Technical and Vocational Stream
Learning Resource Material

Basic Electrical Installation
And
Workshop Technology

(Grade 9)
Electrical Engineering

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Publisher: Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Layout by Khados Sunuwar

Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Electrical engineering has been developed in line with the Secondary Level Electrical engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students, parents and concerned stakeholders.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Nandabikram Adhikari, Er. Chitra Bahadur Khadka, Mr. Damberdhwaj Angdembe, Er. Sanju Shrestha is highly acknowledged. This learning resource material is compiled and prepared by Er. Rupesh Maharjan, Er. Jaya Prakash Maharjan, Er. Uddav Giri. The subject matter of this material is edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala. Similarly, the language is edited by Mr. Saroj Kumar Mandal. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes creative and constructive feedback for the further improvement of the material.

2082 BS

Curriculum Development Centre
Sanothimi, Bhaktapur

Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

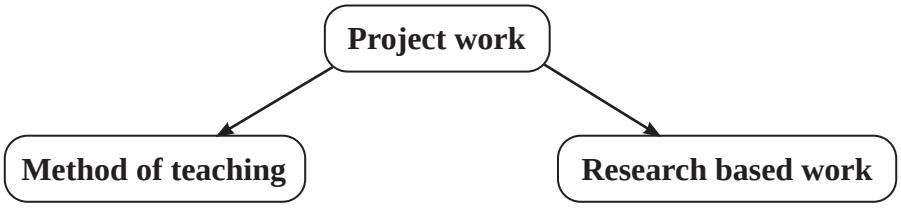
Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions. Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional

resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.
- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, charts, and graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final Projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom Presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.

True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field Trips: Evaluate students' ability to apply knowledge in real-world settings.

List of Abbreviation

mA	milli ampere
PPE	Personal Protective Equipment
IPE	Insulating Protective Equipment
FR	Fire Resistance
CPR	Cardio Pulmonary Resuscitation
NEPA	National Fire Protective Association
NEC	National Electrical Code
IEEE	Institute of Electrical and Electronics Engineers
NESC	National Electrical Safety Code
ICC	International Code Counsil
IBC	International Building Code
IFC	International Fire Code
IECC	International Energy Conservation Code
kWh	Kilo Watt Hour
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
MCCB	Molded Case Circuit Breaker
RCCB	Residual Current Circuit Breaker
RCBO	Residual Current Breaker and Overload
SPD	Surge Protective Device
LPS	Lightning Protection System
HRC	High Rupturing Capacity

TPN	Triple Pole with Neutral
SP	Single Pole
DP	Double Pole
HT	High Tension
LT	Low Tension
AVO	Ampere Volt Ohm
MΩ	Mega Ohm

Electrical Safety Practices

Unit 1

1.1 Concept and Introduction of Safety

Safety is a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community. In other words safety is the process by which we can keep ourselves, other, and our tools and equipment safe from different accident weather it is electrical or other.

1.1.1 Electrical Safety Rules and Regulations in Electrical Installation Work

1. Avoid contact with energized electrical circuit.
2. Treat all devices and wires as if they are live or energized.
3. Work with only one hand if possible.
4. Disconnect the power source before repairing or servicing any electrical equipment.
5. Use only tools and equipment with insulated handles.
6. Never use metallic pen, pencil, scale or any other metallic tool to point out.
7. Shut down the power source if chemical or water is spilled into device.
8. If an individual comes in contact with a live electrical conductor, do not touch the equipment, cord or person. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.
9. If electrical equipment is producing abnormal sound, then it must be reported to technician.
10. Never smoke or light fire near the electrical equipment when it is connected to power source.
11. Read the wiring diagram of equipment carefully before operating.
12. When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear insulated gloves, protective clothes and shoes with insulated soles.
13. Never use or store highly inflammable liquid and gas near the electrical circuit or equipment.

14. DO make sure all electric cords are tucked away, neat and tidy.
15. DON'T plug a bunch of stuff into one outlet or extension cord.
16. Enclose all electric contacts and conductors so that no one can accidentally come into contact with them.

1.1.2 Importance of Workplace Safety

The benefits of maintaining a safe work environment are many, but first and foremost, safety is about what you can do to protect your workers. “It’s the right thing to do. Companies that employ workers have an interest in keeping the workplace safe. Job-related injuries are something that responsible employers avoid. They take the time and use company resources to make sure that the people who come to work each day are safe. Employers should send their workers home in the same condition they came in. When a workplace is safe; workers feel more comfortable and confident when they are in that environment. Productivity gets a boost, and profit margins follow suit. Absenteeism also drops when employers take steps to implement an effective safety program.

Workplace safety is important because it:

- Protects employees and the employer from injuries.
- Teaches workers how to work in a safe environment.
- Helps everyone feel safe and happy.
- Teaches the workers to pay attention to their surroundings.
- Protects companies from law suits, citations and fines.

1.1.3 Electrical Shock

Electrical shock is a physiological reaction caused by electric current passing through the (human) body. Electric shock occurs upon contact of a (human) body part with any source of electricity that causes a sufficient magnitude of current to pass through the victim's skin, muscle.

Causes of Electrical Shock

- Faulty appliances.
- Damaged or frayed cords or extension leads.
- Electrical appliances coming in contact with water.
- Incorrect or deteriorated household wiring.

- Downed power lines.
- Lightning strike.

