Cable Jointer

Electrical Power System

(Job Role)

Qualification Pack: Ref. ID. PSS/Q1002

Sector: Power

Textbook for Class XI

171177

विद्यया ऽमृतमश्नुते

एन सी ई आर टी
NCERT

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OFFICES OF THE PUBLICATION DIVISION, NCERT

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016 — **Phone : 011-26562708**

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085 — **Phone : 080-26725740**

Navjivan Trust Building
P.O.Navjivan
Ahmedabad 380 014 — **Phone : 079-27541446**

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114 — **Phone : 033-25530454**

CWC Complex
Maligaon
Guwahati 781 021 — **Phone : 0361-2674869**

Publication Team

Head, Publication Division	:	*M. Siraj Anwar*
Chief Editor	:	*Shveta Uppal*
Chief Production Officer	:	*Arun Chitkara*
Chief Business Manager	:	*Bibash Kumar Das*
Editor	:	*Bijnan Sutar*
Production Assistant	:	*Mukesh Gaur*

Cover and Layout

DTP Cell, Publication Division

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 Cable Jointer manages the installation, repair and maintenance of electrical cables and fixtures and power line in housing, commercial and institutional setups. The textbook for the job role of 'Cable Jointer' 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 Cable Jointer — Electrical Power System covered through this textbook are as follows:

1. PSS/N1002 Installing, repairing and joining cables
2. PSS/N2001 Use basic health and safety practices at the workplace
3. PSS/N1336 Work effectively with others

Unit 1 of the textbook discusses the basics of electricity. Unit 2 focusses on the various tools and equipment used by a cable jointer and the techniques for handling these. Unit 3 gives an insight into the components of electrical wiring and accessories. Unit 4 explains the procedure of installing cables and Unit 5 discusses about repair and maintenance of cable joints.

I hope this textbook will be useful for students and teachers who will opt for this job role. Any further suggestions for improving this textbook are always welcome.

SAURABH PRAKASH
Professor
Department of Engineering and Technology
PSSCIVE, NCERT

Textbook Development Team

Members

Dipak D. Shudhalwar, *Associate Professor* (CSE) and *Head*, Department of Engineering and Technology, PSSCIVE, NCERT, Bhopal

Gaurav Kathel, Former *Consultant*, PSSCIVE, Bhopal

R. Vishwanathan Iyer, *Deputy General Manager* (Retd), Madhya Pradesh Madhya Kshetra Vidyut Vitaran Company Limited, Bhopal

Sandeep Ratnere, *Work Experience Teacher* (Electrical), Regional Institute of Education, Bhopal

S.P. Tiwari, *Lecturer*, Government Higher Secondary School, Bina, Madhya Pradesh

Sunanda Kumari, *Assistant Programmer*, OIST, Bhopal

Member-coordinator

Saurabh Prakash, *Professor*, Department of Engineering and Technology, PSSCIVE, NCERT, Bhopal

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The Council is grateful to Saroj Yadav, *Professor* and *Dean* (A), NCERT, and Ranjana Arora, *Professor* and *Head*, Department of Curriculum Studies, for carefully evaluating and giving suggestions for the improvement of this book and its finalisation. The Council acknowledges the copy editing and valuable contribution of Shilpa Mohan, *Assistant Editor* (Contractual) and Chanchal Chauhan, *Proofreader* (Contractual), Publication Division, NCERT in shaping this book. The efforts of Pawan Kumar Barriar, *DTP Operator*, and Neha Pal, *DTP Operator* (Contractual), Publication Division, NCERT, Akhilesh Kashiv, *Computer Operator*, Vikas Kumar Kogey, *Graphic Artist* (Contractual), and Pinki Tiwari, *Graphic Designer* (Contractual) PSSCIVE, NCERT, for flawless layout design are also acknowledged.

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. Electricity is now an important part of homes and industries. Almost all the devices at homes, 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 have seen bulbs, tubelights, fans, fridges, TVs and electronic gadgets at your home. All these run on electricity. At present electricity plays a vital role in our day-to-day life and in the country's economy.

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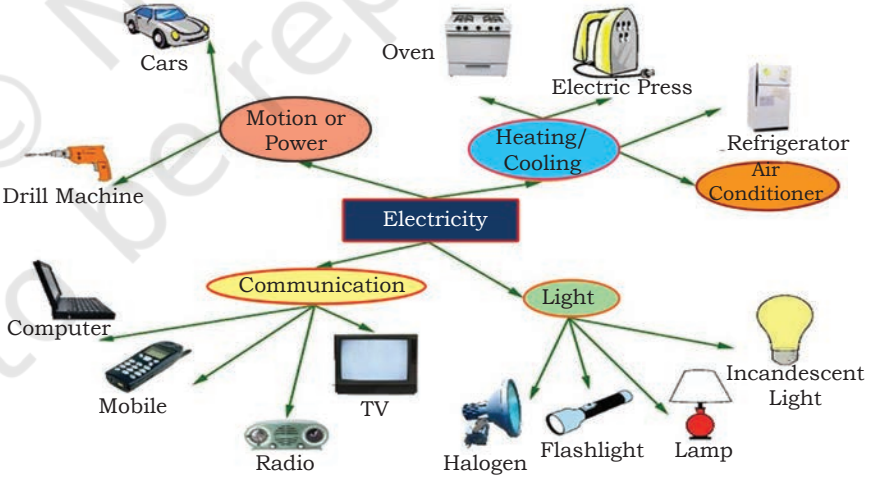


Fig. 1.1 Uses of electricity

Any country's development is measured by the per-person-consumption of electricity. Presently, everything in human life is dependent upon electricity whether it is in the health, transport, agriculture or industrial sectors.

Session 1: Electricity Generation Concept

Origin of Electricity

Electricity is one of the most commonly used forms of energy. The term electricity comes from the Greek word *elektron* which means amber. It is converted from mechanical to electrical energy with the help of a prime mover i.e., from turbine to 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 the 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

From the generating station electricity arrives at homes through wires. Electric lamps, electric heaters, fans, computers, etc., use electricity to work. Many appliances at home 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.

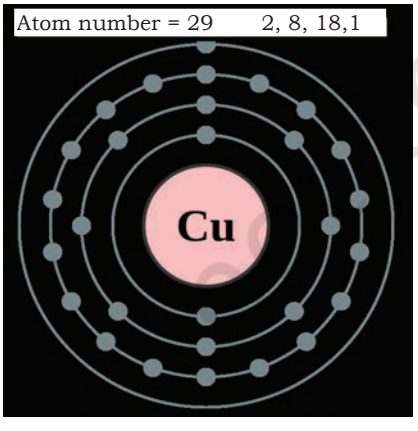
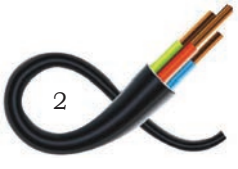


Fig. 1.2 Electrons

There are two types of electric charges—positive and negative. Similar charges repel each other and opposite charges attract. This means that if you put two negative charges close together and let them go, 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 electricity supply fails, electrical torches are used for light. We use electricity to operate the pump that lifts water from wells or ground level to roof-top water tank. We need electricity to run computers in shops, offices, banks and other establishments. Other electrical equipment like AC, geyser, electrical iron, television, refrigerator, induction cooker, oven, etc., require electricity to run them.

Fig. 1.3 Electricity used for lighting

Fig. 1.4 Electricity used for heating

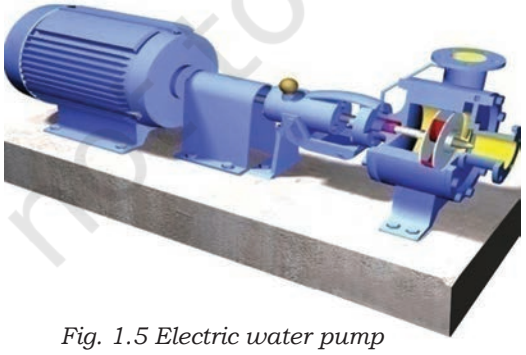


Fig. 1.5 Electric water pump

Generation of Electricity

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

Experiment of Michael Faraday

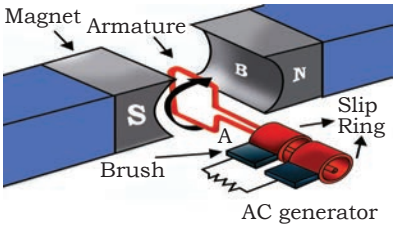


Fig. 1.6 Diagram of electromagnetic generator

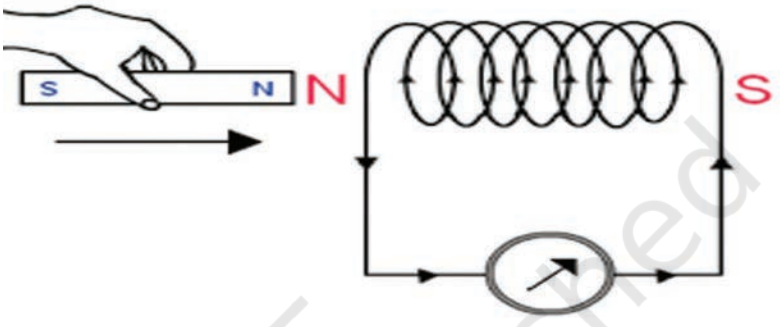


Fig. 1.7 Experiment of Michael Faraday

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).

Electricity Generated by Electrochemical Cell

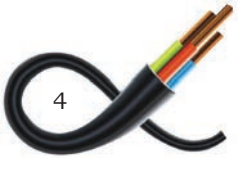
Fig. 1.8 Electrochemical battery

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.

Electricity Generated by Solar Cell

Fig. 1.9 Electricity generated by solar panel

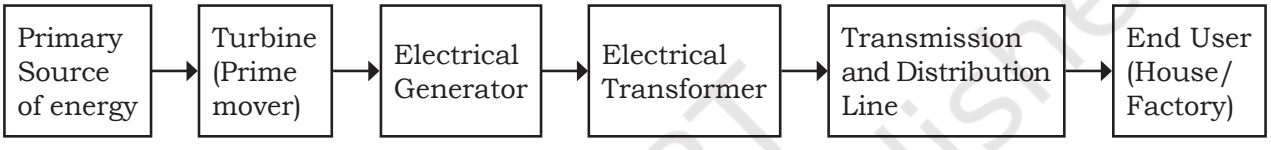
A solar cell (Fig. 1.9) is a device that converts light energy into electrical energy. This conversion is called the photovoltaic effect. Solar cells have many applications. They have been used in situations where electrical power is unavailable, such as in remote areas, earth-orbiting satellites and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



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 of the places in the world the turbine is steam-driven. Water is heated, which turns into steam and spins a steam turbine which drives an electrical generator. In a thermal power station fuel, such as coal, oil or gas is burned in a furnace to produce heat-chemical to heat energy. This heat is used to change water into steam in the boiler and this drives the generator to produce electricity by converting mechanical to electrical energy.

Generation and Transmission of Electricity



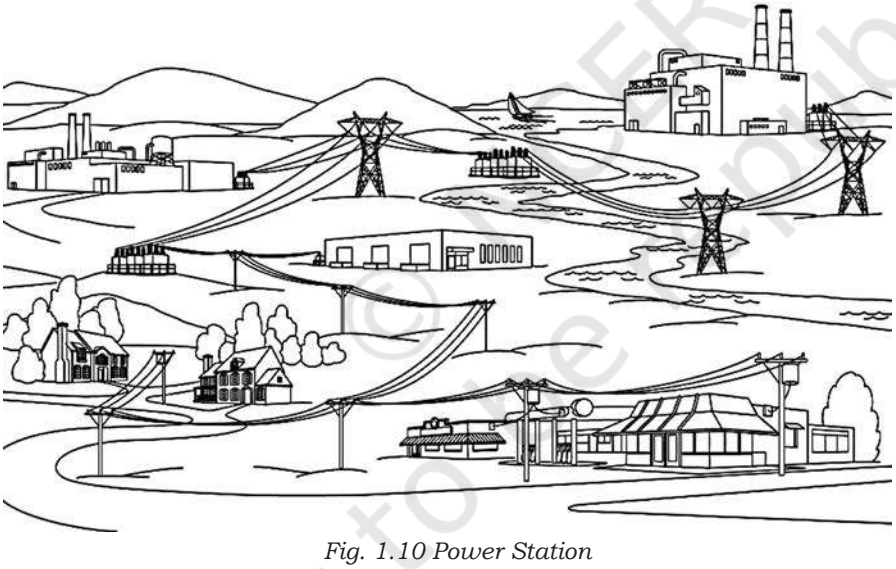


Fig. 1.10 Power Station

Our day starts and ends with the use of various electrical devices. Some of them are LED lights, fan, AC, refrigerator, motor, etc. The source where electricity is generated is far away from residential areas. This place is known as a power station. A power station (Fig. 1.10)

is also known as a power plant or powerhouse. Power station may contain one or more electric generators. Generator converts the mechanical power into electrical power. Most power stations in the world burn fossil fuels like coal, oil and natural gas to generate electricity. But there is an increasing use of cleaner renewable sources, such as solar, wind, wave and hydroelectric energy.

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	**329,231**	**100%**

Source: Central Electricity Authority (CEA)
**Installed capacity with respect to Renewable Energy Sources as on 31.03.2017.*
Renewable Energy sources include small hydro project, gas produced from biomass power, urban and industrial waste power, solar and wind energy.

Practical Exercise

Activity 1

Make an electrical quiz board for list of source of electricity and their sharing percentage (%) in India

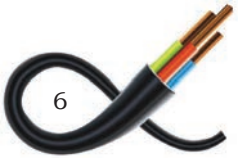
Objective

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.

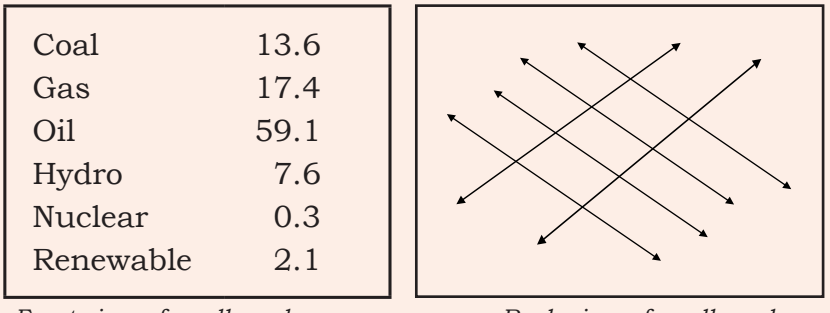
Material required

One card–board (45 cm × 15 cm), insulated copper wire, one 9-volt bulb with holder, one 9-volt battery, 10-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



Front view of cardboard *Back view of cardboard*

Fig.1 Electrical Cardboard

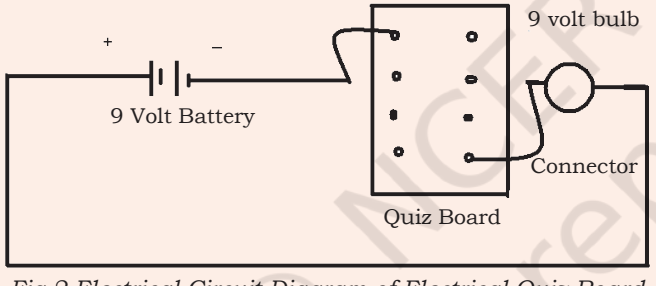


Fig.2 Electrical Circuit Diagram of Electrical Quiz Board

Procedure

1. Take one cardboard (45cm.x15cm.) and fix pieces of insulated wire with two metal connectors at the end of each wire.
2. Paste down name of energy source and percentage as shown in figure.
3. Connect each question to correct answer by a wire at the back of the cardboard.
4. Connect 9-volt battery and 9-volt bulb as shown in 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 board will complete the circuit.
7. If the answer is wrong, the bulb will not glow.

Precautions

1. Every connection should be tight.
2. There should not be any wire left naked.
3. Question and answer should be connected correctly at the back side of the cardboard.

Check Your Progress

A. Fill in the blanks

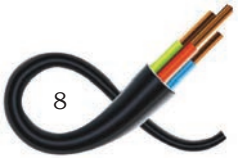
1. The nucleus of an atom is surrounded by negatively charged particles known as _____.
2. Similar electric charges _____ each other and opposite charges _____ each other.
3. Benjamin Franklin's experiments helped in establishing the connection between _____ and _____.
4. Coal, oil or gas is used as a fuel in _____ power stations to convert heat energy into electrical energy.
5. Electromechanical cell is capable of generating electrical energy through _____.

B. Match the columns

1.	Thermal power plant	(a)	Renewable
2.	Wind Power Plant	(b)	Photovoltaic effect
3.	Solar cell	(c)	Water
4.	Michael Faraday	(d)	Law of Electromagnetic Induction

C. Multiple choice questions

1. Electricity was discovered by _____.
   (a) Isaac Newton (b) Benjamin Franklin
   (c) Max Plank (d) Rutherford
2. Which of these is the most commonly used source of energy for power generation in India?
   (a) renewable (b) thermal
   (c) nuclear (d) hydro
3. Which form 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.

D. Write short notes on

1. Use of thermal power plant
2. Generation of electricity
3. Different sources of energy

Session 2: Basic Units and Definition of Electricity

Electricity

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

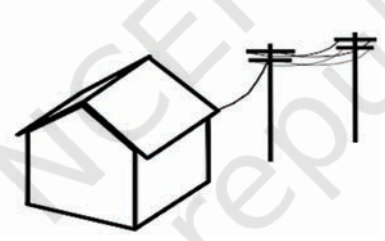


Fig. 1.11 Electricity as form of energy

Various Effects of Electric Current

(a) Heating effect: Heat is produced in a conductor, like nichrome, due to flow of current through it. It is called heating effect (Fig. 1.12) of electric current or Joule's law of heating. When electricity flows through a conductor like tungsten, light is emitted (Fig. 1.13) from the surface of conductor due to heating, such as in an electric bulb.

Fig. 1.12 Electric heater

Fig. 1.13 Electric bulb

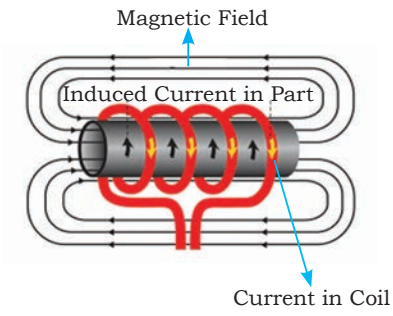


Fig. 1.14 Magnetic effect of electric current

(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. 1.14) is produced around the conductor through which current is flowing. This effect is called magnetic effect of electric current. When electricity flows through the human body contraction of nerves occurs, which can be fatal.

(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 (Fig. 1.15).

Fig. 1.15 Physical effect of electricity on human body

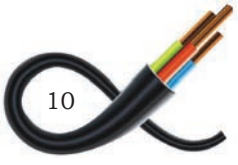
Voltage, Current, Resistance, Capacitance and Inductance

If we place two objects charged to different potential side by side, charge will not move from one object to the other. Now if the two are connected using a conductor, the flow of charge will take place. 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.

We know that flowing water constitutes water current. Similarly, if the electric charge flows through a conductor that means there is an electric current in the conductor. In a torch, the cells provide necessary potential difference for the flow of charges or an electric current through the torch bulb to glow. We have also seen 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 the analogy of water flow. 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.

Voltage plays an important role for flow of charges in a conducting wire. The electrons move only if there is a difference of electric pressure known as 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 other.

Voltage

Voltage is the force required to make electricity flow through a conductor (Fig. 1.16). It is also called electric potential difference or electromotive force (EMF). Voltage may also be defined as the energy difference between the positive and negative terminals of a battery. This energy difference is measured in volts and represented by the symbol 'V' or 'E'.

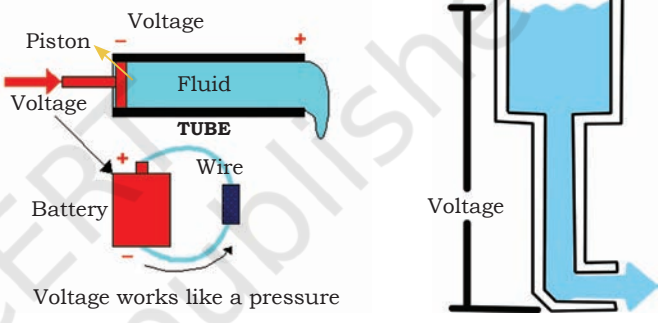
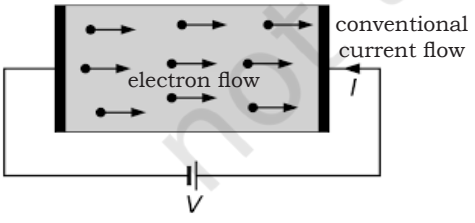


Fig. 1.16 Voltage

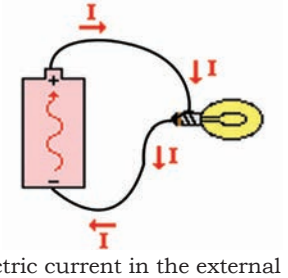
Current

Current is the flow of electrons in a material from one atom to the next atom in the same direction (Fig. 1.17). Just as pressure causes current to flow in a circuit, voltage causes current to flow in the conductor (Fig. 1.18). Current is measured in amperes and is denoted by the symbol 'I'.



