter
3. Smart meter

B. Fill in the Blanks

1. A ____________ meter lets you for your energy before you use it.
2. In India ____________meters were used in olden times.
3. Smart meters use a ____________ to send meter readings.

SESSION 3: INSTALLATION OF METERS

Electricity meters are required to register the energy consumed within an acceptable degree of accuracy. Any significant error in the registered energy can represent a loss to the electricity supplier, or the consumer being over billed. The accuracy is generally laid down in statute for the location in which the meter is installed. Statutory provisions should also specify a procedure to be followed should the accuracy be disputed.

Every meter is tested in a meter testing lab for checking its accuracy and a certificate is issued before installing the meter at consumer premises.

In India, any installed electricity meter is required to accurately record the consumed energy, but it is permitted to under-read by 5%, or over-read by 5%. Disputed meters are initially verified with a check meter operating alongside the disputed meter. The final resort is for the disputed meter to be fully tested both in the installed location and at a specialist calibration laboratory.

The disputed energy meters are removed from the premise and properly sealed with the signature of the consumer before sending it to the laboratory for testing. After testing the energy meter the lab issues a certificate regarding the percentage slow and fast for billing.

Approximately 93% of the disputed meters are found to be operating satisfactorily. A refund of electricity paid for, but not consumed (but not vice versa) will only be made if the laboratory is able to estimate how long the meter has been misregistering.

Installation of Meters

The installation of meters includes the steps given below.

1. Distribution company or licensee, as the case may be, shall examine, test and regulate all meters before installation and only faultless meters shall be installed.
2. The meter shall be installed at locations, which are easily accessible for installation, testing, commissioning, reading, recording and maintenance. The place of installation of meter shall be such that minimum inconvenience and disruptions are caused to the site owners and the concerned organisations.
3. In case of single-phase meters, the consumer shall ensure that there is no common neutral or phase or looping of neutral or phase of two or more consumers on consumer's side wiring. If such common neutral or phase or looping of neutral or phase comes to the notice of the licensee, they shall suitably inform the consumer through installation report or regular electricity bills or meter test report as applicable.

Notes

Fig. 4.14 Earth leakage circuit breaker

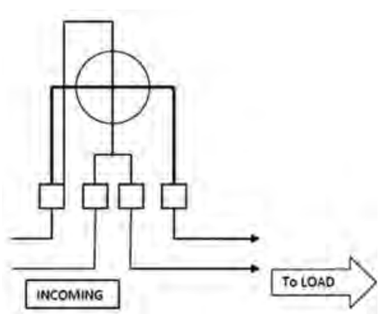


Fig. 4.15 Single-phase whole current meter (Connection Diagram)

4. Consumer shall install the Earth Leakage Protective Device (ELPD) (Fig. 4.14) in accordance with the provisions of the rules or regulations in this regard.
5. If the earth leakage indication is displayed in the meter, the licensees shall suitably inform the consumer through installation report or regular electricity bills or meter test report as applicable.
6. In case CTs (Current Tranformers) and VTs (Voltage Tranformers) form part of the meters, the meter shall be installed as near the instrument transformers as possible to reduce the potential drop in the secondary leads.

Installation of Different Energy Meters

How to connect Single-phase Energy Meter (1-phase, 2 Wire)?

Fig. 4.15 shows the connection of single-phase (1-phase, 2 Wire) kWh meter (Digital or Analog Energy Meter) from the supply to the main distribution board. The red wire shows the live or line or phase and the black shows the neutral wire.

Single-phase Whole Current Meter

1. Various LED indicators are present on the meter, i.e., constant, pulse, ELT (earth load tamper).
2. If the power is ON, the constant pulse will show a constant indication, as the name suggests.
3. If the load is ON, the pulse indicator will blink. As specified on the meter box, a certain number of pulses will make a unit. For example, there are meters with 6400, 3400, 1200, etc., pulses per hour. For a typical meter having specifications of 3200 pulses, it will record 1 unit if 1 kW is used for 1 hour.
4. The ELT LED will be blinking in the tampered or unusual condition when there is a leakage of current through earth. This, additionally, indicates that the current is getting a separate return path through earth rather than the meter.
5. The LED indicating REV (Revolution) will be blinking in case of tampered or unusual conditions when there is a reverse current flowing through the meter. For example, if 5A is flowing through the phase wire, 8A is returning through neutral wire.