Effect of Electrical Shock

- A shock can cause muscle spasms, muscles, ligaments and tendons may tear as a result of the sudden contraction caused by an electric shock.
- A shock can cause cardiac arrest if a current of 50 mA passes through the heart.
- The respiratory system can be paralyzed and the heartbeat can either become very fast and irregular or can completely stop beating
- A shock can cause burns to tissues and organs
- A shock can affect the nervous system
- A shock can bring unbearable pain

1.1.4 Importance of Electrical Safety

It is important to follow the same systematic approach used for other occupational health and safety issues, when dealing with electrical safety. No one could overstate the importance of Electrical Safety knowledge. It is imperative to know how to work safely with or within the vicinity of electricity because electrical current in regular businesses and homes have enough power that if exposed to, can be fatal.

All electrical systems can potentially cause harm. Four of the main types of injuries that occur as a result of electrical current include: electrocution, electric shock, burns, and falls. These types of incidents can occur in various instances.

Electricity is one of nature's most powerful and dangerous forces; in fact, electricity is one of the leading causes of death at work. It is unsafe for the untrained to conduct electrical work. It is simply not worth the risk. Saving money is not worth a life.

1.1.5 Safety Signs

To have safety signs in the workplace is very essential. A visible instruction from a safety sign gives clear indication and lessens the likelihood of accidents to employees and non-employees, and therefore creates a safer working environment.

Importantly, having safety signs will help to follow with the Health and Safety (Safety Signs and Signals) Regulations, which makes us safer during any kind of works.

Generally, the following signs should be properly managed for any kind of works.

- Fire safety signs
- Emergency exit signs
- Road traffic regulations within the workplace
- Prohibition sign

These 4 important safety signs can be broken into categories: Prohibition, Warning, Mandatory and Emergency.

Prohibition Signs

A sign prohibiting behavior likely to increase or cause danger are included in prohibition signs. For e.g. “No access for unauthorized personnel”. These signs should be used for “Do Not” commands. For example – to indicate that smoking is not allowed in a particular area. In the workplace they should be used to reinforce instructions prohibiting dangerous activities.

Figure 1.1: Prohibition Sign

Signs prohibiting an activity appear as a circular red band with a single diagonal cross line descending from left to right at a 45-degree angle. The background should be solid white with the imagery indicating the nature of the command in black.

Warning Signs

A sign giving warning of a hazard or danger are included in warning signs. For e.g. “Danger: High Voltage”. These signs should be used to make people aware of a nearby danger. For example, a flammable liquid store. Signs warning of a particular hazard appear as a black band in the shape of an equilateral triangle. The background within the band should be yellow with the imagery indicating the type of hazard in black, positioned centrally on the sign.

Figure 1.2: Warning signs

Mandatory Signs

A safety sign prescribing specific behaviour is shown in these signs. For e.g. “Personal Protective Equipment Must Be Worn”.

These signs should be used to indicate actions that must be carried out in order to comply with statutory requirements. For example, self-closing fire doors that must be kept closed to comply with the fire risk assessment should be labeled with “FIRE DOOR KEEP SHUT” signs. An area of a construction site where hard hats should be worn should also have appropriate signs at the entry points.

The colours are used to convey the mandatory nature of the instructions but due to the amount of text normally required, a rectangular format is used. The general mandatory sign of a white exclamation mark on a blue circle may be used in conjunction with a fire instructions notice.

Signs indicating mandatory requirements consist of a blue circle with the pictogram or text in white positioned centrally.

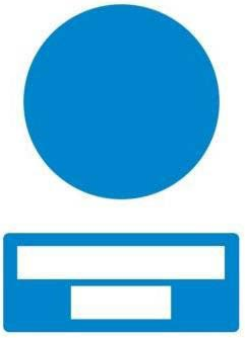


Figure 1.3: Mandatory signs

Emergency Signs

A sign giving information on emergency exits, first aid, or rescue facilities are included in these signs. For e.g. “Emergency Exit”. These information signs should be used to indicate escape routes, emergency exits and first aid equipment.

Safe condition signs appear as a green rectangle or square with the imagery or text in white positioned centrally. For example “PUSH BAR TO OPEN” is not required to comply and there is no imagery with that meaning.

Figure 1.4: Emergency signs

Colour / Meaning or purpose / Instruction and information

- Red /Prohibition sign /Dangerous behaviour; stop; shutdown; evacuate
- Yellow or Amber / Warning sign /Be careful; take precautions; examine
- Blue/Mandatory sign/Specific behaviour or action; wear protective equipment
- Green/Emergency escape and First-aid sign /Doors; exits; escape routes; equipment and facilities

Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE): shoes, gloves, safety glasses and hard hat Personal Protective Equipment (PPE) refers to items typically worn by a worker to provide protection from recognized hazards. Depending on the job task to be performed, PPE for the electric power industry generally includes safety glasses, face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and flame-resistant (FR) clothing.

In addition to PPE, electric power workers often use Insulating Protective Equipment (IPE), such as line hoses, rubber hoods, rubber blankets, and insulating

Live-line tools (for example, hot sticks, switch sticks, or shotgun sticks) for protection.

However, since IPE is not worn, it is technically not considered to be PPE.

Helmets normally need be worn only when working on outdoor switchgear, where they serve to protect against falling objects and collisions with solid objects at head height. Outdoor substations should always be considered ‘safety helmet’ areas and helmet wear made compulsory.

Hearing protectors are only required in a noisy situation, which may occur during construction works.

Eye protection should be worn when working with hazardous fluids, particularly mineral oil, to prevent splashes into the eye. They should always be worn when washing down the internal parts of oil circuit breakers.

Safety footwear should be routinely worn in all working areas and the shoes or boots should incorporate steel toe-cap and non-slip soles.