Flow of current in conductor (Cu)

Fig. 1.17 Flow of electrons



Electric current in the external circuit is directed from the positive to the negative terminal

Fig. 1.18 Flow of current in conductor

Resistance

Fig. 1.19 Electrical resistance

The electrical resistance of an object is a measure of its opposition to the flow of electric current (Fig. 1.19). It is represented by the symbol 'R'. It is measured in ohms, symbolised by the Greek letter omega (Ω) by a measuring instrument called ohm meter.

Example: Some materials offer more resistance than others. Metals, such as silver, copper, aluminium and iron offer less resistance and are known as good conductors of electricity. On the other hand, materials like plastic, glass, mica and rubber offer high resistance and are called bad conductors of electricity, or good insulators.

Capacitance

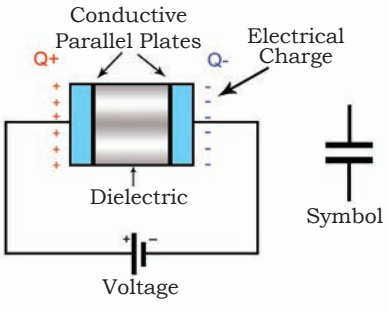


Fig. 1.20 Circuit diagram of a capacitor

Capacitance is a measure of a circuit's ability to store electrical charge (Fig. 1.20). Any object that can be electrically charged exhibits capacitance. If the charges on the plates are +q and −q, respectively, and V is the voltage between the plates, then the capacitance 'C' is given by the formula:

$$C = q/V$$

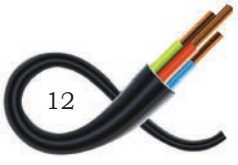
A device manufactured to have a specific amount of capacitance is called capacitor (Fig. 1.21). A capacitor is made up of a pair of conductive plates separated by a thin layer of insulating material. Another name for the insulating material is dielectric material.

A common form of energy storage device is a parallel-plate capacitor. In a parallel plate capacitor, capacitance is directly proportional to the surface area of the conductor plates and inversely proportional to the distance between the plates.

Fig. 1.21 Capacitors

Inductance

Inductance is the property of an electric circuit that opposes any change in electric current. Resistance opposes current flow; inductance opposes changes in the current flow. Inductance is designated by the letter 'L'. The unit of measurement for inductance is Henry (H).



As Henry is a relatively large unit, inductance is often rated in millihenries or microhenries. Inductors are coils of wire wound for a specific inductance. The inductance of a coil is determined by the number of turns in the coil, the coil diameter and length, and the core material (Fig. 1.22).

Current flow produces a magnetic field in a conductor. The amount of current determines the strength of the magnetic field. As current flow increases, field strength increases and as current flow decreases, field strength decreases. Any change in current causes a corresponding change in the magnetic field surrounding the conductor.

Current is constant for a regulated direct current (DC) source, except when the circuit is turned on and off, or when there is a load change. However, alternating current (AC) is constantly changing, and inductance is continually opposing the change. A change in the magnetic field surrounding the conductor induces a voltage in the conductor. This self-induced voltage opposes the change in current. This is known as counter EMF.

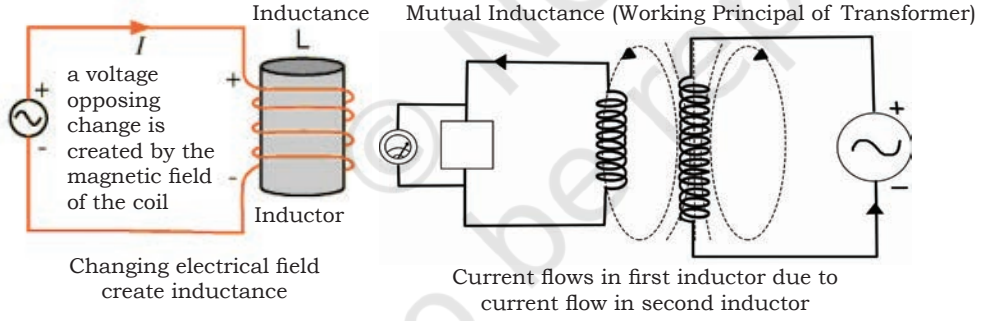


Fig. 1.22 Diagram showing how changes in electrical field create inductance

Electric Circuit

A simple electric circuit (Fig. 1.23) consists of a voltage source, some type of load and conductors to allow electrons to flow between the voltage source and the load. An electric circuit can be either in series or parallel.

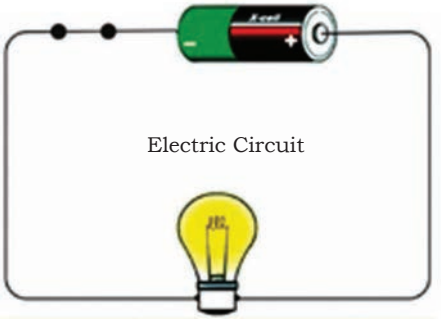


Fig. 1.23 Simple Electric Circuit

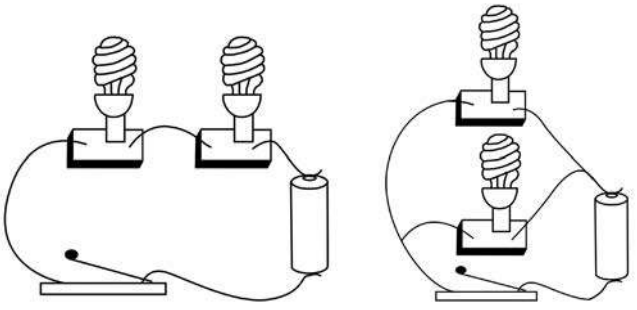


Fig. 1.24 Series and Parallel Circuit

Series Circuit

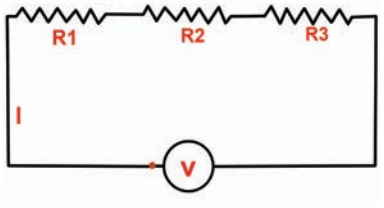


Fig. 1.25 Diagram of Series Circuit

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 a series (Fig. 1.25).

This circuit is called 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 be arranged in parallel and the circuit is called parallel circuit (Fig. 1.26).

In Parallel Circuit

Resultant Resistance $\left(\frac{1}{R_t}\right) = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}$

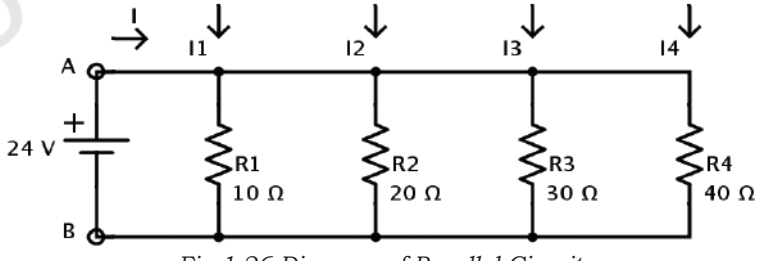


Fig.1.26 Diagram of Parallel Circuit

Ohm's Law

Ohm's law describes the way current flows through a resistance when a different electric potential (voltage) is

applied at each end of the resistance. One way to think of this is as water flowing through a pipe. The voltage is like the water pressure, the current is the amount of water flowing through the pipe, and the resistance is the size of the pipe. The more the resistance, the less the current will flow through the electric circuit. Ohm's law shows that current varies directly with voltage and inversely with resistance.

Voltage is calculated by multiplying the current with the resistance, or

E = IR

This is called Ohm's law (Fig. 1.27). Ohm's law can be expressed in three ways:

E = IR or I = E/R or R = E/I

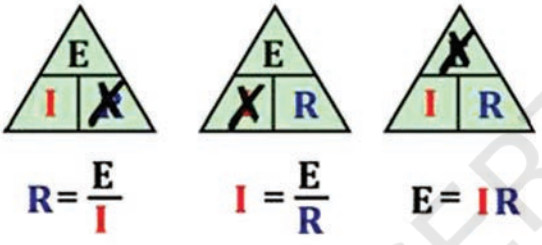


Fig. 1.27 Equation Triangles in Ohm's Law

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 I (current entering in the node) + I (current leaving the node) = 0.

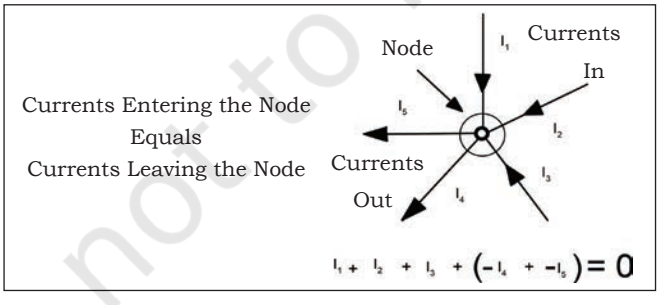


Fig. 1.28 Diagram of Kirchhoff's Current Law

This idea by Kirchhoff is commonly known as the Conservation of Charge or Kirchhoff's Current Law (KCL) (Fig. 1.28).

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.
Then this means we can also rewrite the equation as:

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

Kirchhoff's Second Law — the 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. 1.29). This is called Kirchhoff's Second Law or law of Conservation of Energy.

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

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

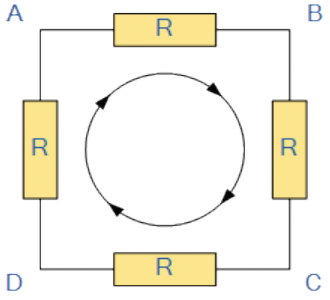


Fig. 1.29 Diagram of Kirchhoff's Second Law

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 the final voltage sum will not be equal to zero. We can use Kirchhoff's voltage law 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, such as

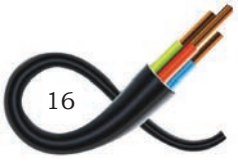
(a) Nodes: when any resistance is connected in the circuit the two terminals of resistance are called nodes.

(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, these are called meshes.

These terms are used in circuit analysis so it is important to understand them.



Check Your Progress

A. Fill in the blanks

1. Light emitted from the surface of conductor is due to _____ of electric current.
2. Magnetic effect of current was discovered by _____.
3. An electric bulb glows when current passes through _____, a conductor.
4. If a changing magnetic field is connected with the coil of a conductor, then _____ is induced in it.

B. Match the columns

1.	Voltage	(a)	Storing Charge
2.	Current	(b)	Obstruction in flow of charge
3.	Resistance	(c)	Flow of charge
4.	Capacitance	(d)	Pressure

C. Multiple choice questions

1. The potential difference between two points is _____
   (a) one volt energy (b) volume
   (c) pressure (d) temperature
2. The chemical reaction within a cell generates _____ across the terminals of the cells.
   (a) energy (b) potential difference
   (c) pressure (d) current
3. Kirchhoff's Current Law states that the algebraic sum of all currents entering and leaving a node must be equal _____.
   (a) one (b) two
   (c) three (d) zero
4. In any electrical circuit when physical condition (temperature, diagram and length) of a conductor are constant 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 a _____.
   (a) parallel circuit (b) series circuit
   (c) closed circuit (d) open circuit

D. Short answer questions

1. Explain Ohm's Law in brief with the help of a diagram.
2. Electric current has various effects on chemicals, conductors, the human body, etc. Discuss with suitable examples.
3. An inductor can be defined as an energy storage device. Why?
4. Describe the different parts of a circuit.

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 like bulbs, heaters, etc., transfer energy from the mains supply to heat and light our homes. Electric energy also operates our appliances, such as TV, microwave and computers, etc. The units measured by an electricity meter and used to calculate the consumption (electricity bill), are kilowatt hours. The cost of each unit of electricity varies. The electricity bill is calculated by multiplying the number of units used by the cost of a unit.

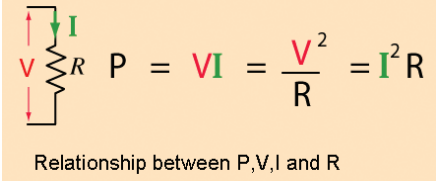


Fig. 1.30 Diagram shows relationship between P,V, I and R

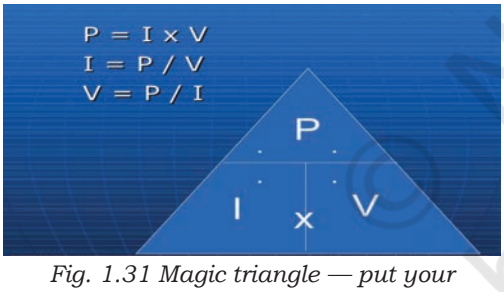


Fig. 1.31 Magic triangle — put your thumb on any one unit and get related Equation

Electrical Power

It is the rate at which electrical energy is consumed by an electrical appliance.

The unit of electrical power is watt.

1000 watt = 1 kilowatt

Electrical Power in DC and AC Circuit

Electrical Power in DC Circuit (Figs. 1.30 and 1.31)

$P = V \times I$

$P = I^2R$

$P = V^2/R$

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

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. 1.32).

Electrical Energy = power × time

Electrical Energy = watt × hour

Electrical Energy = 1000 watt × 1 hour

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 electrical power they are likely to consume. Symbols of electrical circuit are shown in Fig. 1.34.

Electrical power (Fig. 1.33) is also expressed as the rate at 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.

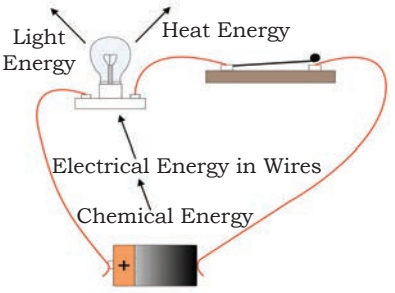


Fig. 1.32 Diagram shows conversion of chemical energy into electrical energy

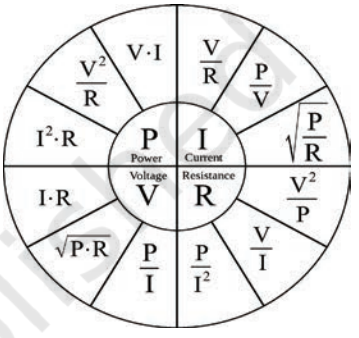


Fig. 1.33 Diagram of electrical power circulation

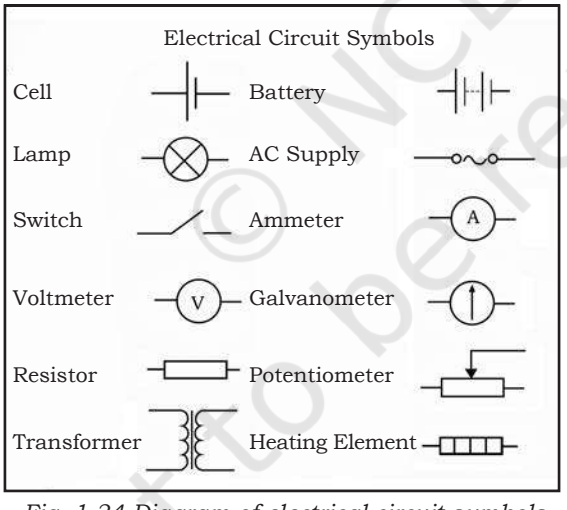
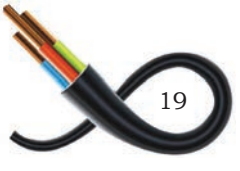


Fig. 1.34 Diagram of electrical circuit symbols

Use of Voltmeters and Ammeters

Voltmeters

1. Voltmeter is always connected across the device or in parallel.
2. Voltmeter has a very high internal resistance, so as not to draw a large current from the circuit.



Ammeters

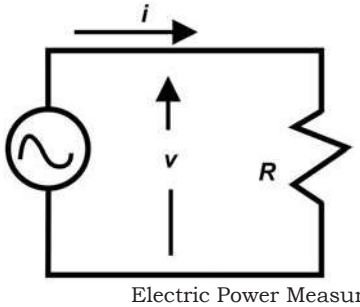
1. Ammeter is always connected in series.
2. Ammeter has a very low internal resistance, so as not to generate a drop in potential.

Power and Energy Calculation in DC and AC system

(a) Watt: This is a unit of power. It is the rate at which electricity is being used at a specific moment: 1 kilowatt= 1000 watt, 1 Megawatt= 1000,000 watt.

Example 1: 09-watt LED light bulb consumes 09 watts of electricity at any moment when turned on.

(b) Watt-hour: This is a unit of energy. One watt-hour is the energy consumed when one watt of power is used for one hour: watt-hour = watt × hour. Commercial unit of energy is 1 kilowatt-hour (1 kWh)



P = V*I ..... For DC
P = V*I*Cos(θ) .....For AC

Electric Power Measurement

Fig. A

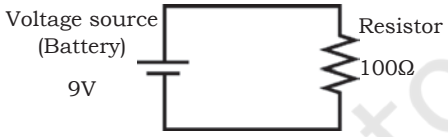
Example 2: 09-watt LED bulb, which draws 09 watts at any one moment, uses 09 watt-hours of electricity in the time of one hour.

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



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

Calculation of Power: As per formula Power in DC circuit —

Electrical Power = Voltage × Current

$$P = V \times I$$

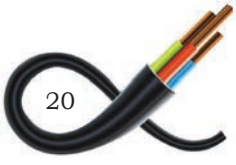
As per Ohm's Law V=IR (where R = resistance of the circuit)

$$I = V/R$$

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 hour)

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

Solution: Energy consumed by above electrical circuit is 8.1 unit.

Question: Calculate the electrical power and energy consumed in 5 hour of the electrical DC given circuit (Fig. B).

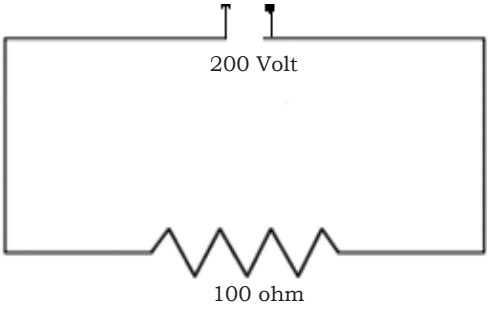


Fig. B

Check Your Progress

A. Fill in the blanks

1. Electrical power involves _____, _____, and _____ of electrical energy.
2. _____ is the rate at which electricity is used at a specific moment.
3. A _____ is always connected across the device or in parallel.
4. The commercial unit of electricity is known as _____.
5. Ammeter has a low internal resistance so as to not generate a _____ in potential.

B. Match the column

1.	Battery	(a)	Current indicating device
2.	Galvanometer	(b)	Resists the flow of a 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) direct current
   (c) power (d) energy
2. The internal resistance of an ammeter is _____.
   (a) high (b) low
   (c) zero (d) infinite
3. What is required to produce electric current?
   (a) Voltage (b) Source of energy
   (c) Electric field (d) All of these

4. Potentiometer is an electric device that gives variable _____.
   (a) power (b) resistance
   (c) voltage (d) current

D. Short answer questions

1. What is one commercial unit of electrical energy? Explain briefly.
2. 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.
3. 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 that flows through LED bulb.
   (b) the amount of electrical energy used by the LED bulb in 8 hours.

E. Draw the electrical symbols of the following

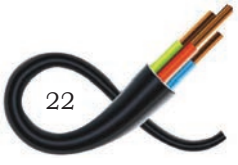
1. Cell
2. Battery
3. Bulb
4. Resistance
5. Switch

SESSION 4: IMPORTANCE OF EARTHING SYSTEM

Earthing is set up in an electrical circuit to ensure safety. This system provides an alternative path for high and dangerous current to flow to the earth so that the problem of electric shock and damaging of equipment 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 all equipment are earthed and if the equipments' insulation fails there can be dangerous current present on the surface of the equipment. This may cause a short-circuit and the fuse will blow off immediately.



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 good conductor known as earth electrode. Earthing is done to save human life from the danger of electrical shock, in case human body comes in contact with live wire of electricity (Fig. 1.35).

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

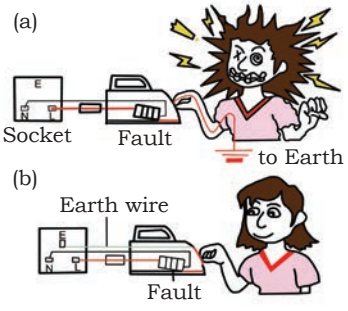


Fig. 1.35 Proper Earthing

Specifications 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 2.9mm² or 14 SWG
3.	Resistance of earth	Not greater than 8 ohm

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

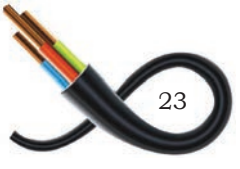
Points to be earthed

1. Earth pin of 3 pin and 5 pin plug and socket.
2. All metal parts of 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 leakage current.