How to Connect 3-phase 4-wire Energy Meter

Three-phase or Poly-Phase (3-phase, 4 Wire) (Digital or Analog Energy Meter) from the supply to the main distribution board (Fig. 4.16).

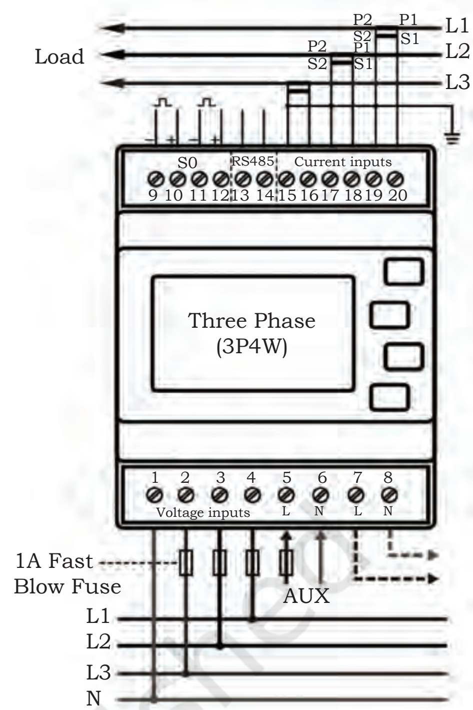


Fig. 4.16 Three-phase Whole Current Meter (Connection Diagram)

Low Tension Current Transformer (LT CT) Meter (3-Phase 4-Wire Meters with CTs)

CTs are available in the ratio of 50, 100, 200, 300; 400/5A. CT has to be accurately selected for consumer meter. Rating of CTs should fall within 50 to 80% of the maximum load current of the consumer. The polyphase meters are provided with maximum demand indicators (MDI), which are additional mechanisms attached to the meters to record the rate of consumption over a fixed period each time (30 minutes). Higher rating CTs say 800, 1000, 1200, 1500, 2000/5A are commonly used for energy audit as distribution transformer meters.

Three-Phase Whole Current Meter (Electronic Meter)

These meters are used in conjunction with current transformers, as here the value of load current is so high that the meter cannot withstand it directly (Fig. 4.17).

Fig. 4.17 Three-phase four-wire meter with CT

While calculating, the multiplying factor is taken as unity considering that the rating of CTs connected match with the energy meter. In case different ratio CTs are used, MF is additionally added.

For example, if LT CT meters are rated CTR 60/5A, 100/5A and 200/5A and they are connected with identical CTs of ratio 60/5A, 100/5A and 200/5A, MF will always remain 1.

Installation of LT CT Operated Meter

Ensure all current transformers are installed as per the wiring diagram (which can also be found under the terminal cover of the meter), the correct polarity of current transformers is essential, i.e., (p1 facing mains) and (p2 facing load) (Fig. 4.18). Check if ALL S1 and S2

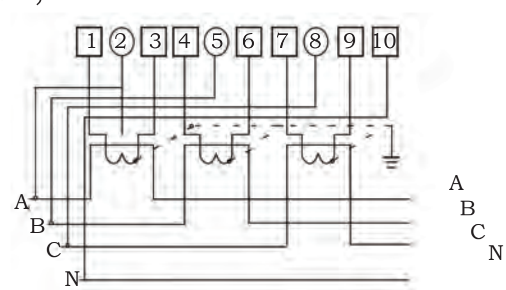


Fig. 4.18 Installation Phase 4 Wire CT Operated Meter

connections are correct as per wiring diagram otherwise there will be problems with the register displays. For health and safety reasons it should be noted that if a current transformer is operated with the secondary (S1 and S2) open circuited, dangerous voltages may be generated at the secondary terminals or leads.

Installation Notes

To ensure that the meter reads correctly installation should be done as follows:

1. Connect the meter according to the wiring instructions (which can be found inside the terminal cover). Note the voltage inputs to the meter must be externally fused and terminal 11 is the neutral, tying down the three voltages.
2. The CT cables should be kept as short as possible, use 2.5mm cable to maintain accuracy.
3. CTs match the ratio of the meter being fitted (e.g., 200/5 amp meter = 200 amp CTs.)
4. CTs must be fitted on to the cable the correct way round so that (P1) side is towards the mains and (P2) is facing the load.
5. The cables from the CTs must be connected the correct way round observing (S1) and (S2) markings on the meter and the CT.
6. Always connect (S1) to the first terminal of the phase and (S2) to the third terminal. The smaller middle terminal is for a voltage connection from that phase.
7. Check the RST indicator, this should be on — if it is 'off' one or more phase voltages is missing — if it flashes the phases are in the wrong order, two will have to be swapped over (the CT wires will also have to be moved to keep them with the right voltage).
8. Check if the meter is operating in the correct direction — the arrow symbol (or disc, if disc driven) should show left to right. Open all the voltage fuses then try one phase at a time and check if each phase makes the meter go in the correct direction.
9. Check the red light, it should flash if power is being measured.