Figure 1.5: Personal protective equipment

1.1.6 Electrical Fire

A failure or malfunction within the electrical components of equipment or machinery can cause electrical fires. Electrical fires originate in electric wires, cables, circuit breakers, and within electrical components. Fires start in electrical panels from overloaded circuits or age of the panel. The panel and circuits become overloaded when the distribution of electricity is inadequate. Occasionally, lighting equipment

acts as a source of heat that is too close to easily combustible materials

Causes of Electrical Fire

Electrical systems may cause a fire risk. The common causes of electrical fires and preventive measures to maintain your electrical systems are as follows.

- Poor maintenance
- Old equipment and appliances
- Not keeping up with safety codes
- Electrical panels and circuit breakers

Classification of Fires

Fires can be classified into different categories based on the type of fuel that is burning. The most commonly used classification system for fires is based on the following classes:

Class A fires: These are fires involving ordinary combustibles such as wood, paper, cloth, or plastics. Class A fires are typically extinguished by cooling the fuel source with water or other extinguishing agents.

Class B fires: These are fires involving flammable liquids such as gasoline, oil, or grease. Class B fires are typically extinguished by smothering the fuel source with foam, powder, or carbon dioxide.

Class C fires: These are fires involving electrical equipment such as appliances, wiring, or circuit breakers. Class C fires require specialized extinguishing agents that are nonconductive and can extinguish the fire without damaging the equipment.

Class D fires: These are fires involving flammable metals such as magnesium, titanium, or potassium. Class D fires require specialized extinguishing agents that are specifically designed to extinguish fires involving these types of metals.

Class K fires: These are fires involving cooking oils, grease, or animal fats. Class K fires are typically extinguished by using specialized extinguishing agents that react with the oils and fats to create a soapy foam that smothers the fire.

Controlling Electrical Fire

There are several classes of fires, and electrical fires fall under the Class C category. In the case of a fire occurring in an electrical panel, do not try putting it out with water. Trying to

put out the fire with water will only worsen the situation and puts you and others in more danger. Water conducts electricity, and dumping water on or near a power source can cause you a severe electrical shock. It might even make the fire worse.

Two options to put out an electrical panel fire is a handheld fire extinguisher or an automatic fire suppression system. If using a fire extinguisher, make sure it has a rating for extinguishing Class C fires. The drawback of using a fire extinguisher is that a person must be present when the fire starts. A person will need to grab the fire extinguisher, open the electrical panel, and release the fire suppression agent from the extinguisher.

For 24/7 protection for an electrical panel, an automatic fire suppression system is the ideal choice. The pneumatic fire detection tubing is routed through the electrical panel and connects to a cylinder that contains the fire suppression agent. In the event of a fire, the tubing will burst and deploy the agent to suppress the fire. For electrical panels, it is recommend to us a clean agent. The clean agent leaves no residue and is not harmful to people. It is nonconductive and noncorrosive and will not damage the electrical panel.

As a residential homeowner or commercial business owner, electrical fires pose a real threat. Unfortunately, they are a common occurrence. You should keep this in mind when installing or upgrading your electrical system and when performing general maintenance. Taking preventive measures will reduce the risk of a fire in an electrical panel.

1.2 Rescue Operation- First aid Treatment- Artificial Respiration

1.2.1 Effect of Current Through the Human Body

Electric Shock may be defined as “Dangerous event or condition due to direct or indirect electrical contact with energized conductor or equipment and from which a person may sustain electrical injury from shock, damage to workplace environment, damage to property or both.

An electric shock will occur when a human body becomes a part of any electric circuit. The magnitude and duration of current flow through body are the main factors for the seriousness of Electrocution. The amount of the current passing through the body mainly depends on the body resistance. For dry condition human body resistance is around 1Mohm and whereas for wet condition is around 1kohm.

The effects of electrical current through the human body vary according to:

- The voltage

- The time the current flows
- The value of the current
- The frequency of the network
- The pathway of the current
- The ability of the person to react

Current	Effect
1mA	Barely perceptible
1-3mA	Perception threshold (most cases)
3-9mA	Painful sensation
9-25mA	Muscular contraction (can't let go)
25-60mA	Respiratory paralysis (may be fatal)
60mA or more	Ventricular fibrillation (probably fatal)
4 A or more	Heart paralysis (probably fatal)
5 A or more	Tissue burning (fatal if vital organ)

1.2.2 First Aid

First aid is the assistance given to any person suffering a sudden illness or injury, with care provided to preserve life, prevent the condition from worsening, or to promote recovery. It is done on the spot of accident before getting treatment from medical experts.

First Aid for Electric Shock

The following life support procedures are recommended for the rescue and care of shock victims

1. Remove the victim from further danger (move only if necessary) but don't endanger yourself. This can be achieved by de-energizing the equipment from the supply switch, cutting cable or wire to apparatus using wooden handle axe, protect your eyes against any flash, use dry stick, leather belts or non-conductor to move away victim from contact.
2. Check whether patient is breathing or not, keep him/her in reclining comfortable position and loosen all clothing about the neck chest and abdomen

3. Don’t give him liquid food; try to keep the victim breathing.
4. If victim isn’t breathing give CPR(cardio pulmonary resuscitation)

1.2.3 Cardio Pulmonary Resuscitation (CPR)

CPR stands for Cardio Pulmonary Resuscitation. It is an emergency life-saving procedure that is done when someone's breathing or heartbeat has stopped. This may happen after a medical emergency, such as an electric shock, heart attack, or drowning.

CPR combines rescue breathing and chest compressions.

- Rescue breathing provides oxygen to the person's lungs.
- Chest compressions keep oxygen-rich blood flowing until the heartbeat and breathing can be restored.

CPR techniques vary slightly depending on the age or size of the person, including different techniques for adults and children who have reached puberty, children 1 year old until the onset of puberty, and infants (babies less than 1 year of age).