2. maintain the line voltage constant.
3. protect large machine and building from atmospheric lighting.
4. avoid the risk of accident in electrical substation and other installation.

Earth resistance of different electrical installation

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

1. **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.
2. **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 the earth's surface.
3. **Pipe earthing:** Pipe earthing is cheaper and the best form of earthing. In this type of earthing a hollow pipe of 38 mm diameter and 2.5 meter long GI is placed underground of the earth and covered with charcoal and salt.
4. **Plate earthing:** In this type of earthing system, a plate of either copper with dimensions 60cm × 60cm × 3.18mm or galvanised iron (GI) of dimensions 60cm × 60cm × 6.35 mm is buried vertical in the earth pit which should not be less than 3 meter from the surface of ground.

The most commonly used types of earthing are

(a) 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

in ground to work as earth electrode. The depth depends upon the soil conditions; there is no hard and fast rule for this. The earth electrodes are connected to the top section of the pipe with nut and bolt. The pit area around the GI pipe is filled with alternate layer of salt and charcoal for reducing earth resistance. It can take heavy leakage current for the same electrode size in comparison to plate earthing. Water is filled through a pipe to maintain the resistance of earth electrode. Pipe earthing (Fig. 1.36) is the best form of earthing and it is also a cheap method of earthing.

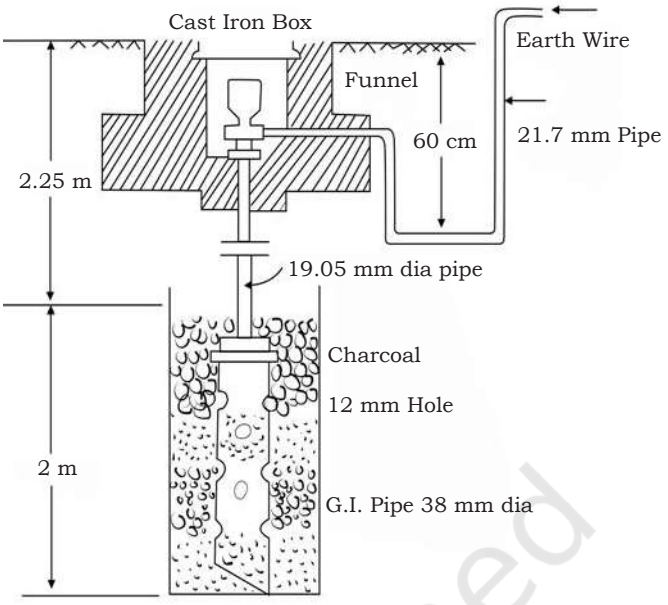


Fig. 1.36 Pipe earthing

Earthing pipes are also known as earthing electrode pipes, these can be used in houses, offices as well as in power stations. Earthing pipes are used in electrical installation, transmission line and other installation. Copper pipe is generally used in 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 pipe, being above the ground level makes it easy to check for any discontinuity. To have an effective earthing in summer season, pipe earthing gives us the freedom to put 2–3 buckets of water through the funnel, which helps in achieving effective earthing. This is one of the most widely used methods of earthing.

(b) 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.

Earthing plate is filled with alternate layers of salt and coke not less than 46 cm (1.5 feet) so 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 GI in case of GI plate earthing (Fig. 1.37).

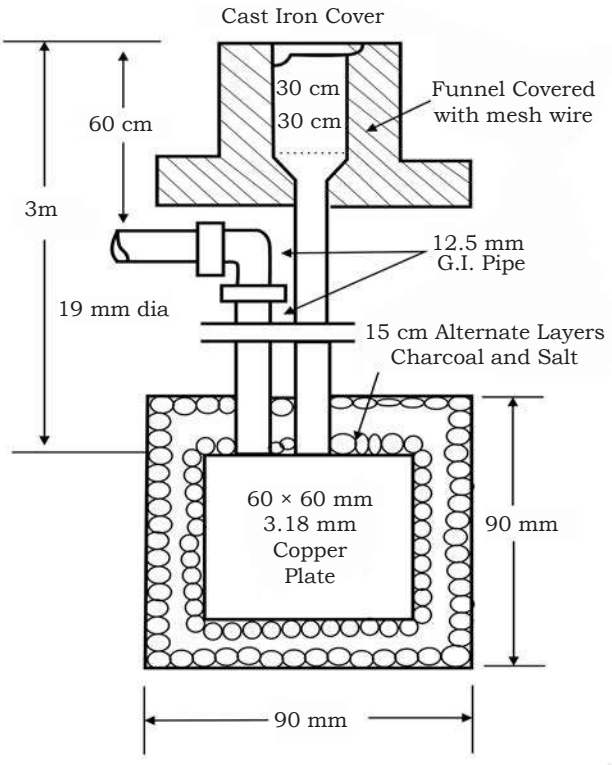


Fig. 1.37 Plate earthing

1. For GI earthing plate size should be – 600 mm × 600 mm × 8.30 mm

2. For copper earthing plate size should be – 600 mm × 600 mm × 3.15 mm

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 electrical energy to be safely dissipated thereby minimising the danger caused by leakage. Earthing is the key to safety i.e., protection of personnel, equipment, wiring, machines and instruments. Another advantage of earthing in the context of communication tower is to reduce electromagnetic interference.

Both plate or pipe earthing can be used. However, plate earthing is preferred in small buildings and pipe earthing is preferred for multistorey buildings as well as electrical substations. All metallic parts of electric machines must be earthed for safety of the equipment.

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 an arc between the cloud and the earth's 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 a flash of lightning.

The possibility of lightning is more on tall trees and buildings rather than on 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, 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 the 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.

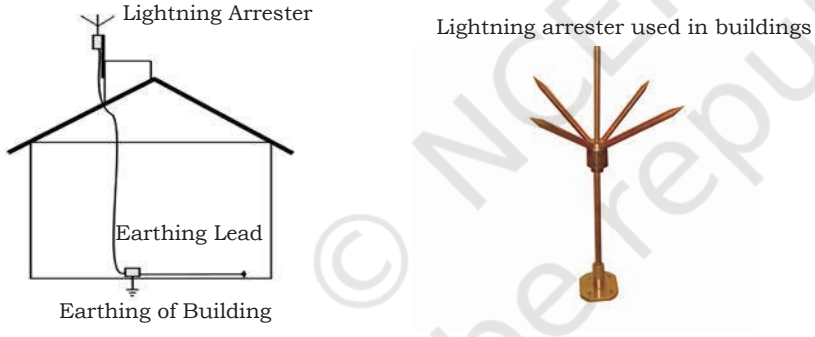


Fig. 1.38 Lightning arresters

Lightning arresters (Fig.1.38) 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 a voltage greater than the normal line exists in the circuit, the lightning arrester immediately provides a path to the earth and thus limits and drains off the excess voltage.

Working of Lightning Arrester

1. A lightning arrester does not absorb any charge caused by lightning.

2. A lightning arrester diverts the charge towards the ground.
3. A lightning arrester limits the voltage produced by atmospheric lightning.
4. A lightning arrester will work at the time of lightning because it produces very high voltages.
5. A lightning arrester provides protection against lightning surges during the rainy season.

Earth Resistance

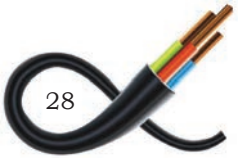
1. Earth resistance depends on following factors
   (a) Type of earth soil
   (b) Temperature of earth
   (c) Humidity in earth
   (d) Minerals in earth
   (e) Length of electrode in the earth
   (f) Electrode shape and size
   (g) Distance between two electrodes
   (h) Number of electrodes
2. Maximum earth resistance allowed is as follows:
   (a) Major power station — 0.5 ohms
   (b) Major Sub-stations — 1.0 ohms
   (c) Minor Sub-station — 2 ohms
   (d) Neutral Bushing — 2 ohms
   (e) Service connection — 4 ohms
   (f) L.T Lightning Arrestor — 4 ohms
   (g) L.T. Pole — 5 ohms
   (h) H.T. Pole — 10 ohms
   (i) Tower — 20-30 ohms

Earth Tester and Earth Resistance

Earth tester is used to measure earth's resistance. If earth resistance is high, certain processes need to be adopted.

Working of Earth Tester

Earth tester consists of hand operated D.C. generator, 4 spikes and connecting wire. These spikes are



connected through wire to terminals of earth tester. Spikes are inserted in the ground to check the earth resistance. Current is fed to the spikes through DC generator. DC current is converted into AC current by the converter and AC current received from spike is again converted in DC current with the help of a rectifier. While going to generator, AC current is fed to the spike driven in earth because there should not be electrolytic effect.

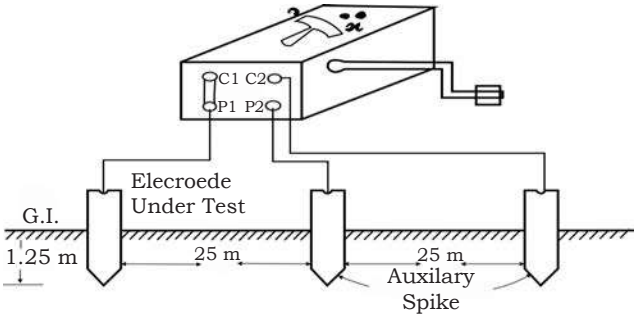


Fig. 1.39 Measurement of Earthing Resistance—Three-Point Method

Three-point Method

In this method, earth tester terminals C1 and P1 are shorted (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. These two spikes are kept in the same line at a distance of 25 meters and 50 meters due to which, there will not be mutual interference in the field of individual spikes. If we rotate the generator handle with specific speed, we get the earth's resistance directly on scale. This method of testing is known as three point method (Fig. 1.39).

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 earth in same line at the 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 we rotate generator handle with specific speed, we get earth's resistance value of that place.

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

If earth's resistance is higher than done the above values, following treatments can be to minimise resistance:

(a) Oxidation on joints should be removed and joints be tightened.

(b) Sufficient water should be poured in earth 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 be made.

Check Your Progress

A. Fill in the blanks

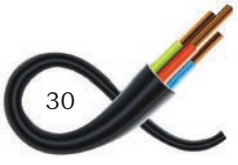
1. The metallic connection between electrical machines and devices with earth plate is known as _____.
2. Absence of earthing causes _____.
3. The resistance between earth electrode and earth in ohms is called _____.
4. Lightning arrester prevents damage of _____.

B. Match the columns

1.	Large Power Station	(a)	5.0 to 8.0 ohm
2.	Major Power Station	(b)	5 ohm
3.	Small Sub-Station	(c)	2 ohm
4.	In House wiring and such other case	(d)	1 ohm

C. Multiple choice questions

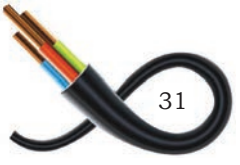
1. Maximum earth resistance value of major power station is _____
   (a) 0.5 ohm
   (b) 2 ohm
   (c) 1 ohm
   (d) 8 ohm
2. One of the most common type of earthing is _____.
   (a) plate earthing
   (b) pipe earthing
   (c) rod earthing
   (d) strip earthing
3. Earthing pipes are not used for _____.
   (a) electrical installation
   (b) transmission line
   (c) industry
   (d) atmospheric light



4. For maintaining moisture around the earthing we use _____.
   (a) salt and charcoal
   (b) sugar
   (c) oil
   (d) none of them
5. Every metallic electrical pole must be _____.
   (a) grounded
   (b) earthed
   (c) phase
   (d) neutral

D. Short answer questions

1. Explain the process of pipe earthing.
2. The high resistance of earth needs to be controlled for certain processes. Analyse the importance of earth tester in this context.
3. Draw a simple diagram of plate earthing.
4. Discuss the factors which affect earth's resistance.



Cable Jointer Electrical Power System-Class 11 - Unit 1 Session- 1

A. Fill in the blanks

1. The nucleus of an atom is surrounded by negatively charged particles known as _____.
2. Similar electric charges _____ each other and opposite charges _____ each other.
3. Benjamin Franklin's experiments helped in establishing the connection between _____ and _____.
4. Coal, oil or gas is used as a fuel in _____ power stations to convert heat energy into electrical energy.
5. Electromechanical cell is capable of generating electrical energy through _____.

B. Match the columns

1.	Thermal power plant	(a)	Renewable
2.	Wind Power Plant	(b)	Photovoltaic effect
3.	Solar cell	(c)	Water
4.	Michael Faraday	(d)	Law of Electromagnetic Induction

C. Multiple choice questions

1. Electricity was discovered by _____.
   (a) Isaac Newton (b) Benjamin Franklin
   (c) Max Plank (d) Rutherford
2. Which of these is the most commonly used source of energy for power generation in India?
   (a) renewable (b) thermal
   (c) nuclear (d) hydro
3. Which form 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.

D. Write short notes on

1. Use of thermal power plant
2. Generation of electricity
3. Different sources of energy

Cable Jointer Electrical Power System-Class 11 - Unit 1 Session-2

A. Fill in the blanks

1. Light emitted from the surface of conductor is due to _____ of electric current.
2. Magnetic effect of current was discovered by _____.
3. An electric bulb glows when current passes through _____, a conductor.
4. If a changing magnetic field is connected with the coil of a conductor, then _____ is induced in it.

B. Match the columns

1.	Voltage	(a)	Storing Charge
2.	Current	(b)	Obstruction in flow of charge
3.	Resistance	(c)	Flow of charge
4.	Capacitance	(d)	Pressure

C. Multiple choice questions

1. The potential difference between two points is _____
   (a) one volt energy (b) volume
   (c) pressure (d) temperature
2. The chemical reaction within a cell generates _____ across the terminals of the cells.
   (a) energy (b) potential difference
   (c) pressure (d) current
3. Kirchhoff's Current Law states that the algebraic sum of all currents entering and leaving a node must be equal _____.
   (a) one (b) two
   (c) three (d) zero
4. In any electrical circuit when physical condition (temperature, diagram and length) of a conductor are constant 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 a _____.
   (a) parallel circuit (b) series circuit
   (c) closed circuit (d) open circuit

D. Short answer questions

1. Explain Ohm's Law in brief with the help of a diagram.
2. Electric current has various effects on chemicals, conductors, the human body, etc. Discuss with suitable examples.
3. An inductor can be defined as an energy storage device. Why?
4. Describe the different parts of a circuit.

Cable Jointer Electrical Power System-Class 11 - Unit 1 Session-3

A. Fill in the blanks

1. Electrical power involves _____, _____, and _____ of electrical energy.
2. _____ is the rate at which electricity is used at a specific moment.
3. A _____ is always connected across the device or in parallel.
4. The commercial unit of electricity is known as _____.
5. Ammeter has a low internal resistance so as to not generate a _____ in potential.

B. Match the column

1.	Battery	(a)	Current indicating device
2.	Galvanometer	(b)	Resists the flow of a 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) direct current
   (c) power (d) energy
2. The internal resistance of an ammeter is _____.
   (a) high (b) low
   (c) zero (d) infinite
3. What is required to produce electric current?
   (a) Voltage (b) Source of energy
   (c) Electric field (d) All of these
4. Potentiometer is an electric device that gives variable _____.
   (a) power (b) resistance
   (c) voltage (d) current

D. Short answer questions

1. What is one commercial unit of electrical energy? Explain briefly.
2. 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.
3. 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 that flows through LED bulb.
   (b) the amount of electrical energy used by the LED bulb in 8 hours.

E. Draw the electrical symbols of the following

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

Cable Jointer Electrical Power System-Class 11 - Unit 1 Session-4

A. Fill in the blanks

1. The metallic connection between electrical machines and devices with earth plate is known as _____.
2. Absence of earthing causes _____.
3. The resistance between earth electrode and earth in ohms is called _____.
4. Lightning arrester prevents damage of _____.

B. Match the columns

1.	Large Power Station	(a)	5.0 to 8.0 ohm
2.	Major Power Station	(b)	5 ohm
3.	Small Sub-Station	(c)	2 ohm
4.	In House wiring and such other case	(d)	1 ohm

C. Multiple choice questions

1. Maximum earth resistance value of major power station is _____
   (a) 0.5 ohm
   (b) 2 ohm
   (c) 1 ohm
   (d) 8 ohm
2. One of the most common type of earthing is _____.
   (a) plate earthing
   (b) pipe earthing
   (c) rod earthing
   (d) strip earthing
3. Earthing pipes are not used for _____.
   (a) electrical installation
   (b) transmission line
   (c) industry
   (d) atmospheric light
4. For maintaining moisture around the earthing we use _____.
   (a) salt and charcoal
   (b) sugar
   (c) oil
   (d) none of them
5. Every metallic electrical pole must be _____.
   (a) grounded
   (b) earthed
   (c) phase
   (d) neutral

D. Short answer questions

1. Explain the process of pipe earthing.
2. The high resistance of earth needs to be controlled for certain processes. Analyse the importance of earth tester in this context.
3. Draw a simple diagram of plate earthing.
4. Discuss the factors which affect earth's resistance.

Unit 2

Handling of Tools and Equipment

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Introduction

When you work with appliance repair, you need to be familiar with 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. Therefore, it is necessary to be sure that you are equipped with enough knowledge to properly use the tools that will be needed. Always remember to take them when you are working on a job.

Fig. 2.1 Tools used in electricity

Various tools and equipment are required for maintaining as well as erection of various electrical components (Fig. 2.1). Therefore, it is necessary to know about various tools and equipment to operate them safely.

Fig. 2.2 Screwdriver

Fig. 2.3 Types of screwdrivers

Session 1: Tools and Equipment

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

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

(b) Ratchet: It is used to allow rotary motion in only one direction and preventing 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 nut or a bolt. A spanner is available with 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 it.

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

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

(g) Hammer: It is used to fix nails in walls and wood, fit parts, or forge metal and 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/ remove the components on/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. 2.13 Soldering or desoldering station

Fig. 2.4 Ratchets

Fig. 2.6 Wrench

Fig. 2.5 Spanner

Fig. 2.7 Wire cutter and plier

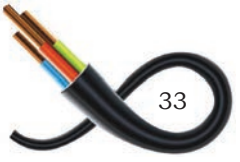


Fig. 2.14 Crimping tool

Fig. 2.15 Voltmeter

Fig. 2.16 Ammeter

(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 potential difference between two points in the electric circuit (Fig. 2.15).

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

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

(p) Megohmmeter or 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, current, etc (Fig. 2.19).

Fig. 2.17 Watt meter

Fig. 2.18 Megger

Fig. 2.19 Multimeter

Check Your Progress

A. Fill in the blanks

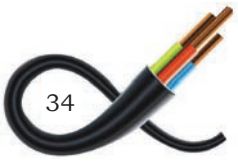
1. _____ is used to allow rotary motion in only one direction. It is used to tighten nuts and bolts.
2. Crimping tool is used for joining wires with _____ or _____ objects.
3. In an electric tester _____bulb is used.

B. Identify whether the following statements are True or False

1. Always examine the tool for damages before use.
2. It is OK to wear loose clothing, dangling objects and jewellery using hand tool.
3. Keep cords and hoses away from heat, oil and sharp edges.
4. Before connecting any electrical equipment to a power source, make sure the power is on.

C. Short answer questions

1. Can a wire cutter be used in place of a plier? Explain in brief.
2. How do tools and equipment help ease an electrical technician's work?



Session 2: Tools and Equipment Used for Cable Laying

Preparations of Cables and Equipment for Cable Laying Activities

Tools and equipment are used for various electrical activities. We should take care while handling the 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) are given here.

Fig. 2.20 Cable drum with cable

Tools and Equipment used in Cable Laying Activities

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

Fig. 2.21 Cable drum without cable

Cable Drums

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

Fig. 2.22 Angle rollers

Pulling Methods and Calculations

Proper methods should be used while laying the cable in the field. Suitable 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 cable in an open trench presents no serious difficulty. The cable is first placed on rollers 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 not to damage them during installation. The correct method of laying of cables for installation in a duct is shown in Fig. 2.23.

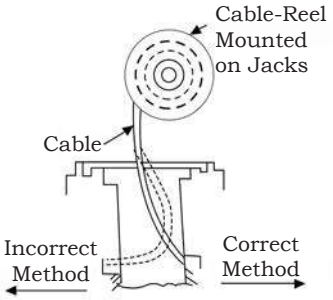
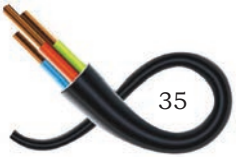


Fig. 2.23 Pulling Methods



Testing of Underground Cables

After laying cables underground or above the ground, proper testing is done to check the faults caused, if any, due to the laying. The cables are tested for short circuiting 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 his job without proper hand tools, which he carries 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:

(a) Combination Pliers

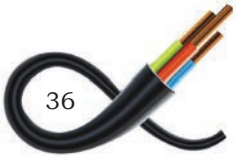
Fig. 2.25 Combination plier

It is used for cutting, removing insulation, jointing and twisting the electric wires and cables even on live-line. A lineman's pliers have special design, which multiplies force through leverage. These pliers usually have grips for better handling than bare metal handles. The grips also have 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).

(b) Adjustable Wrench

Fig. 2.26 Adjustable wrench

It 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 (Fig. 2.26).