Access to Meter

The owner of the premises, where the meter is installed, shall provide access to the authorised representative(s) of the licensee for installation, testing, commissioning, reading and recording and maintenance of meter (Fig. 4.19).

Fig. 4.19 Concerned person checking the meter

Sealing of Meters

Sealing Arrangements

All meters shall be sealed by the manufacturer at its works. In addition to the seal provided by the manufacturer at its works, the sealing of all meters shall be done at various sealing points as per the standards given in the schedule below:

1. Sealing of interface meters, shall also be done by both the supplier and the buyer.
2. Sealing of consumer meters shall also be done by the licensee.
3. Sealing of energy accounting and audit meters shall be done by licensee or generating company.
   (a) A tracking and recording software for all new seals shall be provided by the manufacturer of the meter so as to track the total movement of seals starting from manufacturing, procurement, storage, record keeping, installation, series of inspections, removal and disposal.
   (b) The seal shall be unique for each utility, and name or logo of the utility shall be clearly visible on the seals.
   (c) Only the patented seals (seal from the manufacturer who has official right to manufacture the seal) shall be used.
   (d) Polycarbonate or acrylic seals or plastic seals or holographic seals or any other superior seal shall be used.
   (e) Lead seals shall not be used in the new meters. Old lead seals shall be replaced by new seals in a phased manner and the time frame of the same shall be submitted by the licensee to the appropriate Commission for approval.


Fig. 4.20 Sealing meter

Removal of Seals from Meters

Seal of the consumer meter shall be removed only by the licensee. No consumer shall tamper with, break or remove the seal under any circumstances. Any tampering, breaking or removal of the seal from the meter shall be dealt with as per relevant provisions of the Act (Fig. 4.20).

Meter Failure or Discrepancies

In case the consumer reports to the licensee about consumer meter readings as not commensurate with their consumption of electricity, stoppage of meter, damage to the seal, burning or damage of the meter, the licensee shall take necessary steps as per the procedures given in the Electricity Supply Code of the appropriate Commission read with the notified conditions of supply of electricity.

Quality Assurance of Meters

1. The distribution licensee shall put in place a system of quality assurance and testing of meters with the approval of an appropriate Commission.
2. The licensee shall set up appropriate number of accredited testing laboratories or utilise the services of other accredited testing laboratories. The licensee shall take immediate action to get the accreditations of their existing meter testing laboratories from NABL, if not already done.
3. The generating company or licensee shall ensure that all type, routine and acceptance tests are carried out by the manufacturer complying with the requirement of the relevant IS or BS or IEC as the case may be.

Calibration and Periodical Testing of Meters

Consumer Meters

The testing of consumer meters is done at site at least once in five years. The licensee may, instead of testing the meter at site, remove the meter and replace the same by a meter duly tested in an accredited test laboratory (Fig. 4.21). In addition, meters installed in the circuit shall be tested if study of consumption pattern changes drastically from the similar months or season of the previous years or if a consumer complaints about a meter. The standard reference meter of better accuracy class than the meter under test shall be used for site testing of consumer meters up to 650 volts. The testing for consumer meters above 650 volts should cover the entire metering system including CTs and VTs. Testing may be carried out through NABL accredited mobile laboratory using secondary injection kit, measuring unit and phantom loading or at any accredited test laboratory and recalibrated if required at manufacturer's works.

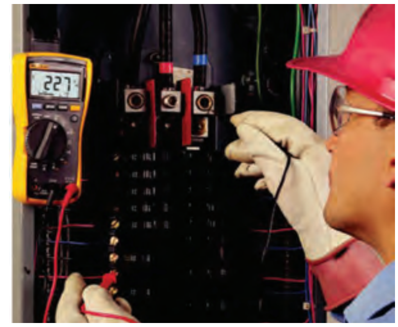


Fig. 4.21 Calibration of electric meters

Additional Meters

In addition to any meter which may be placed for recording the electricity consumed by the consumer, the licensee may connect additional meters, maximum demand indicator or other apparatus. These can be used to ascertain or regulate either the quantity of electricity supplied to the consumer, or the number of hours during which the supply is given, or the rate per unit of time at which energy is supplied to the consumer, or any other quantity or time connected with the supply to consumer:

- provided that the meter, indicator or apparatus shall not, in the absence of an agreement to the contrary, be placed otherwise than between the distributing mains of the licensee and any meter.
- provided further that, where the charges for the supply of energy depend wholly or partly upon the reading or indication of any such meter, indicator or apparatus as aforesaid, the licensee shall, in the absence of an agreement to the contrary, keep the meter, indicator or apparatus correct.