Performing CPR right away can double or even triple a person’s chance of surviving cardiac arrest. If a person is not breathing, his heartbeat will stop. Do CPR to help circulation and get oxygen into the body. First, open a person’s airway to check if they are breathing (don’t begin CPR if a patient is breathing normally).

Procedure for CPR

- Position your hand and make sure the patient is lying on his back on a firm surface. Kneel beside him and place the heel of your hand on the center of the chest
- Interlock fingers, keeping your arms straight, cover the first hand with the heel of your other hand and interlock the fingers of both hands together. Keep your fingers raised so they do not touch the patient’s chest or rib cage.
- Give chest compressions and lean forward so that your shoulders are directly over the patient’s chest and press down on the chest about two inches. Release the pressure, but not your hands, and let the chest come back up. Repeat to give 30 compressions at a rate of 100 compressions per minute
- Open the airway and move to the patient’s head. Tilt his head and lift his chin to open the airway again. Let his mouth fall open slightly.
- Give rescue breaths, Pinch the nostrils closed with the hand that was on the forehead

and support the patient's chin with your other hand. Take a normal breath, put your mouth over the patient's, and blow until you can see his chest rise.

- Watch chest fall. Remove your mouth from the patient's and look along the chest, watching the chest fall. Repeat steps five and six once.
- Repeat chest compressions and rescue breaths. Place your hands on the chest again and repeat the cycle of 30 chest compressions, followed by two rescue breaths. Continue the cycle.

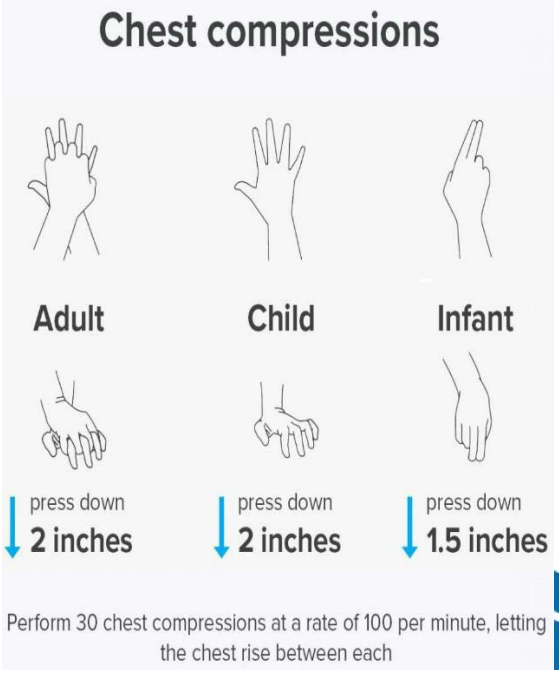


Figure 1.6: CPR procedure

Figure 1.7: Chest compression

Exercise

Choose the correct answer from the given alternatives.

1. What is the full form of CPR?

a. Cardio Pulmonary Respiration

b. Cardio Pulse Respiration

c. Cardio Pulmonary Resuscitation

d. Cardio pulse esuscitation

2. In which class of fire, electrical fire lies?

a. Class A b. Class B c. Class C d. Class D

3. Class C fire is extinguished by

a. Water b. Foam c. Gas d. Kerosene

4. What is the full form of PPE?

a. Personal Protective effort b. Personal Protective equipment

c. Personal private equipment d. Protective personal equipment

5. Which equipment is used to protect eyes?

a. Helmet b. Gloves c. Glass d. Boot

Write short answer to the following questions.

1. Write down any eight safety rules and regulation for electrical installation.
2. Define electric shock. What are the causes of electric shock?
3. Mention class of fire with their extinguisher.
4. Explain the first aid procedure for electric shock.
5. What is CPR? When is it apply and how?

Write long answer to the following questions.

1. Discuss the safety measures to be followed doing the electrical works.
2. Categorize the different classes of fire. And explain them in detail.

Project Work

1 Present personal protective equipment in chart paper with their respective use. (In group)

2. Presentation about class of fire and their extinguisher. (In group)

3. Class interaction with CPR videos.

Wiring Regulation

Unit 2

2.1 Electrical Codes

Electrical code represents the set of standards and practices that must be followed when designing, installing, testing and commissioning of electrical works. This code ensures safety and proper designs and installations with diligence, care and attention to detail. It also specifies the proper materials to be used, the methods and protocols to be followed to get it all done etc.

Every state or even cities and country level regulatory agencies may have their own electrical code used in buildings. There are three main bodies that set and maintain standards for national and international electrical code. These bodies publish codes for electricians, contractors, construction inspectors and other regulators to reference. These bodies are:

- National Fire Protection Association (NFPA)
  - National Electrical Code (NEC)
- Institute of Electrical and Electronics Engineers (IEEE)
  - National Electrical Safety Code (NESC)
- International Code Council (ICC)
  - International Building Code (IBC)
  - International Fire Code (IFC)
  - International Energy Conservation Code (IECC)

The National Fire Protection Association (NFPA) established the National Electrical Code (NEC) as a standard for electrical safety in residential, commercial, and industrial buildings.

Most of the codes follow the National Electrical Code but there can be some changes as per requirement. When carrying out electrical works, it is important to follow both national and local electrical codes to ensure all components are installed safely and function properly.

The electrical code of Nepal for public buildings is Nepal National Building Code, NBC 207.

2.1.1 Basics of Nepal National Building Code

- NBC (Electrical requirements for Public Buildings)

NBC 207 has been prepared considering the provisions of Electricity Act 2049 and Electricity Rule 2050. This code includes general guidance for Electrical Wiring Installation ensuring prevention of short circuiting.

NBC 207 recommends to practices of electrical wiring, definitions, design and construction and inspection & testing of installation respectively.