(c) Pipe Wrench

It is used to open, close, conduit GI pipes and valves. 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 steel (Fig. 2.27).

Fig. 2.27 Pipe wrench

(d) Measuring Tape

It is used to measure the length of wires, cables 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. 2.28 Measuring tape

(e) Hammer

It is used to pierce nails, centre punch, rawl plug and chisel. Common sizes are 1, 2.5, 3 and 5 lbs (Pounds). A lineman's hammer is best suited to driving 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. 2.29 Hammer

(f) Ratchet with Drill Bit (Hand Drill)

It is used to make holes on wooden cross arms and wooden cleats for tight fitting High Tension and Low Tension cables emanating from DP structures, or LT transformer bushings (Fig. 2.30).

Fig. 2.30 Ratchet with drill bit (hand drill)

(g) Electric Drill Machine

It has the below mentioned properties:

- 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.

Fig. 2.31 Electric drill

(h) Bench Vice

A vice is a mechanical apparatus used to secure an object to allow work to be performed on it. In electrical

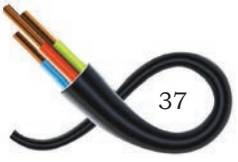


Fig. 2.32 Bench vice

works, cutting does play an important role. Cutting an electrical conduit has to be secure enough so that a smart cut is made. A bench vice (Fig. 2.32) is a perfect way to do this. Bench vice is used to grip the job (object) which has the following features:

- Base Plate (permanently fixed on the working table sides).
- Fixed Jaw (fixed with Base Plate)
- Moving Jaw (could be moved according to the thickness of 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. The desired capacity chain pulley is hooked at the centre to lift heavy load for loading and unloading at site (Fig. 2.33).

Fig. 2.33 Chain pulley

(j) Tripod

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

Fig. 2.34 Tripod

(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).

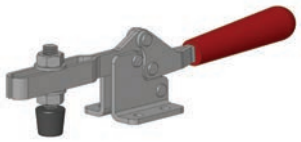


Fig. 2.35 Come along clamp

(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).

Fig. 2.36 Ratchet device

The senior 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 are almost same for all states. Electricians working in the field must have the following tools with them as given 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 tone	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 fault. Fault indicators (Fig. 2.37) are devices which indicate the passage of fault current. When properly applied, they can reduce operating costs and reduce service interruptions by identifying the section of cable that has failed.

Fig. 2.37 Fault indicator

Dos and Dont’s 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 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 any damage or breakdown to your teacher immediately.

Precautions

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

Check Your Progress

A. Multiple choice questions

1. Which of the following is used to measure power of an electric circuit?



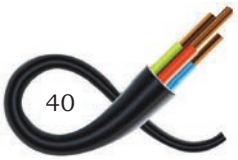
(a) Wattmeter (b) Megger (c) Ammeter

2. Which of the following is used to turn a nut or bolt?



(a) Spanner (b) Plier (c) Cutter

3. If a worker on a live-line gets electrocuted, first _____.
   (a) call a doctor
   (b) switch off supply
   (c) take the person away from the spot
   (d) provide artificial respiration
4. Pliers are classified by their _____
   (a) width
   (b) length
   (c) nose shape and intended work
   (d) handle



5. This tool is known as _____.
   (a) screw driver
   (b) combination plier
   (c) wire cutter
   (d) crimping tool

6. A generator provides the pressure for the electrical current to travel through electrical conductors (wires). What is this measure of electrical force called?
   (a) Watts
   (b) Amps
   (c) Volts
   (d) Current
7. When working on a circuit, use approved tools with _____.
   (a) rubber gloves
   (b) an International Efficiency (IE) rating
   (c) insulated handles
   (d) None of the above
8. If 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
9. Damaged tools must be removed from service and properly _____.
   (a) repaired
   (b) destroyed
   (c) tagged
   (d) carried

B. State whether the following statements are True or False

1. Safety glasses shall always be worn whenever you are using power hand tool.
2. Never use electric tools in wet conditions.
3. If a tool doesn't work for a particular job, you should alter it, so it does work.

Cable Jointer Electrical Power System-Class 11 - Unit 2 Session-1

A. Fill in the blanks

1. _____ is used to allow rotary motion in only one direction. It is used to tighten nuts and bolts.
2. Crimping tool is used for joining wires with _____ or _____ objects.
3. In an electric tester _____bulb is used.

B. Identify whether the following statements are True or False

1. Always examine the tool for damages before use.
2. It is OK to wear loose clothing, dangling objects and jewellery using hand tool.
3. Keep cords and hoses away from heat, oil and sharp edges.
4. Before connecting any electrical equipment to a power source, make sure the power is on.

C. Short answer questions

1. Can a wire cutter be used in place of a plier? Explain in brief.
2. How do tools and equipment help ease an electrical technician's work?

Cable Jointer Electrical Power System-Class 11 - Unit 2 Session-2

A. Multiple choice questions

1. Which of the following is used to measure power of an electric circuit?



(a) Wattmeter (b) Megger (c) Ammeter

2. Which of the following is used to turn a nut or bolt?



(a) Spanner (b) Plier (c) Cutter

3. If a worker on a live-line gets electrocuted, first _____.
   (a) call a doctor
   (b) switch off supply
   (c) take the person away from the spot
   (d) provide artificial respiration
4. Pliers are classified by their _____
   (a) width
   (b) length
   (c) nose shape and intended work
   (d) handle

5. This tool is known as _____.

   (a) screw driver
   (b) combination plier
   (c) wire cutter
   (d) crimping tool

6. A generator provides the pressure for the electrical current to travel through electrical conductors (wires). What is this measure of electrical force called?
   (a) Watts
   (b) Amps
   (c) Volts
   (d) Current

7. When working on a circuit, use approved tools with _____.
   (a) rubber gloves
   (b) an International Efficiency (IE) rating
   (c) insulated handles
   (d) None of the above

8. If 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

9. Damaged tools must be removed from service and properly _____.
   (a) repaired
   (b) destroyed
   (c) tagged
   (d) carried

B. State whether the following statements are True or False

1. Safety glasses shall always be worn whenever you are using power hand tool.
2. Never use electric tools in wet conditions.
3. If a tool doesn't work for a particular job, you should alter it, so it does work.

Unit 3

Electrical Wiring Components and Accessories

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Introduction

Electricity requires an electric path to flow and there are many conducting materials used for this purpose. There are many semi conducting 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 the different types of wiring and how they is done.

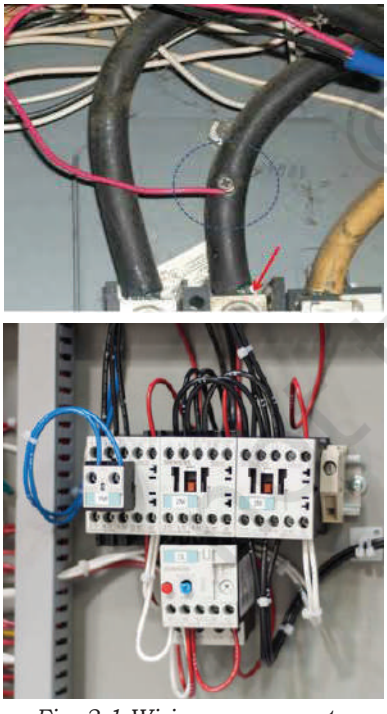


Fig. 3.1 Wiring components

Session 1: Identifying and Selecting the Wiring Materials and Components

Wiring materials

Electrical wire is made of materials like copper, aluminium and silver. As silver is expensive, mostly copper and aluminium are used in wiring.

Materials are classified into three types according to their properties:

1. Conducting materials
2. Insulating materials
3. Semiconductor materials

Conducting Material

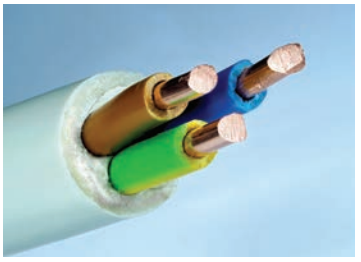


Fig. 3.2 Copper wire

(a) Copper

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

It is used in wiring and cable making.

(b) Aluminium

Fig. 3.3 Aluminium wire

It is light weight and cheaper in comparison to copper. Therefore, this type of conducting material is mostly used in electrical wiring. It is silvery–white in colour and it has a soft texture. It is often used in wiring and making cable (Fig. 3.3).

Insulating Materials

Insulating materials are used for insulating purpose. These types of materials are bad conductors of 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 Sockets

(a) Switch

A switch is used to make or break an electrical circuit. It is used to switch 'on' or 'off' the supply of electricity to an appliance.

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 wooden boards fixed on the surface of a wall. It is of three types

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

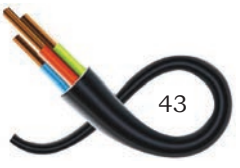


Fig. 3.5 One-way switch

Fig. 3.6 Two-way switch

Fig 3.7 Intermediate switch

Fig. 3.8 Flush Switch

Fig. 3.9 Bed switch

- **One-way switch:** It is used to control single circuits and lamp (Fig. 3.5).
- **Two-way switch:** It is used to divert the flow of current to either of two directions. The two-way switch can also be used to control one lamp from two different places as in the case of staircase wiring (Fig. 3.6).
- **Intermediate switch:** It is used to control a lamp from more than two locations (Fig. 3.7).

(i) *Flush switch:* It used for decorative purpose (Fig. 3.8).

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

(b) Holders

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

It is 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/plug

The socket outlet has an insulated base with the moulded or socket base having three terminal sleeves (Fig. 3.13).

Fig. 3.13 Socket

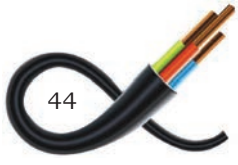
(e) Main switch

To control the electrical circuit a main switch is used. Through the main switch, the power in a building is controlled completely (Fig. 3.14).

Fig. 3.11 Batten holder

Fig. 3.12 Ceiling rose

Fig. 3.14 Main switch/ Main MCB



(f) PVC casing-capping wiring

PVC capping is done in order to cover the wires. It includes casing also. This casing-capping wiring is also known as open wiring, as it is done outside the wall.

Materials required for PVC casing-capping wiring (Figs. 3.15 and 3.16) include

1. wire
2. casing enclosures made up of plastic
3. capping made up of plastic
4. T. Joints VIR (Vulcanised Indian Rubber) or PVC (Polyvinyl chloride) insulated wire
5. junction box
6. elbow
7. casing and capping joints

Fig. 3.15 PVC casing-capping accessories

Fig. 3.16 PVC casing-capping bend

Wooden casing-capping wiring is old fashioned. Now PVC or VIR insulated wires are enclosed within the PVC casing enclosure and PVC capping is used to cover the casing.

Advantages of casing-capping wiring

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

Disadvantages of PVC casing-capping wiring

- Costly
- Not suitable for humid weather
- High risk of fire

Miniature Circuit Breaker (MCB)

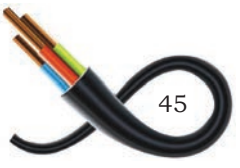
A MCB is used in new constructions instead of the older types of fuses. Circuit breakers are small devices used to control and protect the electrical panel and the other devices from overflowing of electrical power (Fig. 3.17).

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 can handle larger amounts of power. The breaker can manage the flow of energy, distributing the voltage even when many devices run off the same power circuit.

Lights

MCBs are used in the lighting system of the house, because they can deal with the amount of power needed to lightening 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 food stores.

Heaters

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

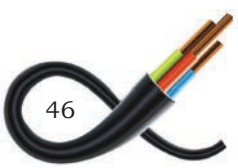
Conduit Wiring

Fig. 3.18 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 (Fig. 3.18 and 3.19) must be installed by electricians as per standard regulations. For workshops and public buildings, conduit wiring is the best and most desirable system of wiring. It provides protection and safety against fire.

Types of Conduits

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



Materials used in Conduit Wiring

- GI (Galvanised Iron) wire
- Elbow
- Coupling
- VIR (Vulcanized Indian Rubber) or PVC (Poly Vinyl Chloride) insulated cables
- Lock nut
- Clip
- Junction Box

Advantages of conduit wiring

- Safe
- Better appearance
- No risk of fire
- No risk of damage of cable insulation
- Safe from humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

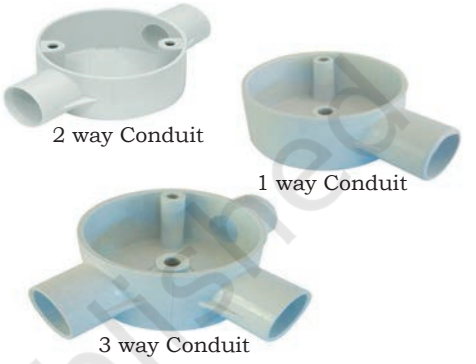


Fig. 3.19 Conduit wiring components

Disadvantages of conduit wiring

- Expensive
- Installation is not easy
- Not easily customisable for future use
- Hard to detect faults

Concealed Wiring

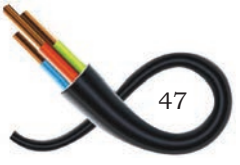
It is laborious to install this wiring. The layout of this wiring is done under the plaster of the wall of the building.

Advantages of concealed wiring

- Safe
- Better appearance
- No risk of fire
- No risk of damage of cable insulation
- Safe from humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

Disadvantages of concealed wiring

- Expensive
- Installation not easy
- Not easily customisable for future use
- Hard to detect faults



Colour Code

Wiring for AC and DC circuit are colour coded for identification of individual wires (Table 3.1).

Table 3.1 AC power circuit wiring colour codes

Function	Label	New 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. Fill in the blanks

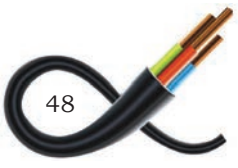
1. Wiring material is of three types _____, _____ and _____.
2. A switch is used to make or break _____.
3. Open wiring is also known as _____ wiring.
4. _____ are devices used to control and protect the electrical panel from overflowing electrical power.

B. 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. PVC casing and capping are used for covering the wires.

C. Multiple choice questions

1. Concealed wiring is immune to_____
   (a) humidity
   (b) heat
   (c) light
   (d) dust



2. Pendant holder is used for_____
   (a) fixing the bulb
   (b) fixing the fan
   (c) for hanging the bulb
   (d) to hang the fan
3. A two-way switch is used for _____
   (a) control one bulb from 2 points
   (b) control two bulbs from 2 points
   (c) control multiple bulbs from 2 points
   (d) control one bulb from one point

D. Short answer questions

1. Why is PVC casing-capping preferred over wooden casing-capping wiring?
2. How does an MCB help in managing electrical power?
3. Why is conduit wiring used in homes?
4. Discuss the importance of colour codes in electrical wiring.

Session 2: ICTP Switch and Distribution Board

ICTP (Iron Clad Triple Pole) Switch

It is used alongwith the energy meter to isolate the supply of electricity 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 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 of a load, for example, bulb, TV, etc. and power supply is started by using a switch. The circuit is like an electrical house.

Types of Circuit

1. Open
3. Closed
4. Series
5. Parallel

- **Series circuit:** It is like a stair-case. In this type of circuit r1, r2, r3 are resistances connected in series. In this,

  R = r1+r2+r3

  where R is equivalent to resistance.

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

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

In this, all resistances having positive sides are connected on one end and all negative sides are connected on another end. In this, voltages are same in all the branches.

Fixing Wiring Accessories on Board

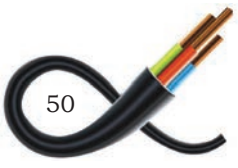
You should know the tools required for fixing the accessories on the board. You should also know the purpose of fixing the accessories.

In-house wiring of the switches, holders and sockets should be fixed on wooden/sunmica 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 Practice 1

Adjust the electrical accessories like, switches, holders, sockets, etc. on the given board or round block. And then mark their positions by a pencil. Remove the covers of the accessories and loosen the screws of terminals. Make a powder of chalk and pour it in the holes of the terminal. Mark the point on them by the poker.

Now make the holes on the round block or board by the drilling machine where the points have been marked. 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 by the poker. Then fix all covers on the accessories.

Tools and materials required

Tools

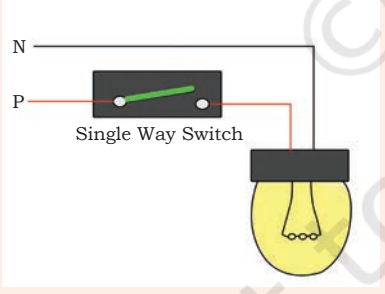
1. Hand drilling machine with a drift bit of 5 centimeter
2. Poker
3. Screwdriver
4. Connector screwdriver 8 cms
5. Combination plier 15 cm
6. Try square
7. Firmer chisel 20 mm
8. Electrician knife 10 cm

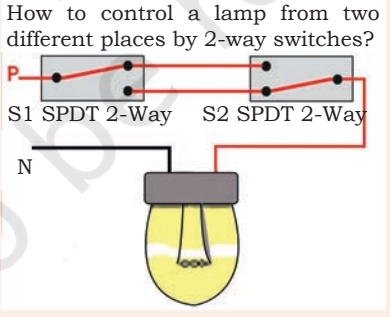
Material

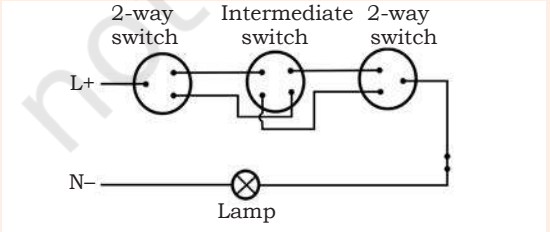
1. Wooden round block/ PVC Round Block
2. Wooden board/ Sun mica Board
3. Single pole one-way switch 5 A, 250V
4. PVC wire
5. Pencil
6. Chalk

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.







A lamp is switched ON and switched OFF from three different places.

Practical Exercise

Activity 1

Aim: Identify and draw the figure of various wiring materials

Procedure

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

Activity 2

Aim: Identify and connect the accessories with the wires

Tools and equipment required

1. Multimeter for measuring the current and voltage.
2. Tools like plier, screw driver will be required.

Procedure

Accessories will be connected with the help of wires.

Precautions

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

Activity 3

Aim : To connect different types of components with wires in a junction box.

Tools and equipment required

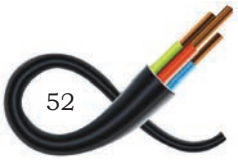
1. Multimeter
2. Tools like screw driver, plier.

Procedure

1. Different types of components will be connected 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.



Questions and Answers

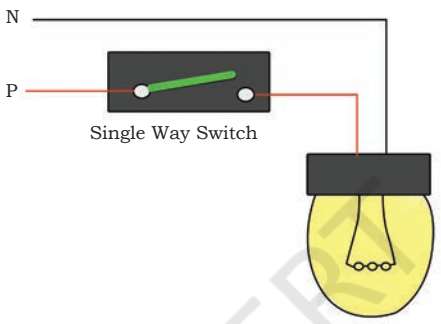
State whether the following are True or False

1. Conduit wiring is used in damp situations.
2. In wiring light point neutral is controlled by switch.
3. In three-pin plug maximum radius pin is used for phase.
4. In conduit wiring CTS wire is used.
5. Lead sheathed wiring age is more than conduit wiring.

Activity 4

Aim

- To familiarise the student with the electrical connection of a lamp to the supply mains.
- To 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 over current which may be caused by a fault or overloading.

Apparatus and material

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

Precautions

1. Make all the connections tight.
2. Check the rating of the fuse.

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.

Activity 5

Aim: To check the connection of the lamp by one switch (series)

Apparatus

Lamp 100W/220V, holder, one-way switch, PVC wire 1/18 SWG etc.

Tools and equipment

S. no.	Particular	Specification	Quantity
1.	Plier	Slide cutting plier Combination plier	1 1
2.	Screwdriver		1
3.	Phase tester	6"	1

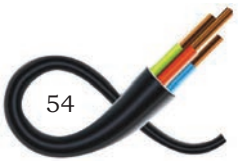
Procedure

Take a PVC 1/18 SWG wire about 1 meter in length and cut it in two pieces of equal length with side cutting plier. Remove the insulation of nearly 1 cm of both ends of each wire with the help of combination plier. Now take the holder and screw the nut with the help of screw driver. Fit each end of both the wire in the bolt and screw the nuts. Now cover the holder, connect one end of the wire to the top point of the switch. Take 1 foot of another wire and connect it to the bottom of the switch.

Connect the switch wire to phase and another wire to neutral. Switch it on. If the bulb glows then our connection is right.