Adoption of New Technologies

The distribution licensee shall make out a plan for introduction and adoption of new technologies, such as prepaid meters, time of the day meters (TOD), automatic remote meter reading system through appropriate communication system with the approval of the appropriate Commission or as per the regulations or directions of the appropriate Commission or pursuant to the reforms programme of the appropriate government.

Standards Common to All Types of Meters

These standards provide for specification of meters, immunity to external factors, sealing points and functional requirements that are required from a regulatory perspective. Detailed technical specification shall be prepared by the purchaser of the meter.

The meter shall have downloading facilities of metered data through Meter Reading Instrument (MRI).

Immunity to External Factors

The meter shall be immune to external influences like magnetic induction, vibration, electrostatic discharge, switching transients, surge voltages, oblique suspension and harmonics; and necessary tests shall be carried out in accordance with relevant standard.

Sealing Points

Sealing shall be done at the following points (as applicable):

(a) Meter body or cover
(b) Meter terminal cover
(c) Meter test terminal block
(d) Meter cabinet

The accuracy class of current transformers (CTs) and voltage transformers (VTs) shall not be inferior to that of associated meters. The existing CTs and VTs not complying with these regulations shall be replaced by new CTs and VTs, if found defective, non-functional or as per the directions of the appropriate Commission. In case the CTs and VTs of the same accuracy class as that of meters cannot be accommodated in the metering cubicle or panel due to space constraints, the CTs and VTs of the next lower accuracy class can be installed.

The voltage transformers shall be electromagnetic VT or capacitive voltage transformer (CVT).

Anti-tampering Features

(a) The meter shall not get damaged or rendered non-functional even if any phase and neutral are interchanged.

(b) The meter shall register energy even when the return path of the load current is not terminated back at the meter, and in such a case the circuit shall be completed through the earth. In case of metallic bodies, the earth terminal shall be brought out and provided on the outside of the case.

(c) The meter shall work correctly irrespective of the phase sequence of supply (only for poly phase).

(d) In case of 3 phase, 3 wire meter even if reference Y phase is removed, the meter shall continue to work. In the case of 3 phase, 4 wire system, the meter shall keep working even in the presence of any two wires, i.e., even in the absence of neutral and any one phase or any two phases.

(e) In case of whole current meters and LV CT operated meter, the meter shall be capable of recording energy correctly even if input and output terminals are interchanged.

(f) The registration must occur whether input phase or neutral wires are connected properly, or they are interchanged at the input terminals.

(g) The meter shall be factory calibrated and shall be sealed suitably before dispatch.

(h) The meter shall be capable of recording occurrences of a missing potential (only for VT-operated meters) and its restoration with date and time of first such occurrence and last restoration along with total number and duration of such occurrences during the above period for all phases.

Additional anti-tampering features including logging of tampers, such as current circuit reversal, current circuit short or open and presence of abnormal magnetic field may be provided as per the regulations or directions of the appropriate Commission or pursuant to the reforms programme of the appropriate government.

These days, meters have the technology to identify theft and log the tamper with date and time stamping.

These meters can keep record of large number of tampers, normally 200 tampers in three-phase meters and 100 tampers in single-phase meters. These meters are also programmed to record the energy at their maximum current rating under certain tamper condition to penalise the consumer or to discourage the consumer from attempting the theft.