Bureau of Indian Standards (BIS) has formulated certain rules and regulations to promote the safety and the right usage of equipment. BIS has published the following code of practice for public safety standards in order to promote the right to information, transparency and accountability in a proper manner to the public.

NBC 207 states the following practices:

Rating of Cables & Equipment

1. The current-carrying capacity of different types of cables shall be chosen in accordance with good practice. Cable size shall be 1.5, 2.5, 4, 6, 10, 16, shall be 1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240, 300, 400, 500 mm2.
2. The current ratings of switches for domestic and similar purposes are 5 A and 15A.
3. The current ratings of isolators and normal duty switches and composite units of switches and fuses shall be selected from one of the following values: 6, 10, 16, 25, 32, 63, 100, 160, 200, 320, 400, 500, 630, 800, 1000 and 1250 A.
4. The ratings of rewirable and HRC fuses shall be in accordance with good practice.
5. The current ratings of miniature circuit breakers shall be chosen from the values given below: 6, 10, 16, 25, 32, 40, 63, 80, 100, 125 A.
6. Lighting and levels of illumination: Lighting installation shall take into consideration the many factors on which the quality and quantity of artificial lighting depends. The modern concept is to provide illumination with the help of a large number of light sources not of higher illumination level. Also, much higher levels of illumination are called for than in the past, often necessitating the use of fluorescent lighting suitably supplemented with incandescent fittings, where required.

7. For specific requirements for lighting of special occupancies, reference shall be made to good practice. Electric wiring installations in hospitals shall be done in accordance with good practice. For guidelines for electrical installation in residential buildings, reference may be made to good practice.

8. Cables: The smallest size of the cable that shall be used, will depend upon the method of laying cable, permissible maximum temperature it shall withstand, the prospective short-circuit current to which the cable may be subjected, the characteristics of the overload protection gear installed, load cycle and thermal resistivity of the soil. Short-circuit rating curves will serve as an approximate guide for selection of the size of cables.

9. Residual current breaker should be used as to avoid electrocution and fire of from electricity hazards in case of Hospital building.

10. Minimum standard size of wiring cable for light and power shall be specified as follows:

    - Light circuit - 2.5 sq.mm PVC insulated copper stranded cable
    - Power circuit - 4.0 sq.mm PVC insulated copper stranded cable.

    NBC-207 includes guidelines on the following topics:

    1. General Requirement
    2. Power Factor Improvement in Consumer's Installation
    3. Planning of Electrical Installation
    4. Distribution of Supply & Cabling
    5. Rating of Cables & Equipment
    6. Wiring
    7. Earthing
    8. Inspection and Testing of Installation
    9. Lightning Protection of Building
    10. Telecommunication and other services

NBC (Provisional Recommendation on Fire Safety)

National Building Code NBC-107 provides fundamental requirements for fire safety in ordinary buildings (commercial and office buildings). These requirements do not necessarily cover the fire safety provisions needed for other buildings. For the design of

such other buildings, other relevant Codes and Standards which might be followed have been suggested.

This code suggests the need to install lightning arresters/conductors.

“A lightning arrester shall be located in the highest part of every building and it shall be connected by a conductor to an earth rod buried in the earth. The lightning arrester shall be so located that as much as possible of the building lies inside the surface of an imaginary cone having a vertex angle of 45 degrees and its apex at the top of the arrester.”

2.1.2 Basics of Nepal Electricity Rules, 2050

Nepal Electricity Rules, 2050 is the rule made by Government of Nepal in which different standard are defined related with the Nepal electricity.

a. Standard supply voltage for single phase is 230V and for three phase is 400V
b. Voltage fluctuation shall not be allowed not more than 5% in standard value.
c. Standard supply frequency is 50 Hz, and fluctuation shall not be allowed more than 2.5%.
d. Power factor shall not be allowed less than 0.8 lagging.
e. No electric lines of any kind shall be carried out from above house.
f. Insulation resistance of electric system of 230/400V and wiring shall be at least 5Mohm.
g. The electric wires to be use for any purpose should be adequate capacity required for that work.
h. Single phase switch is not allowed to be installed in the neutral wire.
i. While working in a place having live line of electricity work shall have to be done by using insulated gloves, tools etc.

Exercise

Choose the correct answer from the given alternatives.

1. What is the full form of NEC?

a. Nepal Electricity code
b. National electricity color
c. National electrical code
d. National electrical color

2. What is the full form of NEA?

a. National electrical authority
b. Nepal Electricity Authority
c. National electricity authority
d. New electrical authority

3. Cable size used for lighting circuit.

a. 4mm sq.
b. 3mm sq.
c. 2.5 mm sq.
d. 6mm sq.

4. Cable size used for power circuit.

a. 2.5 mm sq.
b. 4 mm sq.
c. 1 mm sq.
d. 1.5 mm sq.

5. The function of earthing is

a. To complete circuit
b. To protect the system
c. To provide retuning path
d. To control current

Write short answer to the following questions.

1. What does NEC stand for?
2. What is the main purpose of the NEC?
3. What is the color code for ground wire in NEC?
4. What is the standard voltage for residential wiring as per NEC?
5. What is the wire color coding for 3-phase systems under NEC?

Write long answer to the following questions.

1. Describe the general rules provided by NEC for wiring in residential buildings.
2. Discuss the NEC code requirements for overcurrent protection devices (circuit breakers and fuses).
3. Explain how NEC ensures protection against electric shock, fire, and short circuits.