Precautions

1. Phase is always controlled by the switch.
2. Part of the wire with removed insulation should not be open.



3. Twisted wire fitted in the holder should be put in such a way that the two wires should not touch each other.
4. Carefully remove the insulation part so that the wire should not cut.
5. Do not touch any naked electrical wire unless you are sure that there is no current in the wire

Activity 6

Aim: Check the connection of lamp by two switches (parallel)

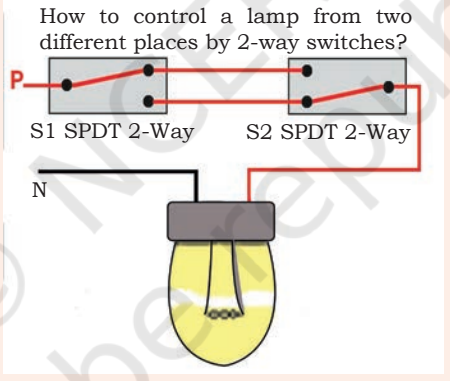
Related information

The circuit consists of one lamp and one pair of two way switches are connected.

The common points in switches S1 and S2 are C1 and C2 respectively. The common point C2 is connected to position 2 of the switch S2. Now if the common C1 is connected to 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. The lamp will glow.

Apparatus

1. One lamp holder, (pendent) 5 A, 250V.
2. One lamp 40 Watts, 250V.
3. Two two-way switch, 5A, 250V.
4. Connecting wires
5. Insulated plier
6. Electricians knife
7. Screw driver



Procedure

1. Connect the lamp with the two switches S1and 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 1and 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. Fill in the blanks

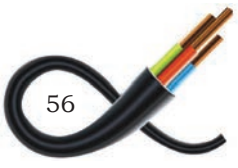
1. Distribution board is used for dividing an electrical power feed into _____.
2. In an electric circuit, the positive side is connected to the _____, and the switch is used to start the power supply.
3. Switches should be connected to the _____wire of supply.
4. The _____ protects an electric circuit.

B. Multiple choice questions

1. Switches, holder and socket are fixed on _____ boards.
   (a) sunmica (b) iron
   (c) steel (d) copper
2. In a lamp, electrical energy is converted into_____
   (a) electric (b) resistance
   (c) light (d) current
3. 3. All branch voltages are same in _____ circuit.
   (a) series (b) shunt
   (c) parallel (d) electrical
4. Distribution board is also known as a _____.
   (a) breaker panel (b) panel board
   (c) electrical panel (d) All of these

C. Short answer questions

1. Silver is a good conductor of electricity, but it is rarely used as a wiring material. Why?
2. Write down the properties of copper and aluminium and about their applications in electrical wiring.
3. Aluminium is the most commonly used metal for electrical wiring. Why?
4. List the different types of holders.
5. List the disadvantages of casing capping wiring.
6. Which material is used in conduit wiring?
7. List the advantages of conduit wiring.
8. Write the colour codes of AC power circuit for single phase circuit.



Session 3: Workplace Health and Safety Measures

Workplace hazardous systems are designed to protect the health and safety of workers. Information must be provided about the safe handling, usage, storage and disposal of hazardous systems. Workplace hazard is something that can have potential to harm the technician. There are hazards in every type of job and every type of workplace. Everyone at the workplace shares the responsibility to identify and control the hazards. The technician must first recognise the hazards at the workplace. When the technician installs or assembles the components, she/he may have to face hazards which are related to the workplace. For instance, these hazards can be associated with the installation and assembly process of a water purifier. The technician should be aware of the hazards associated with the installation of a water purifier. Majority of the hazards can be avoided by being aware and taking appropriate precautions.

Electrical Hazard

An electrical hazard defines a dangerous condition. This dangerous condition is related to energised equipment or a conductor at workplace. If a technician comes in contact with the energised equipment, then the equipment may cause injury to the technician. There is a possibility of being electrocuted or getting an arc flash burn, thermal burn or blast injury while assembling the components in a unit. Many of the hazards can be avoided by being aware and taking appropriate precautions. This will ensure safety at workplace (Fig. 3.22).

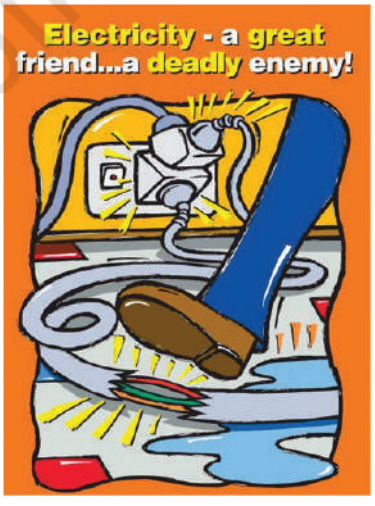


Fig. 3.22 Safe work in an electrical system

Points that need to be remembered for working safely around electrical panel and cabinet are as follows.

1. Watch out for loose cords and wires. Loose cords and wires can cause physical hazards and even electrical hazards. Hazard Tape should be placed if a cord or wire is placed on a pathway.

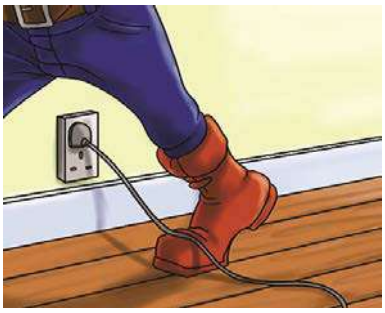


Fig. 3.23 Loose cord which can be hazardous

Fig. 3.24 Hazard tape

2. Wear proper personal protective equipment. The kind of personal protective equipment (PPE) required around a machine will depend upon the type of machine and task the employee is performing. Nevertheless gloves, hardhats, safety glasses, earplugs and other gears are important to use where necessary. For safety, signs can be posted near panels reminding employees to wear PPE (Figs. 3.23 and 3.24).
3. Use caution around heat sources. Some panel and equipment get hot while operating. Everyone should be aware of these areas and use caution when nearby. PPE like gloves or flame-resistant clothing may be required in these areas.
4. Be careful when cleaning: When cleaning around a panel or equipment, one should note other possible hazards too (Fig. 3.24):
   - Fire and explosion hazards
   - Need for PPE during cleaning
   - Risk of electric shock

Follow visual and written instructions panel, equipment has signs and labels on them alerting employees to hazards (Fig. 3.25).

Fig. 3.25 Personal protection equipment

5. Be cautious while testing, replacing the components in the panel. All levels of voltage should be considered equally dangerous. Even the voltage levels which cannot produce electrical shock should also not be ignored. We should check and confirm that the circuit is dead before touching it for repairing maintenance or any other work.
6. Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of electric current (Fig. 3.26).
7. Never use equipment with damaged insulation or broken plugs.
8. If you are repairing an electrical device always turn off the mains supply.

9. Always use insulated tools while working.
10. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.
11. Never try repairing energised equipment. Always check that is de-energised first by using a tester.

Fig.3.26 Avoid water while working with electricity

Chemical hazards are caused due to

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

Fire Extinguisher

A fire extinguisher (Fig. 3.27) is a protection device used to cease fire. It is the basic first aid equipment which can be effectively used for controlling fire. A fire extinguisher is a cylindrical pressure vessel containing an agent which can be discharged to cease a fire. A fire extinguisher should always be available in areas where persons work with electrical equipment.
Different parts of a fire extinguisher are shown in Fig. 3.27.

The following steps demonstrate the operation of a fire extinguisher in case of a fire emergency.

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

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

Step 3: Use the fire extinguisher by squeezing the lever

Step 4: Sweep it from side to side

Fig. 3.27 Parts of fire extinguisher

First Aid for Electrical Emergencies

Electrical accidents cause countless injuries. Injury could be minimised and many lives saved if proper rescue techniques and treatments are used. Electrical accidents may occur at any time or place. Timely response and treatment of victims is a major concern. When an electrical accident occurs, due to the effect of

muscle clamping, a victim is often incapable of moving or releasing the electrical conductor. Caution should be a primary consideration during any electrical accident or emergency. There should always be an emergency response plan for scheduled electrical maintenance or work.

Electrical Rescue Techniques

(a) Approaching the accident

- Never rush into an accident situation
- Call 108 as soon as possible
- Approach the accident place cautiously

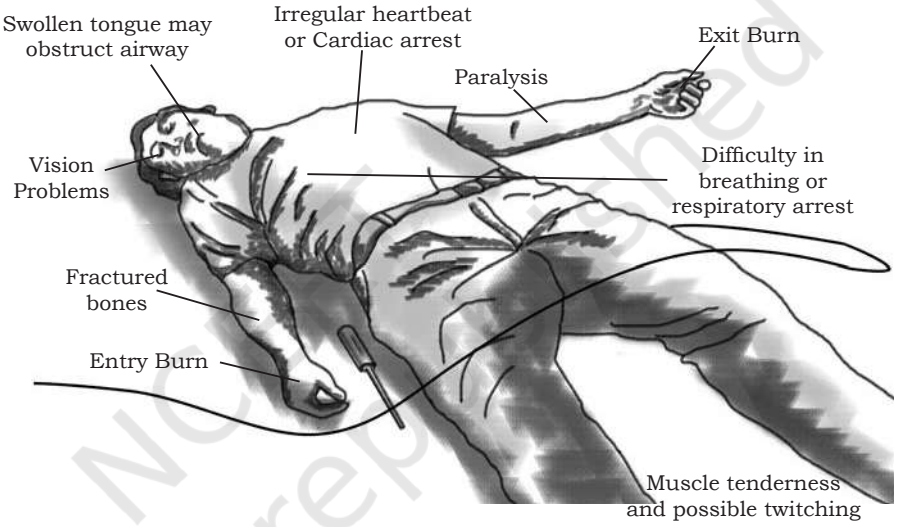


Fig. 3.28 Wireman in an unconscious state because of an electrical shock

(b) Examining the scene

- Visually examine victims to determine if they are in contact with energised conductors (Fig. 3.28).
- Metal surfaces, objects near the victim may also be energised (Figs. 3.29 and 3.30).

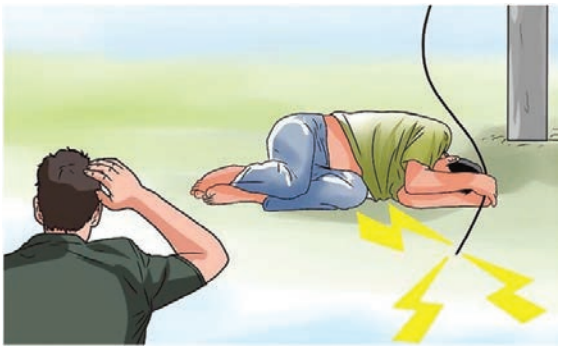


Fig. 3.29 Victim in contact with energised conductor

- You may become a victim if you touch an energised victim or conductive surface. Do not touch the victim or conductive surfaces while they are energised.
- Switch off the electrical circuits if possible.

(c) Hazards and solutions

- Be alert for hazards, such as heated surfaces and fire etc.
- In case you cannot switch off the power source, take extreme care
- Ensure that your hands and feet are dry
- Wear protective equipment, such as gloves and shoes. Stand on a clean dry surface
- Use non-conductive material to remove a victim from the conductor (Fig. 3.30)

Fig. 3.30 Use of non-conductive material to rescue the victim

(d) High voltage rescue

- Special training is required for rescues if high voltage is present
- Protective equipment, such as gloves and shoes must be worn

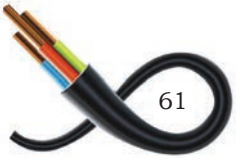
(e) First aid

- A victim may require Cardio-Pulmonary Resuscitation (CPR). Steps to perform in CPR are shown in the Figs. 3.31, 3.32 and 3.33.
- If the victim is breathing and has a heartbeat, give first aid for injuries and treat for shock.
- Ensure the victim gets medical care as soon as possible.
- Physician attending the victim must have detailed information to properly diagnose and care for the victim. The physician must determine whether the victim should be sent to a Trauma or Burn Centre.

Fig. 3.31 Chest compression

Fig. 3.32 Open the mouth for airway

Fig. 3.33 Rescue breathing



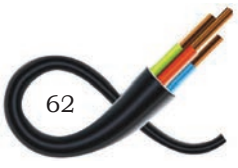
Check Your Progress

A. Fill in the blanks

1. While working with electricity, the technician must wear _____ gloves and shoes.
2. Defective or inadequate insulation may result in _____.
3. CPR stands for _____.

B. Multiple choice questions

1. What are the steps to operate fire extinguisher?
   (a) Identify the safety pin of the fire extinguisher which is generally present in its handle
   (b) Break the seal and pull the safety pin from the handle
   (c) Use the fire extinguisher by squeezing the lever
   (d) All of the above
2. When do we use a fire extinguisher?
   (a) In case of flood
   (b) In case of electric shock
   (c) In case of fire
   (d) In case of burn injury
3. Which of the following is a safety item that a wireman must not have while working?
   (a) Safety boots
   (b) Gloves
   (c) Helmet
   (d) Belt
4. Which of the following steps are required to perform CPR?
   (a) Chest compression
   (b) Open airway
   (c) Rescue breathing
   (d) All of the above



Cable Jointer Electrical Power System-Class 11 Unit 3 Session 1

A. Fill in the blanks

1. Wiring material is of three types _____, _____ and _____.
2. A switch is used to make or break _____.
3. Open wiring is also known as _____ wiring.
4. _____ are devices used to control and protect the electrical panel from overflowing electrical power.

B. 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. PVC casing and capping are used for covering the wires.

C. Multiple choice questions

1. Concealed wiring is immune to_____
   (a) humidity
   (b) heat
   (c) light
   (d) dust

2. Pendant holder is used for_____
   (a) fixing the bulb
   (b) fixing the fan
   (c) for hanging the bulb
   (d) to hang the fan
3. A two-way switch is used for _____
   (a) control one bulb from 2 points
   (b) control two bulbs from 2 points
   (c) control multiple bulbs from 2 points
   (d) control one bulb from one point

D. Short answer questions

1. Why is PVC casing-capping preferred over wooden casing-capping wiring?
2. How does an MCB help in managing electrical power?
3. Why is conduit wiring used in homes?
4. Discuss the importance of colour codes in electrical wiring.

Cable Jointer Electrical Power System-Class 11 Unit 3 Session 2

A. Fill in the blanks

1. Distribution board is used for dividing an electrical power feed into _____.
2. In an electric circuit, the positive side is connected to the _____, and the switch is used to start the power supply.
3. Switches should be connected to the _____wire of supply.
4. The _____ protects an electric circuit.

B. Multiple choice questions

1. Switches, holder and socket are fixed on _____ boards.
   (a) sunmica (b) iron
   (c) steel (d) copper
2. In a lamp, electrical energy is converted into_____
   (a) electric (b) resistance
   (c) light (d) current
3. 3. All branch voltages are same in _____ circuit.
   (a) series (b) shunt
   (c) parallel (d) electrical
4. Distribution board is also known as a _____.
   (a) breaker panel (b) panel board
   (c) electrical panel (d) All of these

C. Short answer questions

1. Silver is a good conductor of electricity, but it is rarely used as a wiring material. Why?
2. Write down the properties of copper and aluminium and about their applications in electrical wiring.
3. Aluminium is the most commonly used metal for electrical wiring. Why?
4. List the different types of holders.
5. List the disadvantages of casing capping wiring.
6. Which material is used in conduit wiring?
7. List the advantages of conduit wiring.
8. Write the colour codes of AC power circuit for single phase circuit.

Cable Jointer Electrical Power System-Class 11 Unit 3 Session 3

A. Fill in the blanks

1. While working with electricity, the technician must wear _____ gloves and shoes.
2. Defective or inadequate insulation may result in _____.
3. CPR stands for _____.

B. Multiple choice questions

1. What are the steps to operate fire extinguisher?
   (a) Identify the safety pin of the fire extinguisher which is generally present in its handle
   (b) Break the seal and pull the safety pin from the handle
   (c) Use the fire extinguisher by squeezing the lever
   (d) All of the above
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   (b) Gloves
   (c) Helmet
   (d) Belt
4. Which of the following steps are required to perform CPR?
   (a) Chest compression
   (b) Open airway
   (c) Rescue breathing
   (d) All of the above

Unit 4

Installation of Cables

Introduction

Electric power can be transmitted or distributed by two systems — overhead power line or underground cable system.

Power cables are used for power transmission and distribution purpose. It is an assembly of one or more individually insulated electrical conductors, usually held together with an overall sheath. It is used for transmission and distribution of electrical power. Electrical power cables may be installed as permanent wiring within buildings, buried in the ground and run overhead or exposed. Flexible power cables are used for portable devices, mobile tools and machinery. Power cables are defined by voltage grade and nominal cross sectional area.

Cables play a very important role in the distribution system. There are many types of cables like Low Tension (LT) cable, 11 kV cable and 33 kV cable. They are designed and manufactured as per voltage, current to be carried, maximum operating temperature and purpose of applications. For mining, extra mechanical strength is given to the cable with double armouring. For wind power plants, flexible and UV protected cables are required. The underground cables have several advantages, such as less liable to damage due to storms.

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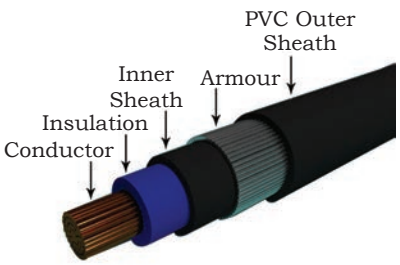


Fig.4.1 Parts of a cable

Cables are used in the places where bare conductor cannot be used due to narrow roads and are used in distribution transformer. LT cables are used for service line also.

Session 1: Laying of Underground Cables

An electrical cable (Figs. 4.1 and 4.2) is an assembly consisting of one or more conductors with their own insulations and screens, individual covering(s), assembly protection and protective covering.

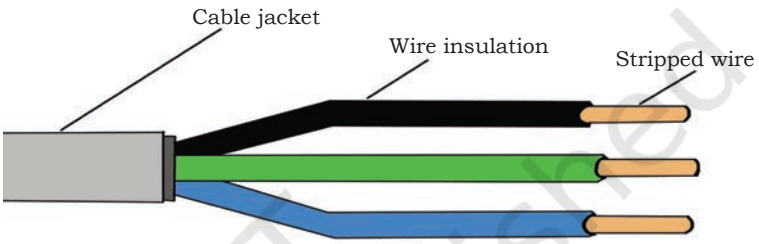


Fig. 4.2 Simple electric cable

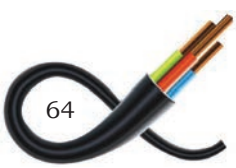
Types of Cables

Cables are named according to the formation, voltage and material used. They are also named according to their use, that is, low tension or high tension cables, etc., as per voltage and single core, two cores, three cores, 3 1/2 core, etc.

Types of cables are classified in different ways on the basis of their uses, voltage and type of insulation used for their construction.

1. PVC (Polyvinyl Carbide Cable)
2. PILCA (Paper Insulated Lead Covered Armoured Cable)
3. XLPE (Cross-linked Poly Ethylene Cable)

Generally, PILC and XLPE cables are used in HT (High Tension) network, and oil or gas filled cables are used for EHV (Extra High Voltage) network. Proper cable end boxes shall be used for these cables. When the cable is not in use, both its ends should be properly sealed. PVC armoured cables are used for LT distribution (Figs. 4.3 and 4.4). A gland should be used at the cable end



to have earth continuity with armouring. It provides rigidity so that the cable does not swing and damage the insulation, and loose connection can be avoided. Apply M-seal to avoid water entry in the cable. While selecting the cable capacity, the safety factor must be taken into consideration. Conductors used in underground cables are made of aluminium and copper.

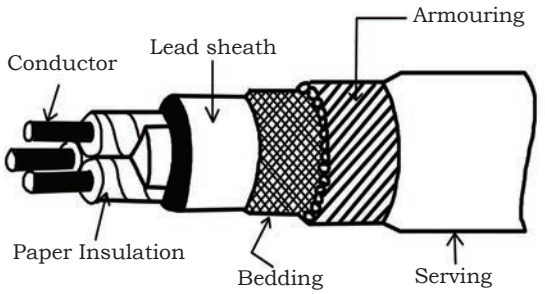


Fig. 4.3 Construction of cables

Generally XLPE (Cross-linked polyethylene) are used. The insulation of the cable must not deteriorate due to the high-voltage stress, ozone produced by electric discharges in air, or tracking. The cable system must prevent contact of the high-voltage conductor with other objects or persons, and must contain and control leakage current.


Fig. 4.4 Cross section of an HT cable

Cross-linked Polyethylene (XLPE insulation)

It is a form of polyethylene with cross-links. It is used predominantly in building services pipework systems, hydronic radiant heating and cooling systems, domestic water piping, and insulation for high tension (high voltage) electrical cables. Cross-linked Polyethylene, commonly abbreviated PEX, XPE or XLPE, is also used for natural gas and offshore oil applications, chemical transportation, and transportation of sewage and slurries (Fig. 4.5).