Let's Revise 1

Indentifying Various Type of Meters

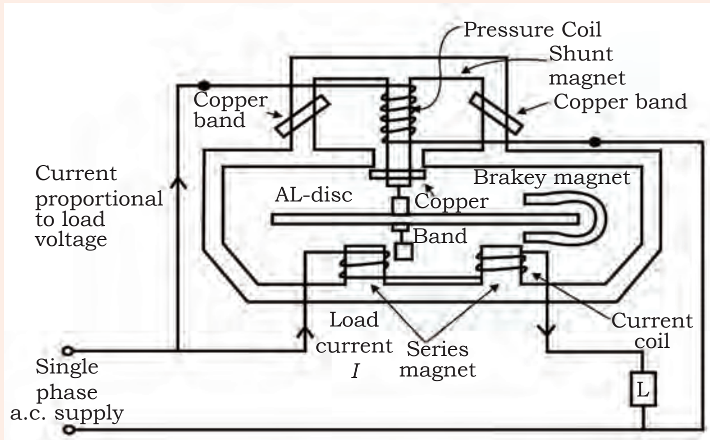
You can see various meters in Meter Testing Lab or Electrical store. Various types of meters are used for measuring the electrical energy being used at consumers' premises. Identify the types of meters shown below.

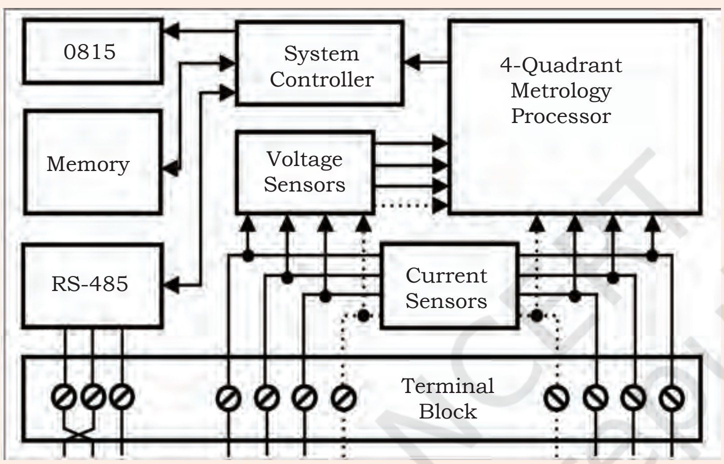
________________ ________________ ________________

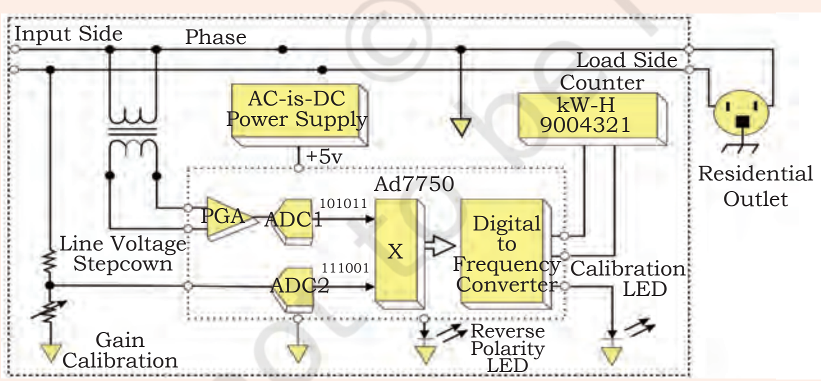
________________ ________________ ________________

Components of Various Types of Meters

You can go in a Meter Testing Lab where meters are tested by opening them. You can see various components of meters like electromechanical meter, analog eletronic meters and digital electronic meters.


Pressure Coil
Shunt magnet
Copper band
Copper band
Current proportional to load voltage
AL-disc
Brakey magnet
Copper
Band
Load current I
Series magnet
Current coil
L
Single phase a.c. supply


0815
System Controller
4-Quadrant Metrology Processor
Memory
Voltage Sensors
RS-485
Current Sensors
Terminal Block


Input Side
Phase
Load Side
Counter
kW-H
9004321
AC-is-DC Power Supply
+5v
Ad7750
PGA
ADC1
101011
ADC2
111001
X
Digital to Frequency Converter
Calibration LED
Residential Outlet
Line Voltage Stepcown
Gain Calibration
Reverse Polarity LED

Practical Procedure of Installation of Single-phase Energy Meter

First inspect the site where the meter is to be installed and observe the following:

(a) cable size is suitable as per load and the cable is open from pole to meter box.

(b) meter box is placed at the right place, i.e., at the door step and at visible height.

(c) earthing is provided or not and earth wire is of required size or gauge.

(d) no naked wire should be visible.

Procedure

(i) Now first wear the hand gloves and cut off the supply from the distribution box and discharge the line using discharge rod and hang the discharge rod in phase wire.

(ii) Put caution board in distribution box before starting the work. Now you have created a safe zone for work.