Project Work

1. Present the different bodies that provide electrical codes. (In group)
2. Presentation about electrical codes for lighting and power circuits. (In group)

Unit 3 Proper use of tools and accessories

3.1 Selection of Proper Tools and their Handling

Selection of wrong tools lead to accident, injuries. Further it may see unprofessionalism, time consuming to complete the job. Hence, we should use proper tools to perform any job satisfactory.

a. Worker should assess the possible risks, hazards before starting any job.

b. Worker should always use the appropriate tool for the task. Using tool that is not designed for specific job may results accidents, injury or damage to the tool itself.

c. Worker should keep tools in well condition by cleaning, inspection and repairing them as per needed. Dull or damaged tools can lead to accidents and injuries.

d. According to the nature of the job, we should use proper personal protective equipment such as safety glass, gloves, hard hats etc.

e. We should follow the manufacturer instructions and waring for using and maintaining tool. Every tool has its own capabilities and limitations.

3.2 Types of Electrical Tools and Materials

1. Line Tester

Phase, electric mains or line tester is a basic tool which is used to test and identify Phase / Live/ Hot or Positive (+) wire / conductor in electrical installation also known as voltage or current detector. Phase or Line Tester is also called Neon Screw Driver or Test Pin.

Figure 3.1: Line Tester

2. Screwdriver

A screwdriver is a tool, manual or powered, for screwing and unscrewing (inserting and removing) screws. A typical simple screwdriver has a handle and a shaft, ending in a tip the user puts into the screw head before turning the handle. Generally there are two types of screw driver + and –

Figure 3.2: Screw driver

3. Combination Plier

Combination pliers are multi-purpose pliers, combining gripping jaws with wire cutters. They can be used for gripping, compressing, bending, twisting, extracting and cutting various materials.

Figure 3.3: Combination Plier

4. Wire Stripper

A wire stripper is a portable handheld tool used by workers, especially electricians, for removing the protective coating of an electric wire in order to replace or repair the wire. It is also capable of stripping the end portions of an electric wire in order to connect them to other wires or to terminals. A wire stripper is often considered an important tool for professional electricians and other related personnel.

Figure 3.4: Wire Stripper

5. Side Cutting Pliers or Diagonal Pliers

Diagonal pliers (or wire cutters or diagonal cutting pliers or diagonal cutters or side cutting pliers) are pliers intended for the cutting of wire (they are generally not used to grab or turn anything).

Figure 3.5: Side cutting plier or diagonal plier

6. Nose Pliers

They can bend, cut and grip where fingers and other tools are too big or clumsy.

Figure 3.6: Nose plier

7. Multimeter

A multimeter or a multitester, also known as a VOM (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter can measure voltage, current, and resistance. There are two types of multimeter namely analog multimeter and digital multimeter, these days digital multimeter are widely used.

Figure 3.7: Multimeter

8. Crimping Tool

A crimping tool is a device used to conjoin two pieces of metal by deforming one or both of them in a way that causes them to hold each other. The result of the tool's work is called a crimp.

Figure 3.8: Crimping tool

9. Drill machine

A drilling machine, called a drill press, is used to cut holes into or through metal, wood, or other materials.

Figure 3.9: Drill machine

10. Measuring Tape

A tape measure or measuring tape is a flexible ruler and used to measure distance.

Figure 3.10: Measuring tape

11. Fish Tape

It is a simple tool that electricians use to pull wire through electrical conduit. A fish tape is long, thin, flat steel wire wound up inside a donut-shaped wheel with a sturdy handle.

Figure 3.11: Fish tape

12. Hammer

Hammer is a tool consisting of a weighted "head" fixed to a long handle that is swung to deliver an impact to a small area of an object.

Figure 3.12: Hammer

13. Soft Hammer or Mallet

These are soft hammers used give light blows where the work surface must not be damaged. They are made of either rubber, plastic or wood.

Figure 3.13: Soft hammer or mallet

14. Claw Hammer

A claw hammer is a tool primarily used for driving nails into or pulling nails from, some other object. Generally, a claw hammer is associated with woodworking but is not limited to use with wood products. It is not suitable for heavy hammering on metal surfaces as the steel of its head is brittle.

Figure 3.14: Claw hammer

15. Hack Saw

It is a basic hand cutting tool used for cutting unwanted material. It is used for cutting metals. It is also used for cutting slots and contours.

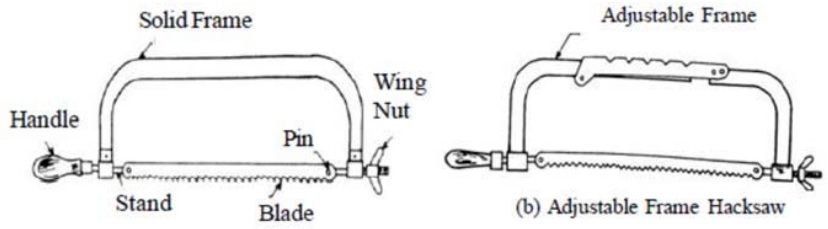


Figure 3.15: Hack saw

16. Plumb Bob

A plumb bob, or plummet, is a weight, usually with a pointed tip on the bottom, suspended from a string and used as a vertical reference line, or plumb-line. It is essentially the vertical equivalent of a "water level".

Figure 3.16: Plumb bob

17. Try Square

A try square is a woodworking or a metalworking tool used for marking and measuring a piece of wood. The square refers to the tool's primary use of measuring the accuracy of a right angle (90 degrees); to try a surface is to check its straightness or correspondence to an adjoining surface. "Try square" is so called because it is used to "try" the squareness.

Figure 3.17: Try square

18. Vernier Caliper

A Vernier caliper is a measuring device used to precisely measure linear dimensions. It is a very useful tool to use when measuring the diameter of a round objects like cylinders.