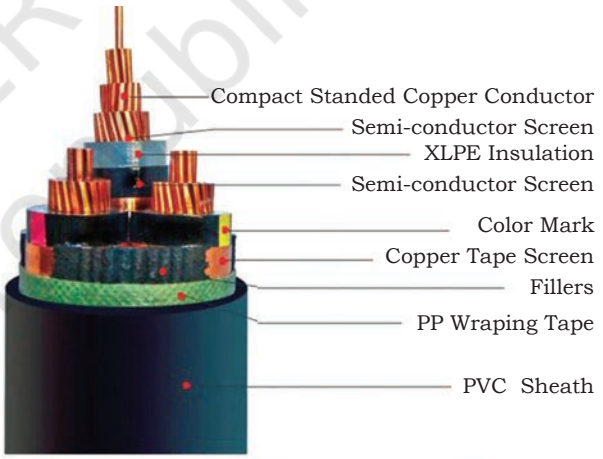


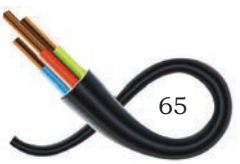
Fig. 4.5 XLPE cable

Paper Insulated Cable

These cables can be classified into two categories based on their construction.

- **Belted:** In a belted cable, the three cores are grouped together and then belted with the paper belt (Fig. 4.6). The gaps between the conductors and the paper insulation are filled with fibrous material, such as jute. This makes the cable to


Fig. 4.6 Belted cable



have a circular cross-sectional shape. The cores are not circular in shape. The cores are insulated from each other with impregnated paper.

Fig. 4.7 Screened cable

- **Screened:** It is an electrical cable of one or more insulated conductors enclosed by a common conductive layer. The shield may be composed of braided strands of copper (or other metal, such as aluminium), a non-braided spiral winding of copper tape, or a layer of conducting polymer (Fig. 4.7).

(a) Construction of belted/PILCA cables

- **Conductor:** copper or aluminium, stranded, sector shaped
- **Insulation over core:** impregnated paper insulation wrapped over each conductor
- **Fillers**: placed in between the cores, made up of jute
- **Insulation over all cores:** belted paper insulation wrapped over all the cores
- **Lead sheath:** to protect the paper insulation from foreign elements and mechanical shock
- **Bedding:** to protect the lead sheath against corrosion. Consists of bitumen compound and impregnated cotton tapes
- **Armour:** provide mechanical strength to the cable, made of steel tape or round galvanised wire
- **Serving:** to protect the armour from corrosion, made of jute yarns coated with bitumen compound (Fig. 4.8).

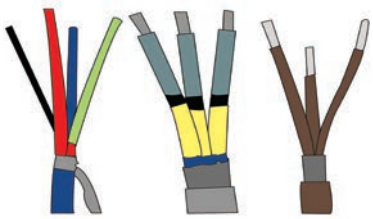


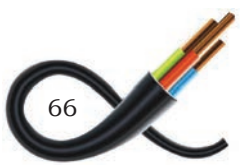
Fig. 4.8 PILCA cable

(b) Disadvantages of PILCA

- Heavy due to lead sheathing
- Less flexible
- Poor resistance to vibration
- Difficulty in sealing and joining

High Tension Cables

A high-voltage cable (HV cable) is a cable used for electric power transmission at high voltage like 11kV, etc. This cable includes a conductor and insulation, and is suitable for being run underground or underwater.



XLPE Cable

XLPE cable means cross-linked polyethylene insulated aluminium conductor armoured cable (Fig. 4.9). In XLPE cable, stranded aluminium conductor is first screened in the form of a semi-conducting extrusion which provides a smooth conductor surface and prevents formation of cavities at the surface of the conductor when the cable is subjected to bending. The screened conductor is insulated with extruded XLPE compound. The insulation is further screened with layer of nonmetallic semiconducting material and over that a non-magnetic metallic screen in the form of copper or aluminium tape is applied. An important advantage of XLPE as insulation for medium and high voltage cables is their low dielectric loss. The dielectric loss factor is about one decimal power lower than that of paper insulated cables and about two decimal powers lower than that of PVC insulated cables. Since the dielectric constant is also more favourable, the mutual capacitance of XLPE cables is also lower, thus reducing the charging currents and earth-leakage currents in networks without the rigid star point earthing.

Fig. 4.9 XLPE cable

PVC Power Cable

Polyvinyl Chloride (PVC) insulated and sheathed cables are used in a wide variety of applications from fixed wiring to flexible installations, and are available in a number of sizes, colours and conductor materials (Fig. 4.10). As PVC is a thermoplastic polymer, PVC properties make it suitable for applications where the cables may be exposed to high or low temperatures (including use of arctic-grade PVC for extreme low conditions), or where protection against UV light is required to avoid degradation. PVC insulation is frequently used owing to its good insulating properties but low corona resistance, and is best suited for low and medium voltage cables and low frequency insulation requirements.

Fig. 4.10 LT PVC power cable

Junction Box

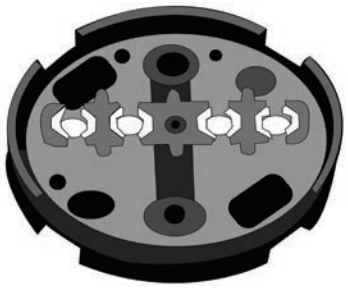


Fig. 4.11 Junction box

An electrical junction box is a container for electrical connections, usually intended to conceal them from sight and deter tampering (Fig. 4.11). A small metal or plastic junction box may form part of an electrical conduit or thermoplastic-sheathed cable (TPS) wiring system. During the laying of underground cables, junction box is used at the point where there is change in direction or another cable has to be laid in different direction.

Advantages of Underground Power Cable System

- Selection of route length is easy and simple
- Safety factor is very high
- Maintenance cost is almost negligible
- It has a good power factor
- It can be laid across zigzag and sharp bend routes with care

Disadvantages of Underground Power Cable System

- In case of any fault, it takes a lot of time to repair.
- Costly in comparison to overhead transmission system because of its initial cost and laying methods.
- Additional load cannot be taken up by the existing cables, hence necessitates the laying of new cables in case of load expansion.

Co-existing Underground Utilities

If the cable route comes across or is between co-existing underground utilities like sewer line, open drain, canal, bridge and other utility cable trench, the cable is protected by inserting it through a 6" GI pipe or as per the diameter of the cable throughout with mortar sealing at both side wall ends to give extra mechanical strength from damage due to exposure. If the cable route is along a bridge and we are unable to maintain the depth on foot path of bridge, then the cable is kept

covered with GI pipe duly clamped on side wall on footpath of the bridge.

In case canal or drain span is more than two metres, an additional MS channel rail is fabricated to lay the GI pipe covered cable route (Fig. 4.12). With rapid development of urban power networks, overhead line system face serious challenges in ensuring reliability of power supply, safety considerations, aesthetic appeal of the cities, for averting road and space congestion, etc. This places a special demand on underground cable network.

Fig. 4.12 Exposed underground sewer pipe

Cable Laying and Installation

Underground cables are, of course, meant to be installed or laid under the ground. The reliability of underground cable network highly depends upon proper laying of cables, quality of cable joints, branch connections, etc. There are a few points that need to be considered while laying and installing underground cables, which are

- selection of the route
- side of the street
- route with least obstacle should be preferred
- future load growth should be kept in mind

Methods of Cable Laying

There are various methods of cable lying, such as

- laying directly into the ground
- drawing in ducts
- laying on racks in air
- laying on rack inside a cable tunnel
- laying along building and structure

Underground Cables

HT cables can also be installed in the buried trenches. For this the cables are directly buried inside the ground (Fig. 4.13).

Fig. 4.13 Underground cables

Cable Trenches

Ladder type cable trays are erected inside the cable trenches and then the High Tension (HT) cables are laid on these cable trays (see Tables 4.1, 4.2 and 4.3). This is depicted in Fig. 4.14.

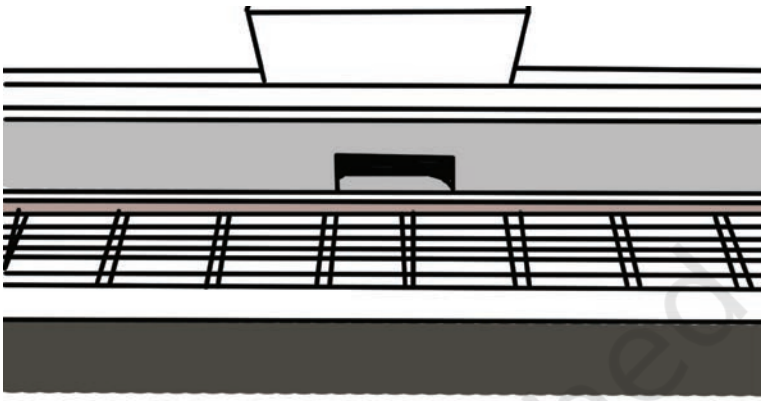


Fig. 4.14 Cable trenches

Cable Trench on the Open Pavement

A sand bed is prepared before the cable is laid over it (Fig. 4.15). Then the cable is covered with cement concrete duct or bricks to protect it from physical damage by pickaxe or hoe (Fig. 4.16). Afterwards, dressing is made with soil. MS route markers are placed at fixed points along the cable route.

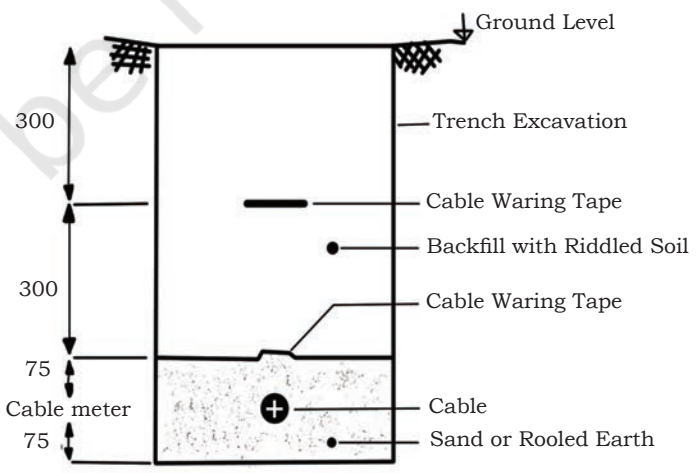


Fig. 4.15 Direct buried cables

Table 4.1 Minimum permissible Bending Radius

Voltage	PILCA	PILCA	PVC and XLPE	PVC and XLPE
	1 Core	3 Core	1 Core	3 Core
Up to 1.1 kV	20D	15D	15D	12D
1.1 to 11 kV	20D	15D	15D	15D
Above 11 kV	25D	20D	20D	15D

***D is diameter of cable**

Bending radius is necessary to take care during fault repairs as maximum number of faults occurr close to joints.

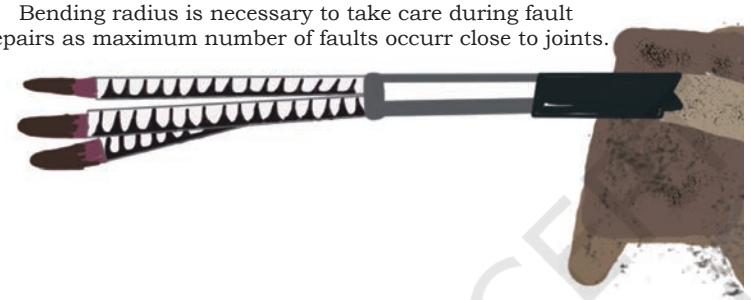


Fig. 4.16 Faults near joints

Table 4.2 Current Rating for HV cables

Cable Type	PILCA		XLPE	
Size of Cable in sq. mm	Rated Current in Amp	Derated Current in Amp	Rated Current in Amp	Derated Current in Amp
3 × 150	190	143	240	182
3 × 240	250	188	315	240
3 × 300	280	211	360	274
3 × 1000	585	445	685	550
3 × 300	290	215	352	264
3 × 400	332	249	402	301

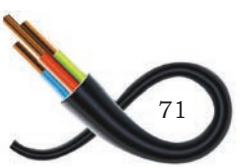


Table 4.3 Current Rating for LT Cables

No. of Cores	Size in sq. mm	Rated Current	Derated Current
4	25	195	85
4	50	133	120
4	150	249	185
4	300	365	275

Fig 4.17 Cable drum with cable

Fig 4.18 Cable drum without cable

Derating Factors

- Cable depth
- Variation in ground and ambient temperature
- Thermal soil resistivity
- Spacing between cables
- Installation condition

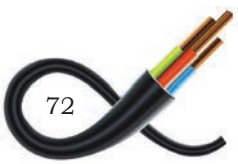
While laying the cables necessary precautions and health and safety practices must be observed. 11 kV cable is laid from cable drums (Figs. 4.17 and 4.18) using erection tools and pulleys.

Other tools for cable laying are: Cable pulling winch, Cable guiding device, cable pulling grip, etc. While laying the cable, statutory clearances from the following authorities (managing co-existing underground utilities) may be obtained.

- Telephones
- Water Supply
- Drainage and Sewerage
- Railways
- Municipal Corporation
- National Highway
- Traffic (Police Department)
- Defence Authorities

Pulling Methods

The cable drum must be mounted on jacks and the cable 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 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 cable for installation in a duct is shown in Fig. 4.19.

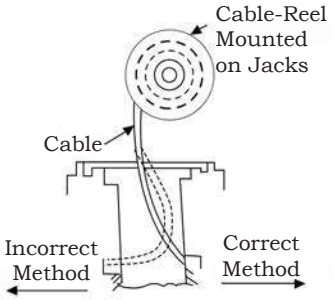


Fig. 4.19 Pulling methods

Underground Cable Testing

The cables are tested for the following faults:

1. Short Circuiting
2. Discontinuity
3. Earth fault

Murray Loop Test

For finding out the exact position of fault, cables are to be repaired without digging the whole cable route trench. For this purpose, the Murray loop test which is based upon the principle of wheat-stone bridge, and bridge megger is used. The Murray loop test is used for the location of faults on lines of low resistance, such as power cables and telephone cables. The circuit for Murray loop test is shown in Fig. 4.20 to locate the fault in a cable.

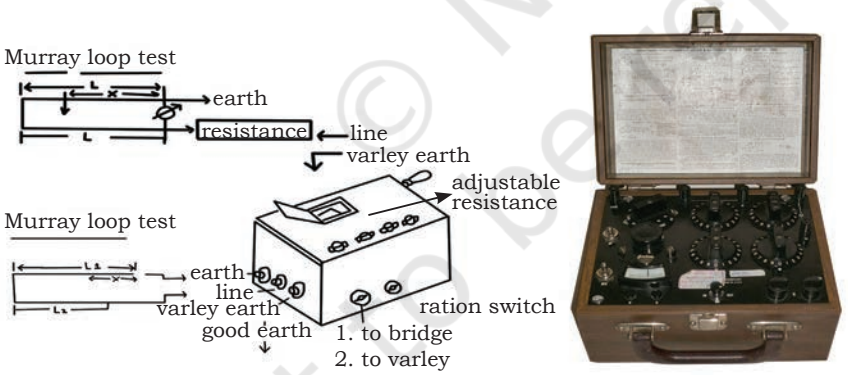


Fig. 4.20 Murray and Varley loop tests

The value of the resistance box (RB) and resistance dial of the instrument is changed till the galvanometer shows null point, that is, zero defection (handle of the meter is rotated at a speed of 160 r.p.m.). With this method we will be able to locate the distance of faulty section of the cable 'X' (as shown in Fig. 4.20).

Connections

The conductors are shorted at its far end by a thick wire.

Precautions

1. For carrying out Murray loop test the only requirement is that all the core conductors should be of same cross-section.
2. If the sound and faulty conductors are of different sizes, it should be taken into account.

In high voltage cables, a high voltage DC is applied to the bridge network.

Varley Loop Test

This test is used to locate the fault of the long length cables; the connections are shown in Fig. 4.20 with the bridge mugger.

- The faulty line is joined at the far end to a good line by any link of negligible resistance.
- The faulty line is then joined to 'earth' terminal and the good line to the 'line' terminal. The 'Varley earth' terminal is connected to good earth.

The comparatively high resistance of the loop under these conditions allows a similar high resistance of R to be used. This means that the value of 'X' will not be greatly affected by small measuring inaccuracies.

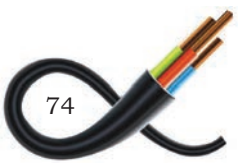
Instructions

It will be seen that the only difference between the circuits is that the variable resistance R is used to obtain balance in the Varley Test, but it is omitted from the Murray Test (or say reduced to zero to be exact).

Check Your Progress

A. Fill in the blanks

1. _____ test is used for the location of faults on lines of low resistance.
2. The current carrying capacity of 150 mm XLPE cable is _____.
3. XLPE cables are used for _____lines.
4. _____are used to lay down the HV cables.



B. Write short notes on

1. Pulling method of cables
2. XLPE cable
3. Disadvantages of PILCA cable
4. Advantages and disadvantages of underground cable

C. Short answer questions

1. Classify various types of cables.
2. List the steps of cable laying.
3. List tools and equipment required for cable laying activities.

Session 2: Laying of AB cables

Aerial Bundled Cables

Aerial Bundled Cables (ABC) should not be confused with the bundle conductors used in high-voltage power transmission (Figs. 4.21 and 4.22). Aerial bundled cables are overhead power lines that use several insulated phase conductors bundled tightly together, usually with a bare neutral conductor. This contrasts with the traditional practice of using non-insulated conductors separated by air gaps.

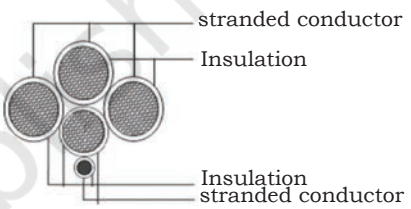


Fig. 4.21 Aerial bundled cable

The main objections to the traditional design are that the multiple conductors are considered external forces which can cause them to touch each other and cause a short circuit. The resultant sparks have been a cause of bushfires in drier climates. This is a potentially dangerous condition. With aerial bundled conductors (ABC), a simultaneous disconnection of all conductors is more likely to occur. In moister climates, tree growth is a significant problem for overhead power lines. Aerial bundled cables would not arc over, if touched by the tree branches. Although persistent rubbing is still a problem, tree trimming costs can be reduced. Areas with large trees and branches falling on lines are a problem for aerial bundled cables as the line degrades over time. Due to the very large strain forces, cracking and breaking insulation can lead to short circuit failures which can then lead to ground fires due to dripping of molten insulation.

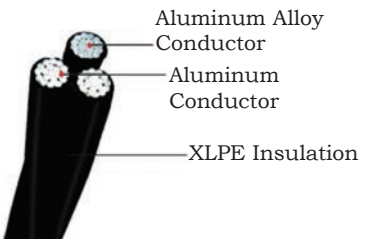


Fig. 4.22 AL/XLPE insulated aerial bundled cables

Construction of insulated overhead power networks with ABC in developed industrialised countries today has almost completely superseded the traditional low-voltage network with bare conductors. Due to its advantageous technical, economic and aesthetical aspects, the low-voltage network type with aerial bundle conductors has found wide application.

Particular designs present a segment of standard product designs for suspension sets, tension sets and jointing equipment most commonly used in construction of low voltage (0.4kV) and medium voltage (10kV and 20kV) power lines with ABC accessories (Fig. 4.23).

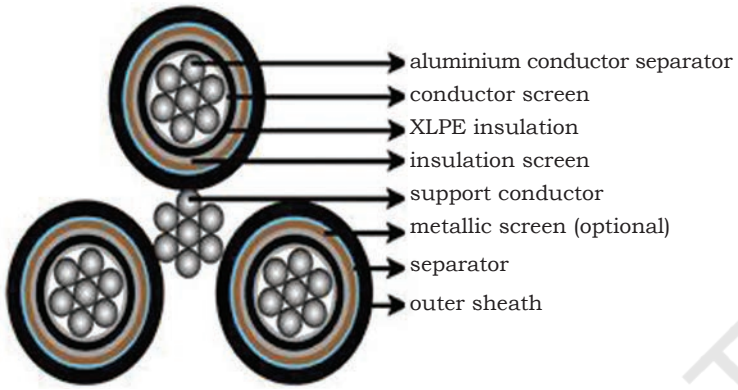


Fig. 4.23 MV aerial bundled conductor (ABC) cables

It is very difficult to tap the AB cables, thus reducing theft of electricity which leads to lower distribution losses.

Advantages of Aerial Bundled Cables

- Aerial bundled cables do not generate any spark when it touches the trees.
- Their appearance is good.
- They can be installed in narrow streets.
- Insulators and cross arms are not required.
- These cables are very safe as only neutral wire gets damaged in case of any accident.
- Electricity theft is merely possible.
- Short circuit is only possible when insulation of a cable is damaged.
- Insulating bridging wires are needed to connect non-insulated wires at either side at junction poles.

Disadvantages of Aerial Bundled Cables

- These cables are costly as compared to conductors.
- Insulation of cables get weaker due to heat of the sun.
- Due to the weight of the cables additional poles are required.

- It requires much longer time to repair the cable and also requires specialised equipment.
- Older installations can cause fires in areas where felling trees is common. Felling of trees may also cause breaks in lines and or insulation leading to short circuit.
- In areas with moderate climate, tree growth is signicant which causes a problem for overhead power lines.

Aerial bundled cables are suitable for these areas as they will not arc over if touched by tree branches. Although persistent rubbing can be a problem, however, tree-trimming costs can be reduced.