(iii) Now fix the single phase meter in a meter box and connect the outgoing phase and neutral as per the diagram shown in meter cover afterwards.

(iv) First, connect the incoming neutral wire in meter terminal and lastly the incoming phase wire.

(v) Tighten the screws of the meter terminals properly. Now put the meter cover or box cover. The premise is now ready for energisation, you can connect the neutral wire of cable to supply neural conductor or neutral in distribution box and then you can connect the phase wire to the line.

(vi) Remove earthing rod and caution board before switching on the supply.

(vii) Now you can check the supply in consumer premise and if you are satisfied with the workmanship and proper working of meter then you seal the meter using seal pliers and lead seal or any other seal.

Practical Procedure of Installation of Poly/3-phase Energy Meter

First inspect the site where the meter is to be installed and observe the following:

(a) cable size is suitable as per load and the cable is open from pole to meter box,

(b) meter box is placed at the right place, i.e., at the door step and proper visible height,

(c) proper earthing is provided or not and earth wire is of proper size/gauge and

(d) no naked wire should be visible.

Procedure

(i) Now first wear hand gloves and cut off the supply from the distribution box and discharge the line using discharge rod and hang the discharge rod in phase wire.

(ii) Put the caution board in the distribution box before starting the work. Now you have created a safe zone for work.

(iii) Now fix the Poly/3-phase meter in the meter box and connect the outgoing phase R, Y, B (three) and neutral.

(iv) First connect the incoming neutral wire in meter terminal and lastly the incoming phase wire R, Y, B (three). Ensure that the screws of the meter terminals are properly tightened. Now put the meter cover or box cover.

(v) The premise is now ready for energisation, you can connect the neutral wire of cable to supply neutral conductor or neutral in distribution box and then you can connect all the three (R, Y, B) phase wires to the line.

(vi) Remove the earthing rod and caution board before switching on the supply.

(vii) Now check the supply in consumer premise and if you are satisfied with the workmanship and working of the meter then you can seal the meter using seal pliers and lead seal or any other seal.

Procedure of Replacement of Single-phase Energy Meter

(i) First wear hand gloves and cut off the supply from the distribution box and discharge the line using discharge rod and hang the discharge rod in phase wire.

(ii) Put caution board in distribution box before starting the work. Now you have created a safe zone for work.

(iii) First remove seals provided in the terminal cover as well as meter box. Now unscrew the phase and neutral wire of incoming as well as outgoing from meter terminal. Next, remove the cable connection from terminal. Now you can remove the meter. If you have a meter for replacement then fix the single phase meter in meter box and connect the outgoing phase and neutral as per the diagram shown in meter cover afterwards.

(iv) First connect the incoming neutral wire in meter terminal and lastly the incoming phase wire.

(v) Tighten the screw of meter terminals. Now put the meter cover or box cover.

(vi) The premise is now ready for energisation, you can connect the neutral wire of cable to supply neutral conductor or neutral in distribution box.

Procedure of Replacement of Poly/3-phase Energy Meter

(i) First wear the hand gloves and cut off the supply from the distribution box and discharge the line using discharge rod. Hang the discharge rod in phase wire.

(ii) Put caution board in distribution box before starting the work. Now you have created a safe zone for work.

(iii) First remove the seals provided in the terminal cover as well as meter box. Now unscrew all the phases and neutral wire incoming as well as outgoing from meter terminal. Now remove the cable connection from terminal.

(iv) Next, remove the cable connection from terminal. And now you can remove the meter.

(v) If you have a meter for replacement then fix the poly/three-phase meter in meter box and connect the outgoing phase R, Y, B (three) and neutral as per the diagram shown in meter cover afterwards.

(vi) First connect the incoming neutral wire in meter terminal and lastly the incoming phase wire R, Y, B (three). Tighten the screw of the meter terminals. Now put the meter cover or box cover. The premise is now ready for energisation, you can connect the neutral wire of cable to supply neural conductor or neutral in distribution box and then connect all the three (R, Y, B) phase wire to the line.

(vii) Remove the earthing rod and caution board before switching on the supply.

(viii) Now check the supply at the consumer premise and if you are satisfied with the workmanship and proper working of meter then you can seal the meter using seal pliers and lead seal or any other seal.

Check Your Progress

A. Fill in the Blanks

1. The LED indicating REV will be blinking in case of tamper or unusual conditions when there is a ____________ flowing through the meter.
2. It is mandatory for a Consumer Energy Meter Technician to wear __________ and to prepare a safe zone for work.
3. Potential transformer is used in an electrical power system for stepping down the system voltage to a _________________ which can be fed to low rating meters and relays.