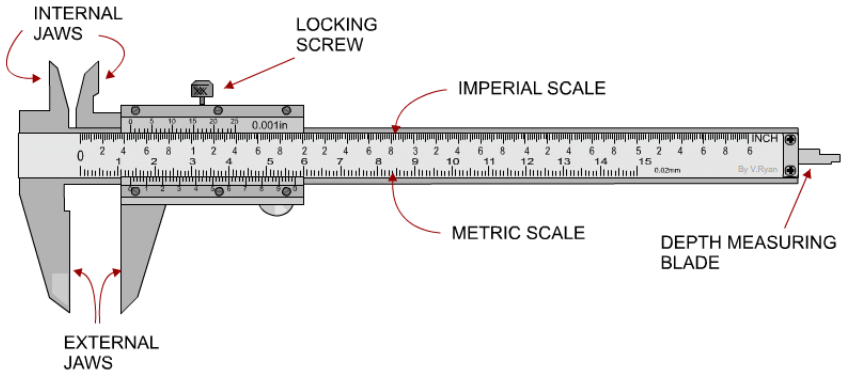


Figure 3.18: Vernier caliper

19. Micrometer

Micrometer screw gauge is used for measuring small dimensions with acute precision. Screw gauge is used for dimensions smaller than those measured by Vernier calipers.

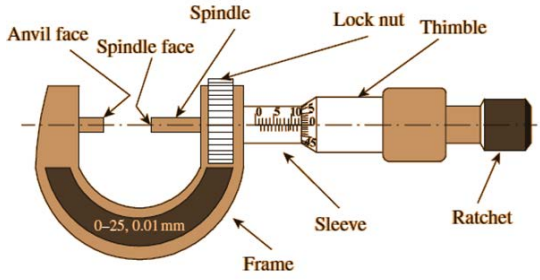


Figure 3.19: Micrometer

20. Divider

Divider, instrument for measuring, transferring, or marking off distances, consisting of two straight adjustable legs hinged together and ending in sharp points.

Figure 2.20: Divider

21. Marking Scribers

Marking Scribers are tools made of steel with hardened and tampered points and knurled on the body to provide grip. Scriber is used for making straight lines on metal surface with the aid of steel rule, try square and templates. The bent end is used to scratch line in places where the straight end cannot reach. The ends are sharpened on an oil stone when necessary.

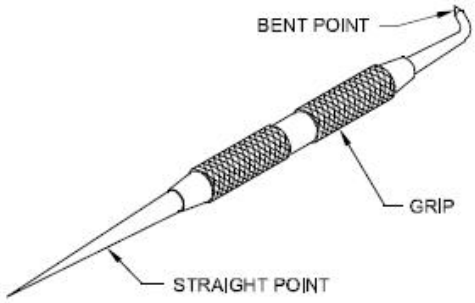


Figure 3.21: Marking scribers

22. Center Punch

A center punch is used to mark the center of a point. It is usually used to mark the center of a hole when drilling holes.

Figure 3.22: Center punch

23. Letter and Number Punch

Also known as letter stamps or number stamps, letter punches are used to emboss the impression of a letter or number into a work piece.

Figure 3.23: Letter and number punch

24. Feeler Gauge

A feeler gauge is a hand-held measuring tool. It has a number of folding metal strips (also known as blades, or leaves) which are machined to specified thickness levels.

Figure 3.24: Feeler gauge

25. Steel Sheet

Sheet metal is metal formed by an industrial process into thin, flat pieces. Sheet metal is one of the fundamental forms used in metal working and it can be cut and bent into a variety of shapes.

Figure 3.25: Steel sheet

26. Bar/Strip

Figure 3.26: Bar/strip

27. Angled Bar

Angle bar, also known as “L-bar”, “L-bracket” or “angle iron, is a metal in the

form of a right angle. Steel angle bar is the most widely used structural steel by the construction industry because of its very economical cost.

Figure 3.27: Angled bar

28. Nuts and Bolts

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten multiple parts together. A bolt is a form of threaded fastener with an external male thread.

Figure 2.28: Nuts and bolts

29. Screws

A screw is a type of fastener, in some ways similar to a bolt (see Differentiation between bolt and screw below), typically made of metal, and characterized by a helical ridge, known as a male thread (external thread).

Figure 3.29: Screws

30. Nails

In woodworking and construction, a nail is a pin-shaped object of metal (or wood,

called a tree nail) which is used as a fastener, as a peg to hang something, or sometimes as a decoration.

Figure 3.30: Nails

31. Rivets

A rivet is a permanent mechanical fastener. Before being installed, a rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite to the head is called the tail. On installation, the rivet is placed in a punched or drilled hole, and the tail is upset, or bucked (i.e., deformed), so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place.

Figure 3.31: Rivets

32. Spanners and Wrenches

A wrench or spanner is a tool used to provide a mechanical advantage in applying torque to turn bolts, nuts or other hard-to-turn items.

Figure 3.32: Spanners and wrenches

33. Chisels

A chisel is a tool with a characteristically shaped cutting edge of blade on its end, for carving and/or cutting a hard material such as wood, stone, or metal. The handle and blade of some types of chisel are made of metal or wood with a sharp edge in it.

Figure 3.33: Chisels

34. Files

A file is a tool used to remove fine amounts of material from a work piece. File is a cutting tool with multiple teeth like cutting edges used for producing smooth surface.

Figure 3.34: Files

35. Energy Meter

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device.

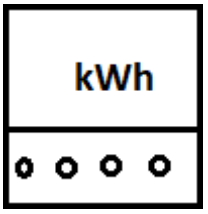


Figure 3.35: Energy meter

36. Accessories for Conduit

a. Bends

These are made up of tin, steel, galvanized iron, PVC or plastic etc. They are used to change the direction of wire by joining two conduits. For e.g. Elbow

b. Clamps/Saddle

They are used to hold conduit or pipe on the wall or ceiling rigidly.

c. Socket

They are used to join two conduits together.

d. Tee

They are used to join two conduits coming from different direction and combine them to run in same direction.