Types of AB Cables

AB Cables for LT Lines

AB cable consists of three phase wire, one neutral wire of lower size and a messenger wire. Configuration of AB cables varies from 95 mm^2 to 150 mm^2. These cables have current carrying capacity from 100 amp to 210 amp as per the load requirement. The messenger wire is used for earthing purpose. These heavy cables are used in LT line. Some time additional wire is also used for the purpose of lighting streetlight.

AB Cables for HT Lines (11kV)

In HT, 11 kV line AB cable consists of three phase wire, one messenger wire of lower size for earthing. AB cables do not have a neutral wire. Configuration of AB cable varies from 95 mm^2 to 150 mm^2.

Stringing and Jointing of Cables

(a) Stringing: The stringing of AB cable is easy through conventional methods but care shall be taken that cable insulation does not get damaged during installation. Dragging of cable on the ground can cause damage of insulation. Tension to be applied during stringing shall be 25% of the breaking load of the messenger wires. This will allow line to sag within the specified limit of 1.5% of the span at the lowest ambient temperature.

(b) Jointing: Mid-span jointing is permissible for LT ABC cable through conventional techniques. It is recommended to join the cable in such a way so as to bring the joints at the supports. Mid-span joining is not recommended in case of HT lines. Line tapping at the support may be allowed under unavoidable circumstances through suitably designed clamp connectors or parallel groove (PG) clamps. Tap off from power conductors in the area where catenaries are under tension is not recommended. The cable may be shorted and earthed through suitable non-liner surge arrestor (Figs. 4.24 and 4.25).

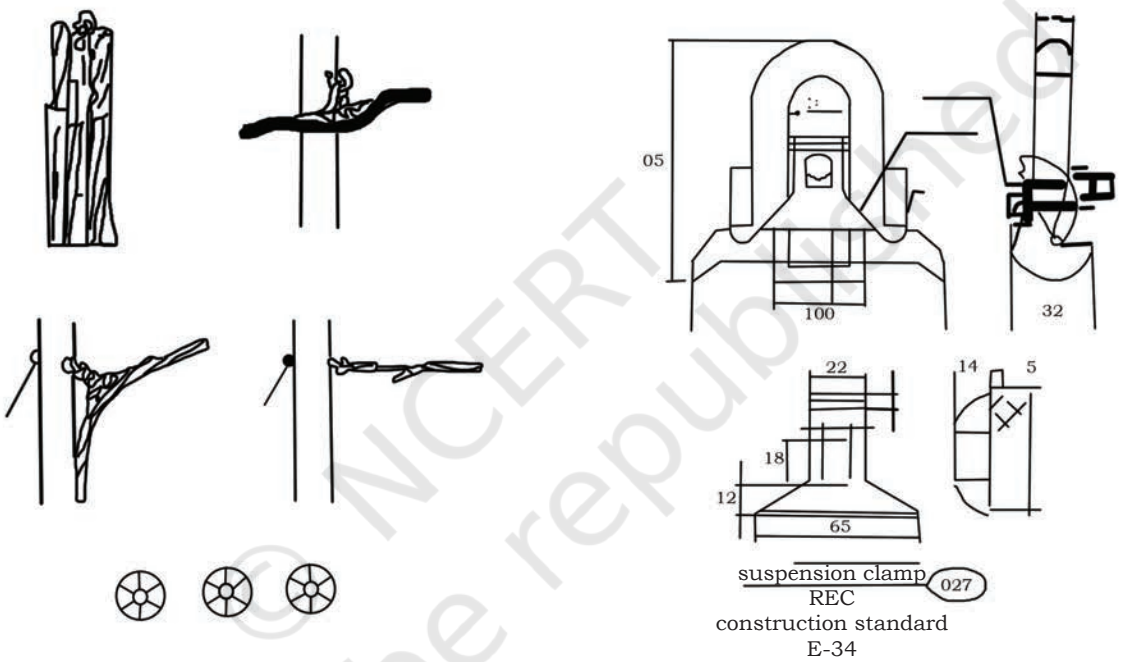


Fig. 4.24 ABC cable laying methods for different locations

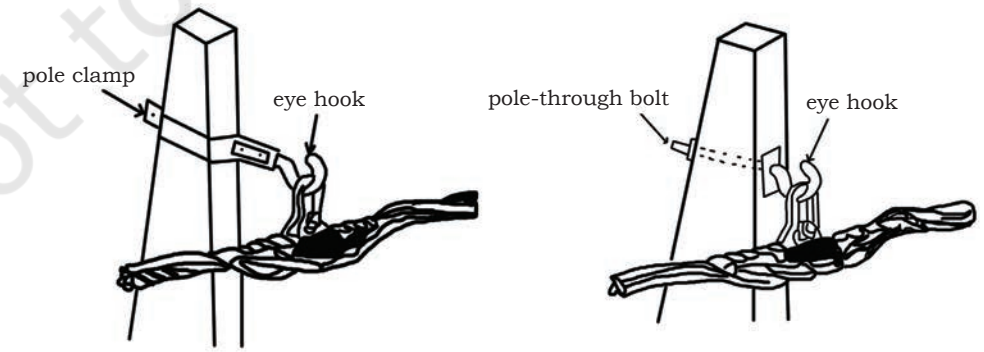


Fig. 4.25 Clamp for AB cable

Check Your Progress

A. Fill in the blanks

1. _____ is used for branching of a service cable from a main cable.
2. Three faults that cables are tested for are _____, discontinuity and earth fault.
3. _____ are overhead power lines using several insulated phase conductors, contrasting with the traditional practice of using non-insulated conductors separated by air gaps.

B. State whether the following statements are True or False

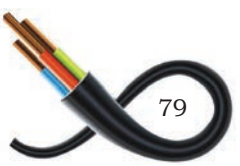
1. Aerial Bundled cables are the same as bundle conductors
2. Mid-span jointing should be avoided in the case of HT lines
3. Laying the cables is important for power distribution. So, no clearances are required

C. Match the columns

Group A	Group B
1. A cable test	(a) Varley Loop Test
2. This test is used to locate the fault of the long length cables	(b) AB cables
3. Short spans, more poles needed	(c) Murray Loop Test

D. Short answer questions

1. Explain the importance of various cable joints.
2. List the advantages of Aerial bundled cables.



Cable Jointer Electrical Power System-Class 11 - Unit 4 Session- 1

A. Fill in the blanks

1. _____ test is used for the location of faults on lines of low resistance.
2. The current carrying capacity of 150 mm XLPE cable is _____.
3. XLPE cables are used for _____lines.
4. _____are used to lay down the HV cables.

B. Write short notes on

1. Pulling method of cables
2. XLPE cable
3. Disadvantages of PILCA cable
4. Advantages and disadvantages of underground cable

C. Short answer questions

1. Classify various types of cables.
2. List the steps of cable laying.
3. List tools and equipment required for cable laying activities.

Cable Jointer Electrical Power System-Class 11 - Unit 4 Session- 2

A. Fill in the blanks

1. _____ is used for branching of a service cable from a main cable.
2. Three faults that cables are tested for are _____, discontinuity and earth fault.
3. _____ are overhead power lines using several insulated phase conductors, contrasting with the traditional practice of using non-insulated conductors separated by air gaps.

B. State whether the following statements are True or False

1. Aerial Bundled cables are the same as bundle conductors
2. Mid-span jointing should be avoided in the case of HT lines
3. Laying the cables is important for power distribution. So, no clearances are required

C. Match the columns

Group A	Group B
1. A cable test	(a) Varley Loop Test
2. This test is used to locate the fault of the long length cables	(b) AB cables
3. Short spans, more poles needed	(c) Murray Loop Test

D. Short answer questions

1. Explain the importance of various cable joints.
2. List the advantages of Aerial bundled cables.

Unit 5

Repairing of Cable Joints

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Introduction

Electrical joints and terminations provide the required electrical connection as well as the mechanical support and physical protection to the cable. It is important for the Cable jointing system to suit the service and operational requirements for all industrial cable jointing environments and applications. These devices are important for jointing the cables and wires. A good cable jointing and installation provides a better supply of power (Fig. 5.1). Cable jointing has become the preferred pick over conventional systems for cable termination, cable abandonment, low voltage cable jointing and cable repair. The cable termination and jointing kits are often specialised in wire installations worldwide.

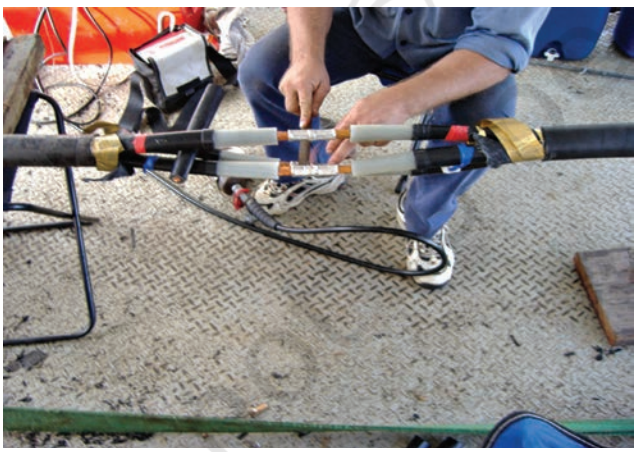


Fig. 5.1 Electrical joint and terminations

Cables play a very important role in the distribution system of power. There are different types of cables like LT cable, 11 KV cable and 33 KV cable. Cables are used in places where bare conductor cannot be used due to narrow roads. Cables are costlier than the conductor and the same cannot be replaced often.

Session 1: Electrical Cable Jointing Methods

Jointing of power cables should be as simple as twisting and taping the wire. For jointing of a cable variety of in-line adapters and connectors are used. The method used for a cable joint depends on the voltage, type of cable, type of joint, type of connector, application and other factors. Proper tools and equipment are to be used for jointing the cable.

Given below are some important factors to ensure reliable connections, such as

- proper size of connectors should be used for a particular cable,
- proper tools and equipment are to be used,
- cuts and stripping should be very clean,
- proper technique is to be used for cable jointing and
- restoring the insulation, outer-sheath and armour.

Western Union Splice Joint

The cables are manufactured for a particular length. To increase the length of a cable a straight joint is used for small solid cables (Figs. 5.2 and 5.3).

1. Remove the insulation of cable
2. Bring the two conductors to a crossed position and then make a long bend or twist in each wire.
3. Wrap the end of one of the wires around the straight portion of the other wire, and then do the same for the other wire. Repeat this for about four or five times.
4. Press ends of the wires down close to the straight portions of the wire to prevent the ends from piercing through the insulation tape.
5. Insulate the joint using the insulation tape

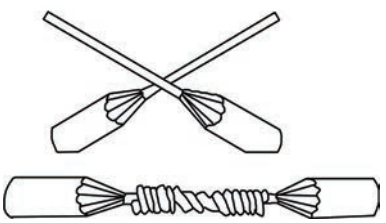


Fig 5.2 Western union splice and straight joints

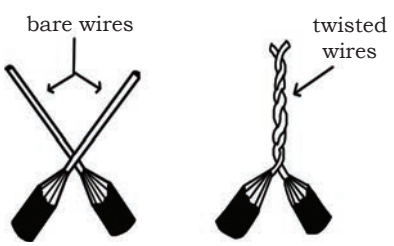
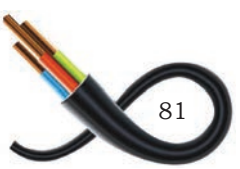


Fig. 5.3 Rattail joints

Fixture Joint

This is a type of branch joint connecting a thin wire (for branch line) to the thick wire (main line), such as those used in lighting fixtures.



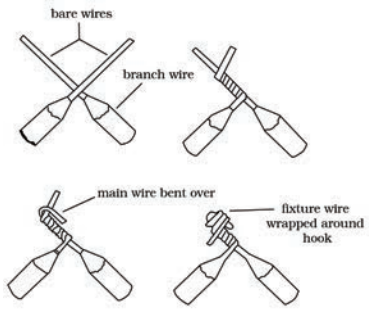


Fig. 5.4 Fixture joint

1. Remove the insulation of wire
2. Wrap the fixture wire around the branch wire
3. Bend the branch wire over the completed turns
4. Wrap the remaining fixture wire over the bent branch wire
5. This can be followed by soldering and taping, or simply taping of the joint (Fig. 5.4).

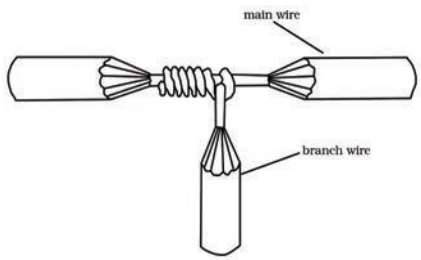


Fig. 5.5 Knotted tap joint

Knotted Tap Joint

The knotted tap joint is also used for branch joints to connect a branch wire (thin wire) to a continuous or main wire (thick wire) (Fig. 5.5).

1. Remove about 1 inch of insulation from the main wire and about 3 inches from the branch wire.
2. Place the branch wire behind the main wire so that three-fourths of its bare wire extends above the main wire.
3. Bring the branch wire over the main wire, around itself, and finally over the main wire so that it forms a knot. Wrap the wire around the main conductor in short, tight turns and trim the end

Joints Using Wire Nut and Split Bolt

The rattail joint is replaced by wire nut. The nut is usually housed in a plastic insulating casing. To make a joint.

1. Strip the conductors
2. Place the two joints to be joined into the wire nut
3. Twist the nut

Split Bolt Connector

The split bolt is used to join big sized conductors. This replaces the knotted tap joint and can be used to join three ends or join a branch conductor to a continuous (main) conductor (see Fig. 5.6).

The bare wires are placed through the space between the two bolts, after which the nut is tightened to ensure

a sound joint. The material required for making straight or branch joints for steel wired armour cables are as follows:

- Connectors
- Copper mesh tape
- Constant force springs for holding the wire armour and copper mesh tape
- Standard PVC/Vinyl tape, which provides a mechanical barrier between the over sheath layer and the armour layer.

Fig. 5.6 Split bolt

Preparing the Cable

Preparing the cable before jointing includes the following steps (Fig. 5.7):

1. Remove the over sheath and the wire armour
2. Separate the wire armour and bend the wires away from the cable, place the support ring under the armour at each side of the joint
3. Cut back the cable insulation
4. Remove the insulation from each of the conductors

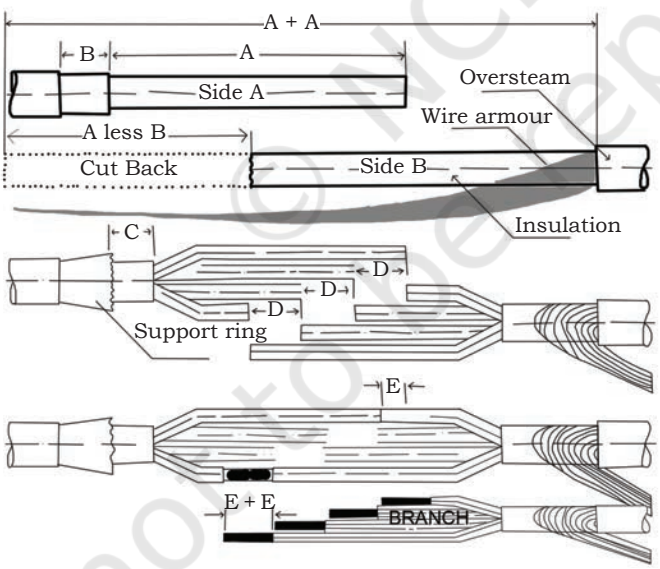


Fig. 5.7 Preparation of a three-core armoured cable

Crimping and Insulating Each Cable

Once the cable is ready, connect each end of the three conductors to a suitable connector (copper or

aluminium). Suitable-sized connectors are to be used. Tightly fix the suitable connectors and test the connection.

Tape the crimped connectors, wrap around and extend to cover at least 25mm of the cable insulation of the conductor entering the connectors (Fig. 5.8).

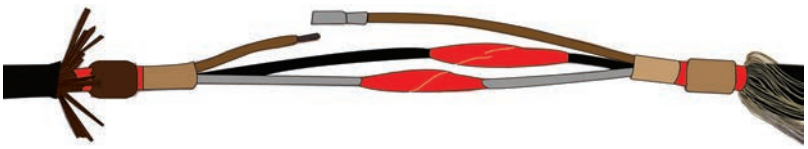


Fig. 5.8 Taped, crimped connectors on individual cables

Binding the Cables

Fig. 5.9 Wires taped together

Bind the wires tightly and then tape them together (Fig. 5.9).

Restoring Armour and Applying Mesh Tape

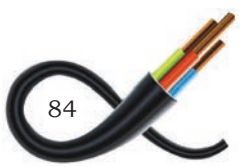
1. Tightly wrap the cable from armour to armour while applying adequate tension around the insulation.
2. Join the wire armour from one end to the other end and cut excess wire to the correct length. Ensure the armour spreads evenly over the entire joint.
3. Wrap the cable with the mesh tape and then use the standard vinyl/PVC tape to wrap over the mesh to provide a insulation against stray wire ends. For the branch joint, bring both the main and branch cables together before wrapping.

Fig. 5.10 Wrapping the cable with mesh tape

Next, use standard vinyl or PVC tape to wrap over the constant force springs placed over the under-armour rings. The tape provides a barrier against sharp edges (Fig. 5.10).

Re-establish the Over Sheath

1. Use a self fusing tape to wrap over the cable and establish the outer sheath. Start in the center and apply one layer of tape to one end, wrapping



over the jacket for at least 25 mm. Apply the tape from the end towards the center so that you have two layers on each side.

2. For branch joints, wrap over the insulation for both the main and the branch cable, by at least 50mm. Bring the two together and fill it in with the insulating putty from both sides. Do this up to 25 mm away from the place where the branch and the main cables are joined.
3. Put the two cables together and bind the main and branch tightly over the filling. Finally, wrap the crotch while pulling the branch away from the main cable (Fig. 5.11).

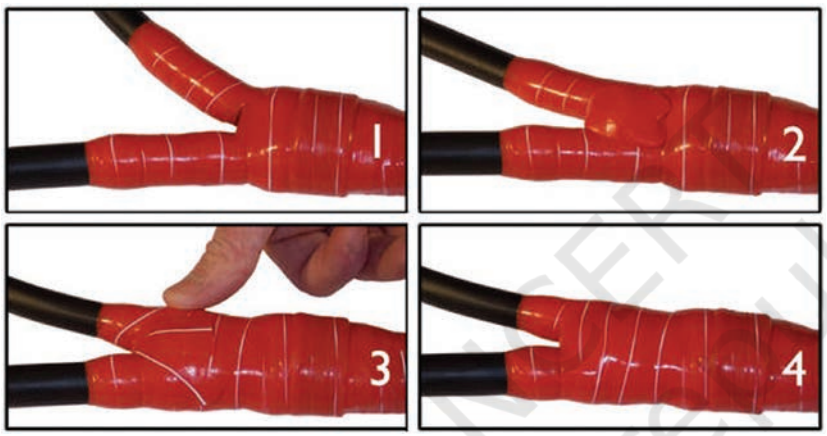


Fig. 5.11 Restoring the over sheath on a branch joint

Electrical Power Cable Terminations

The electrical cable termination is a cable end that connects to the terminal of the equipment or another cable to extend the length (Fig. 5.12).

The method used for termination of the cables varies according to the type of cable, type of connector and application. Some common types of terminations are

- crimp connection
- soldered connection
- compression termination
- wire-wrapping connection
- direct connection
- loop or eye connection

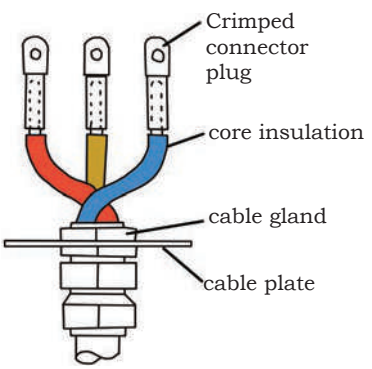


Fig. 5.12 Low voltage cable termination

Some of the factors which are considered for termination of cables are:

- Outdoor or indoor cable
- Voltage of the line
- Overhead or underground cable
- Type of connector on the equipment where the cable will be connected

Cable Joints

A power cable consists of two or more electrical conductors, held together wrapped with insulation and outer surface with an overall sheath (Fig. 5.13). The cables are used for transmission of electrical power. Power cables is being used for permanent wiring within buildings. The cable can be run under ground, run overhead, or exposed. Cables consist of three major components: conductors, insulation and protective jacket. The structure of individual cables varies according to application. Power cables use stranded copper or aluminium conductors, although in some cases solid conductors is used.

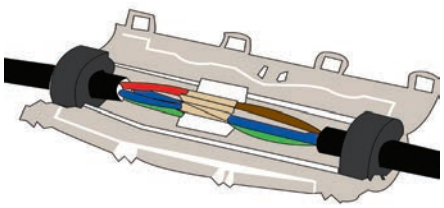


Fig. 5.13 Cable joint

After the introduction of electric cables in electrical circuit the problem of how to join them together arises in order to achieve the degree of insulation, tensile and crushing strengths, conductivity and accessibility. To cope up the requirements a junction box is introduced. The junction box typically incorporates:

- a method of securing the cable conductors (usually by soldering, screw-clamps or compressed ferrules).
- a method of insulation, which may be air, oil, bitumen or insulation applied in the form of tapes.
- a method of enclosure and protection applicable to the environment.