B. Multiple Choice Questions

1. For consumer meters ____________.
   (i) it is the responsibility of the licensee to record the metered data.
   (ii) the licensee shall maintain accounts for the electricity consumption.
   (iii) the licensee shall provide real time display unit at the consumer premises.
   (a) all of the above
   (b) Only (i) and (iii)
   (c) Only (i) and (ii)
   (d) Only (iii)
2. Which of the below mentioned characteristics of the seal used is/are correct?
   (i) Seal is not a lock
   (ii) Seals are used to detect unauthorised entry
   (iii) Seals are a means of security and safety for meters
   (iv) Seals can be made of lead, metal, engineering plastic, etc.
   (a) Only (iii)
   (b) Only (i) and (iv)
   (c) Only (i)
   (d) Only (iv)

ANSWER KEY

Unit 1: Electricity

Session 1: Electricity Generation Concept

A. Fill in the Blanks

1. energy
2. mechanical
3. solar and chemical
4. generator
5. Michael Faraday

B. Match the Columns

1. (b)
2. (a)
3. (d)
4. (c)

C. Multiple Choice Questions

1. (b)
2. (b)
3. (d)
4. (c)
5. (b)

Session 2: Basic Units and Effects of Electric Current

A. Fill in the Blanks

1. heating effect
2. ampere
3. Ohm
4. Farad
5. Henry

B. Match the Columns

1. (a)
2. (c)
3. (b)
4. (d)

C. Multiple Choice Question

1. (c)
2. (b)
3. (d)
4. (a)
5. (b)

Session 3: Concept of Electrical Power and Energy

A. Fill in the Blanks

1. series
2. parallel
3. watt
4. watt-hour
5. 1 kWh (1Unit)

B. Match the Columns

1. (d)
2. (a)
3. (b)
4. (c)

C. Multiple Choice Questions

1. (a)
2. (b)
3. (d)
4. (c)
5. (d)

Session 4: Importance of Earthing System

A. Fill in the Blanks

1. earthing
2. Pipe
3. earth resistance
4. leakage current
5. Ohm

B. Match the Columns

1. (d)
2. (c)
3. (b)
4. (a)

C. Multiple Choice Questions

1. (d)
2. (b)
3. (d)
4. (a)
5. (b)

Unit 2: Handling of Tools and Equipment

Session 1: Tools and Equipment

A. Fill in the Blanks

1. Ammeter
2. cutting wires
3. joining the wires
4. neon

B. Identify whether the following statements are True or False.

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

Session 2: Tools and Equipment used for Cable Laying

A. Multiple Choice Questions

1. (b)
2. (a)
3. (c)
4. (c)
5. (b)
6. (c)
7. (a)
8. (a)
9. (b)
10. (c)
11. (c)

B. State whether the following statements are True or False

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

Unit 3: Electrical Wiring Components and Accessories

Session 1: Identifying and Selecting the Wiring Material and Components

B. Fill in the Blanks

1. copper, aluminium
2. insulating
3. rubber, wood and mica

C. State whether the following Statements are True or False

1. False
2. False
3. True

D. Multiple Choice Questions

1. (b)
2. (c)
3. (a)

Unit 4: Introduction to Energy Meter

Session 1: Importance of Energy Meter

A. Fill in the Blanks

1. modem
2. energy meter
3. Electromechanical induction-type energy meter
4. 1 kilo watt

B. Multiple Choice Questions

1. (a)
2. (c)
3. (b)

Session 2: Types of Meters

A. Fill in the Blanks

1. prepaid
2. electromechanical
3. sim card

Session 3: Installation of Meters

A. Fill in the Blanks

1. acceptable
2. reverse current
3. personnel protective equipment
4. safe value

B. Multiple Choice Questions

1. (b)
2. (a)

Acronyms

AC: *Air Conditioner*
AC: *Alternating Current*
ADC: *Analog-to-digital converter*
BIS: *Bureau of Indian Standards*
BS: *British Standards*
CTR: *Current Transformer Ratio*
CEA: *Central Electricity Authority*
CT: *Current Transformer*
CTS: *Cabe Tyre Sheath*
CVT: *Capacitor Voltage Transformer*
DC: *Direct Current*
EEPROM: *Electrically Erasable Programmable Read-only Memory*
ELPD: *Earth Leakage Protective Device*
ELT: *Earth Leakage Tamper*
GI: *Galvanised Iron*
HV: *High Voltage*
HT: *High Tension*
IEC: *International Electro-technical Commission*
KCL: *Kirchhoff's Current Law*
KVL: *Kirchhoff's Voltage Law*
LED: *Light-emitting Diode*
LT: *Low Tension*
LCD: *Liquid Crystal Display*
LV: *Low Voltage*
MDI: *Maximum Demand Indicator*
MDI: *Maximum Demand Indicators*
MRI: *Meter Reading Instrument*
MDB: *Main Distribution Board*
MCB: *Miniature Circuit Breaker*
PD: *Potential Difference*
PT: *Potential Transformer*
PVC: *Polymerising Vinyl Chloride*
REV: *Revolution*
RTC: *Real Time Clock*
SWG: *Standard Wire Gauge*
TV: *Television*
TRS: *Tough Rubber Sheath*
T&P: *Tools and Plants*
VIR: *Vulcanised Indian Rubber*
VT: *Voltage Transformer*

GLOSSARY

AC Supply: *AC stands for alternating current. In an AC circuit the current changes direction in a cyclic manner. In India, the AC frequency is 50 Hz.*

Ammeter: *a device used to measure the current flowing through a circuit. Ammeter is always connected in series.*

Battery: *combination of two or more cells*

Galvanometer: *current indicating device*

Heating element: *a resistance which generates heat*

Potentiometer: *is an electric element that has a variable resistance. It is used to change the potential difference across the circuit.*

Resistor: *resists the flow of a current and thereby produce heat*

Switch: *electrical current flow controlling device*

Transformer: *an element used to step up or step down the voltage. In an ideal transformer energy is conserved. So if the voltage goes up the current goes down and vice-versa.*

Voltmeter: *a device used to measure potential difference. Voltmeter is always connected in parallel.*

List of Credits

1. Figures have been redrawn and some have been taken from the book *Consumer Energy Technician Manual* of Power Sector Skill Council, NSDC, New Delhi as well as from different sources given below.

Fig no	**Reference**
1.6	https://www.motioncontroltips.com/wp-content/uploads/2017/08/Lorentz-Law-Feature.jpg
1.13	http://www.way2science.com/wp-content/uploads/2012/03/inductionc.jpg
1.16	https://www.researchgate.net/profile/Ahmed_Tarek12/publication/305115547/figure/fig4/AS:382402481410053@1468183264449/Figure-4-basic-structure-of-capacitor_Q320.jpg
1.20	https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp23.gif
1.21	https://blog.prayogindia.in/wp-content/uploads/2017/09/kcl-engineeringprayog.com_.jpg
1.22	https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp7.gif
2.8	https://www.google.com/search?hl=en-IN&authuser=0&biw=1366&bih=576&tbm=isch&sa=1&ei=qM-7LXNy_Nduo9QPDvqHQDw&q=tester+png&oq=-tester+png&gs_l=img.3..0j0i5i30l3j0i8i30.6571.7700..8028...0.0..0.144.548.0j4......0....1..gws-wiz-img.......0i67.kGHlf8C9rjw#imgrc=M-K17D-VGO7GJ-M:
2.20	https://www.google.com/search?q=Cable+Drums&tbm=isch&source=iu&ictx=1&fir=hM-fVBYNTQPaTZM%253A%252C75pU0pKD5FLM-mM%252C_&vet=1&usg=AI4_-kTR9Av3tnKjrN-INnWV6VdP3hiyHOA&sa=X&ved=2a-hUKEwig4a6Az_7hAhUMu48KHdyuCSE-Q9QEwAHoECAgQBA#imgdii=PX43kxl3ngKM-mM:&imgrc=hMfVBYNTQPaTZM:&vet=1
2.21	Drum without cable https://www.google.com/search?q=Cable+Drums&tbm=isch&source=iu&ictx=1&fir=hM-fVBYNTQPaTZM%253A%252C75pU0pKD5FLM-mM%252C_&vet=1&usg=AI4_-kTR9Av3tnKjrN-INnWV6VdP3hiyHOA&sa=X&ved=2a-hUKEwig4a6Az_7hAhUMu48KHdyuCSE-Q9QEwAHoECAgQBA#imgdii=wX2dZEm9a-S19iM:&imgrc=hMfVBYNTQPaTZM:&vet=1
2.22	https://dir.indiamart.com/impcat/cable-roller.html