As per The Electricity Regulations every joint and connection should be mechanically and electrically suitable for its use. In this respect the joint or connection should be of proper construction as regards conductivity, insulation, mechanical strength and protection.

Joints in Non-flexible Cables

Underground cables are joined by ferrules or lugs (crimped) and the outer protection enclosure or box is

usually filled with a plastic or bituminous compound. Such joints are often used above-ground for non-flexible cables and are adequately protected and supported. Other cables which are fixed wiring installations enclosed junction boxes are used to making a joint between two cables. These junction boxes are not securing the cable against strain.

Joints in Flexible Cables

Joints in flexible cables are not usually satisfactory because:

1. stranded conductors are not suitable for certain methods of jointing.
2. mechanical tensile strength and resistance are difficult to maintain.
3. fatigue damage may occur when rigid joint is being done.

Some joints and cable connectors are much more acceptable these incorporate terminals or compression fittings suitable for stranded conductors. Cable clamps are used for plugs to reduce the flexing. Heat-shrinkable or pre-stretched sleeving may be adequate in some cases but other circumstances may demand additional protection.

Types of Cable Joints and Equipment

A great majority of failure in cable network is associated with faulty cable jointing. It is, therefore, essential to use proper jointing technique, good quality insulating material and standard accessories for cable jointing. Cable joints are of three types:

Straight through Joint

Straight through Joints are an important part of today's power cable networks (Fig. 5.14). These joints offer reliability and flexibility to meet the demands of cable network.

Straight through Joints provide

- quick cable preparation
- high electrical insulation
- no moisture ingress

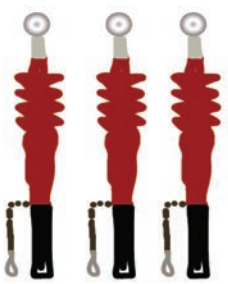
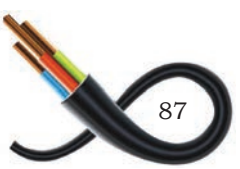


Fig. 5.14 Single Core Straight through Joint Kits



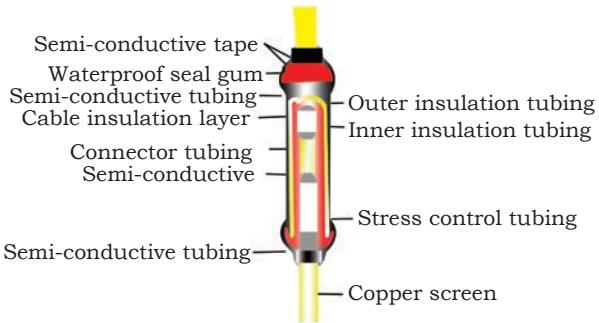


Fig. 5.15 Straight through Joint

- good mechanical strength
- compact dimensions and is suitable for all conductor, shape and material

Straight through Joints are made by metal joining processes, such as welding and soldering (Fig. 5.15).

T-Joint

These types of joints are used for branching of a service cable from a main cable. T-joints are helpful as turning and twisting of cable damages its outer core (Fig. 5.16).

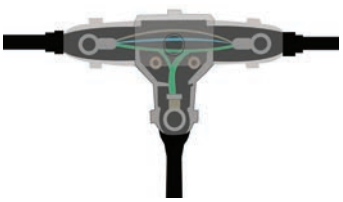


Fig. 5.16 T-Joint

Terminal Joint

These type of joints connect cable to switch gear, transformer terminal or to an overhead line (Fig. 5.17).

Fig. 5.17 Terminal Joint

Conductor Joint

The length of distribution lines are in kilometers and one coil of conductor is unable to solve the length problem. Hence, jointing the conductor is necessary.

Britannia Joint

This type of joint is made only on solid conductors and cannot be made on stranded conductor. Two conductors to be joined are brought in front of each other of about 6 inch (150 mm) of length. Both the conductors should be clean. If the conductor is of copper; it should make good electrical connection. Then ends of both conductors are bent through half centimetre and placed on each other. The length of contact portion should be min. 100 mm. This joint should be bound by 14 mm copper wire as shown in Fig. 5.18.

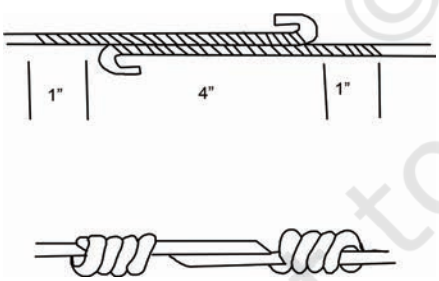


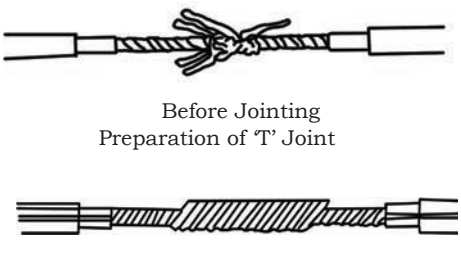
Fig. 5.18 Britannia Joint

Telephone Joint (Western Union)

This joint is used only for solid conductors. It is used for conductors of size 8 SWG or higher size. First, bend is given at 100 to 125 mm from the edge and are placed over each other. Then each one is twisted with another conductor.

Married Joints

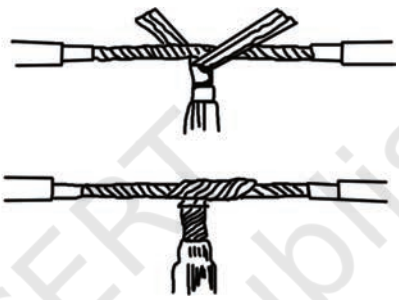
This joint is made between copper conductors having central strand of GI wire (Fig. 5.19). It should not be made between aluminium (Al) conductors. Approximately 175 to 200 mm length conductor strands are unwound. The GI strand of both conductors should be broken up to 175 mm in length. Both conductors should be brought in front of each other and their strands should be woven in each other. The strand of one conductor is twisted on other conductor, and strand of other conductor is twisted on the first. Likewise all the strands twisted and then soldered. This is used only for small span length.



Before Jointing
Preparation of 'T' Joint

After Jointing

Fig.5.19 Married Joint



'T' Joint After Completion

Fig. 5.20 'T' Joint

Sleeve Joint

It can be made with any type of aluminium conductor. Graphite Greece is applied over the conductor and as shown in Figs. 5.20 and 5.21 sleeves should be taken. These sleeves should be placed on the conductor as shown. Sleeves should be twisted by twisting wrench. This joint is made for LT, HT, ACSR, AAC conductor up to 0.06 cm^2.

Fig. 5.21 Sleeve Joint

Compression Joint

This joint is used for conductors of more than 0.06 cm^2 sizes. For jointing, two different sleeves are used. Steel sleeve is used for steel conductor strands and aluminium. sleeve is used for Al. conductor strands. There are two holes in Al. sleeve. Rebating is done

through these holes. Then Al. sleeve to be mounted on one side. The length of steel sleeve is then measured. Its half distance is taken. Suppose it is 'X' cm. Then the ends which are to be joined and more to 'X' cm distance is taken on the conductor is banded there. The Al. strands are opened up to that point and cut. Steel strand should not be touched during this. They are placed in the steel sleeve. They should be kept in front of each other. Then the center of steel sleeve is compressed through compression machine. Then on the half portion of the right side sleeve be compressed and then on the left half portion. Due to compression the length of sleeve will be increased by 6mm on both sides and it will reach Al. strands. Then Al. sleeve should be measured. It should be halved. Suppose it is 'Y' cm then 'Y' cm should be measured and marked on both sides of conductor measured from center of steel sleeve. Both parts of conductor are brought in sleeve in front of each other. The filler parts should be filled in the sleeve by Grease until it comes out of the holes. Both the holes are then closed by rivets and hammered by hammer. There is one stencil mark on Al. sleeve. The first compression will be there; afterwards it will be compressed up to one end. Similarly the other part is compressed up to the other end.

Jumpering

Connecting two conductors or wires is called jumpering (Fig. 5.22).

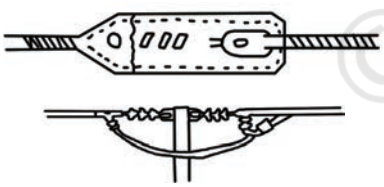


Fig. 5.22 Jumpering

Jumper should not be connected to the main conductor. The jumper should always be connected by PG clamps.

When the jumpers are near metallic portion, all such jumpers are covered with alkathane pipe.

Conductor joints are marked on ACSR conductor when dispatched. Mid-span joint should be made before stringing as the steel strand is not kept continuous. Hence, it is necessary to replace the company joint.

Care should be taken that mid-span joint is not less than 40 ft. from pole. Every joint should be done carefully.

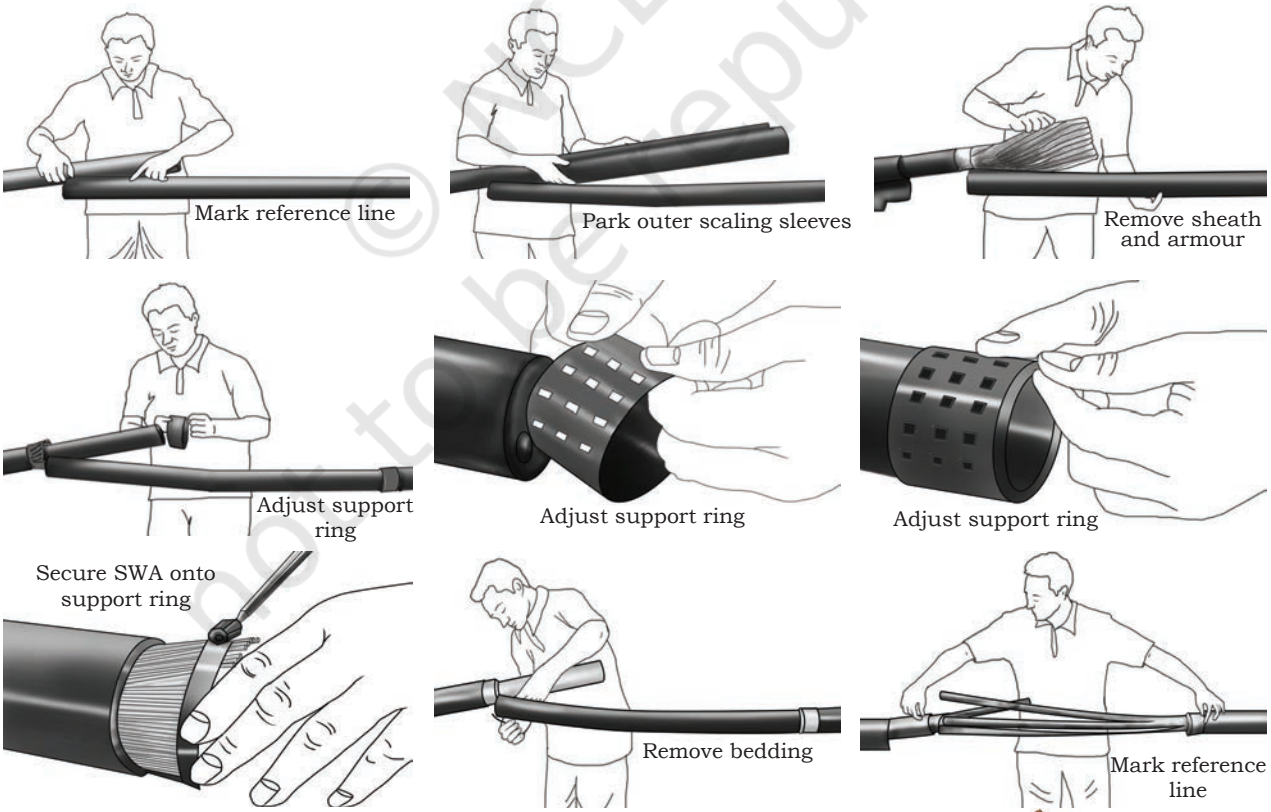
Where conductor strands are cut, repair sleeve is used. Conductor joint strength should be 95% that of conductor, and resistance should be that of a main conductor.

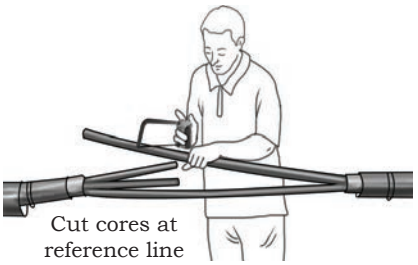
HV Cable Jointers Tools

Using the correct cable tools to prepare industrial and utility cables before cable jointing and terminating reduces catastrophic cable failures. Some of the important cable jointer tools include:

- Cable cutting tool
- Cable crimping tool (hydraulic, battery, ratchet) copper/aluminium cables
- Cable spiking tools for LV-HV cables (cartridge/ hydraulic)
- Heat shrink gas torches for LV-HV jointing
- Screen scoring tools for bonded/easy peel HV cables
- Outer sheath stripping tools, LV-HV cables
- Insulation (XLPE) stripping tools, HV cables
- Insulated tools for live-working
- Cable laying rollers, socks, jacks and pulling equipment
- Conduit duct rods

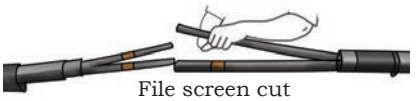
Procedure for Heat Shrink Straight through Joint





Cut cores at reference line

Remove copper tape shield



File screen cut

Remove conductive layer

Remove insulation

Shrink stress control tubing

Park insulation tubing

Apply filler putty

Apply stress control patch

Position insulation tubing

Apply copper mesh shielding

Position and secure armour case

Protect protruding edges

Check Your Progress

A. Write short notes on

1. LT cables Joints
2. Straight through joint
3. Britannia Joint
4. T-joint

B. State whether the following statements are True or False

1. Western Union joint are used for all conductors.
2. Meried joint should not be made between aluminium conductors.
3. Crimping is necessary for jointing the cable.

C. Short answer questions

1. List the steps used in preparing of the cable.
2. Explain the different types of joints.
3. Differentiate between fixture joint and western union splice joint.
4. Explain the procedure for heat shrinking straight through joint.

Cable Jointer Electrical Power System-Class 11 - Unit 5 Session- 1

A. Write short notes on

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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*

Conductor: *is the type of metal which allows the electrical current to flow through it.*

DP: *is erected in mid span of electrical transmission line for sport so that no deflection of single pole and wire take place.*

Galvanometer: *current indicating device*

Heating element: *a resistance which generates heat*

HT line: *High-tension line is a high voltage line. High tension or HT0 supply is applicable for bulk power purchasers who need 11 kilo-Volts or above.*

LT Line: *is a low-tension line is a low voltage line LT supply is of 400 Volts for three-phase connection and 230 Volts for single-phase connection in our country.*

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

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

Stay: *is used to sport the angular poll and end pole. Stay is mainly used to hold the tension of conductor or cable.*

Stringing: *is the term used for tightening and pulling the cables on poles.*

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.*

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Unit 1

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Fig. 1.13 http://www.way2science.com/wp-content/uploads/2012/03/inductionc.jpg

Fig. 1.16 https://www.researchgate.net/profile/Ahmed_Tarek12/publication/305115547/figure/fig4/AS:382402481410053@1468183264449/Figure-4-basic-structure-of-capacitor_Q320.jpg

Fig. 1.20 https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp23.gif

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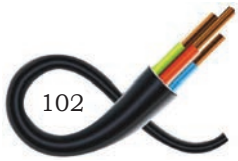
Fig. 1.22 https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/dccircuits-dcp7.gif

Fig. 2.8 https://www.google.com/search?hl=en-IN&authuser=0&biw=1366&bih=576&tbm=isch&sa=1&ei=qM-7LXNy_o9QPDvqHQDw&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:

Fig. 2.20 https://www.google.com/search?q=Cable+Drums&tbm=isch&source=iu&ictx=1&fir=hMfVBYNTQPaTZM%253A%252C75pU0pKD5FLMmM%252C_&vet=1&usg=AI4_-kTR9Av3tnKjrNINnWV6VdP3hiyHOA&sa=X&ved=2ahUKEwig4a6Az_7hAhUMu48KHdyuCSEQ9QEwAHoECAgQBA#imgdii=PX43kxl3ngKMmM:&imgrc=hMfVBYNTQPaTZM:&vet=1

Fig. 2.21 https://www.google.com/search?q=Cable+Drums&tbm=isch&source=iu&ictx=1&fir=hMfVBYNTQPaTZM%253A%252C75pU0pKD5FLMmM%252C_&vet=1&usg=AI4_-kTR9Av3tnKjrNINnWV6VdP3hiyHOA&sa=X&ved=2ahUKEwig4a6Az_7hAhUMu48KHdyuCSEQ9QEwAHoECAgQBA#imgdii=wX2dZEm9aS19iM:&imgrc=hMfVBYNTQPaTZM:&vet=1

Fig. 2.22 https://dir.indiamart.com/impcat/cable-roller.html



Answer Key

Unit 1: Electricity

Session 1: Electricity Generation Concept

A. Fill in the blanks

1. Electrons
2. repel, attract
3. electricity
4. thermal
5. chemical reactions

B. Match the columns

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

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. Michael Faraday
3. tungsten
4. electromotive forces

B. Match the columns

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

C. Multiple choice questions

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

Session 3: Concept of Electrical Power and Energy

A. Fill in the blanks

1. generation, transmission
2. Watts
3. Voltmeter
4. kilowatt hour
5. drop

B. Match the columns

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

C. Multiple choice questions

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

Session 4: Importance of Earthing System

A. Fill in the blanks

1. earthing
2. short circuit
3. earthing lead
4. apparatus

B. Match the columns

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

C. Multiple choice questions

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

Unit 2: Handling of Tools and Equipment

Session 1: Tools and Equipment

A. Fill in the blanks

1. rachet
2. metal
3. plastic
4. neon

B. State whether the following statements are True or False

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

Session 2: Tools and Equipment used for Cable Laying

A. Multiple choice questions

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

B. State whether the following statements are True or False

1. True
2. True
3. False

Unit 3: Electrical Wiring Components and Accessories

Session 1: Identifying and Selecting the Wiring Material and Components

A. Fill in the blanks

1. conducting, insulating, semiconductor
2. electric circuit
3. capping wiring
4. Circuit breakers

B. State whether the following statements are True or False

1. False
2. False
3. True

C. Multiple choice questions

1. (a)
2. (a)
3. (a)

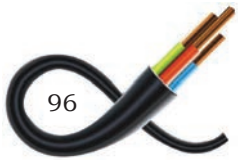
Session 2: ICTP Switch and Distribution Board

A Fill in the blanks

1. subsidiary circuits
2. negative side
3. Phase
4. fuse

B. Multiple Choice Questions

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



Session 3: Workplace Health and Safety Measures

A. Fill in the blanks

1. rubber
2. electric hazard
3. Cardio-pulmonary resuscitation
4. Circuit breakers

B. Multiple choice questions

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

Unit 4: Installation of Cables

Session 1: Laying of Underground Cables

A. Fill in the blanks

1. Murray loop
2. 240 Amps
3. High Tension (HV)
4. Erection stool

Session 2: Laying of AB Cables

A. Fill in the blanks

1. Jointing
2. Over current
3. Aerial Bundled conductor

B. Multiple choice questions

1. (a)
2. (a)
3. (a), (c) and (d)
4. (a)

C. Match the columns

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

Unit 5: Repairing of Cable Joints

Session 1: Electrical Cable Jointing Methods

A. State whether the following statements are True or False

1. False
2. True
3. True

Acronyms

AC: *Air Conditioner*
AC: *Alternating Current*
ADC: *Analog-to-Digital Converter*
BIS: *Bureau of Indian Standards*
BS: *British Standards*
CEA: *Central Electricity Authority*
CT: *Current Transformer*
CTR: *Current Transformer Ratio*
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 Temper*
GI: *Galvanised Iron*
HT: *High Tension*
HV: *High Voltage*
IEC: *International Electrotechnical Commission*
KCL: *Kirchhoff's Current Law*
KVL: *Kirchhoff's Voltage Law*
LCD: *Liquid Crystal Display*
LED: *Light-emitting Diode*
LT: *Low Tension*
LV: *Low Voltage*
MCB: *Miniature Circuit Breaker*
MDB: *Main Distribution Board*
MDI: *Maximum Demand Indicator*
MRI: *Meter Reading Instrument*
PD: *Potential Difference*
PT: *Potential Transformer*
PVC: *Polymerising Vinyl Chloride*
REV: *Revolution*
RST: *Referred for Phase Sequence*

RTC: *Real Time Clock*
SWG: *Standard Wire Gauge*
T&P: *Tools and Plants*
TRS: *Tough Rubber Sheath*
TV: *Television*
VIR: *Vulcanised Indian Rubber*
VT: *Voltage Transformer*

Notes