3.3 Types of Switches and Holders

3.3.1 Switch

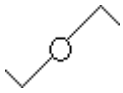
An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are essentially binary devices: they are either completely on ("closed") or completely off ("open"). So switch is the controlling device which is used to break or close the circuit and it is made up of plastic or other insulated substance. But the terminal point is made up of metal such as steel copper alloys etc.

They are rated in terms of current or voltage. In residential house normally 6A/230V rated switch is used. Followings are the different types of switches

a. Single pole one way switch

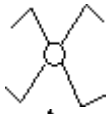
b. Double pole one way switch

c. Triple pole switch



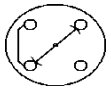
d. Alternate switch (Two way switch)

e. Multi-position switch

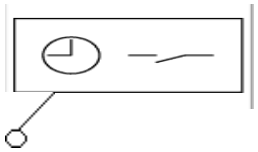


f. Intermediate switch (Cross way switch)

g. Pull way switch



h. Change over switch



i. Time switch

j. Pendant switch

3.3.2 Lamp Holder

A lightbulb socket, light socket, lamp socket or lamp holder is a device which mechanically supports and provides electrical connections for a compatible electric lamp. Sockets allow lamps to be safely and conveniently replaced.

There are various types of lamp holders available in market, most common holders are described below:

1. B22 Bayonet lamp holder
2. E27 Edison Screw lamp holder

1. B22 Bayonet Holder

The "B22" refers to the diameter of the base, which is 22mm. The unique bayonet mechanism allows for easy installation and removal of bulbs, making it a widely-used standard in both residential and commercial lighting.

2. E27 Edison Screw Holder

"E27" refers to the type of base the lamp holder accommodates. The "E" signifies an Edison screw mount, and "27" refers to the 27mm diameter of the base.

a. Batten Lamp Holder: This type of holder is fixed over round blocks or wooden boards with 3 wood screws. To connections to the batten holder are given from beneath the round block by drilling two holes then installed on a wall or ceiling.

b. Pendant Lamp Holder: When a holder is made to hang downward from the ceiling rose with flexible wire. It can also hold a lamp shade. These may be brass or Bakelite.

c. Swivel Lamp Holder: Swivel holder are basically design for controlled wide angle directional lighting which are used for lighting of shop windows. It consists of a ball and socket joint fitted between back plate and holder of lamp.

d. Angle Lamp Holder: Angle holder is used where the lamp is required to be

fixed directly on the wall on round block. The angle holders may be made of brass or Bakelite with brass plunger. The connections to the angle holder are given from behind it through round block.

e. **Push-Pull Lamp Holder:** When a holder is made to hang downward from the ceiling rose securely then these type of holder is always is used. One of the greatest things is locking facility shown in these type holder.

f. **Bracket Lamp Holder:** Bracket holder may be given any shape but generally direction of bulb holder is toward floor at some angle. These type of holder is mostly found in govt. buildings the bracket are used made of wood having batten holder fixed at right angle to its length. The holder has the provision to hold the lamp shade.

3.4 Types of Lamps

An electric light is a device that produces visible light from electric current. In technical usage, a replaceable component that produces light from electricity is called a lamp. Lamps are commonly called light bulbs; for example, the incandescent light bulb. Lamps usually have a base made of ceramic, metal, glass or plastic, which secures the lamp in the socket of a light fixture. The electrical connection to the socket may be made with a screw-thread base, two metal pins, two metal caps or a bayonet cap.

Generally, for interior lighting we use incandescent lamp, fluorescent lamp and LED lamps.

3.4.1 Incandescent Lamp

An incandescent bulb typically consists of a glass enclosure containing a tungsten

filament. An electric current pass through the filament, heating it to a temperature that produces light.

Incandescent light bulbs usually contain a stem or glass mount attached to the bulb's base which allows the electrical contacts to run through the envelope without gas/air leaks. Small wires embedded in the stem support the filament and/or its lead wires. The enclosing glass enclosure contains either a vacuum or an inert gas to preserve and protect the filament from evaporating.

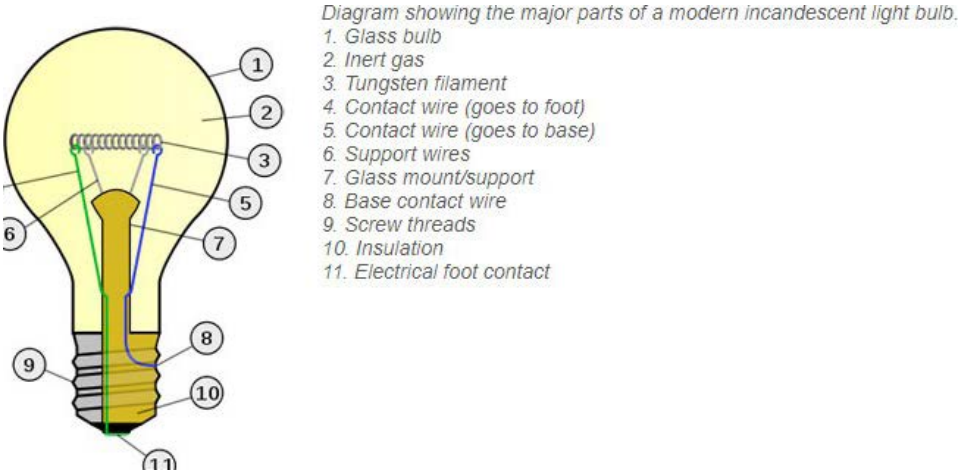


Figure 3.36: Incandescent lamp

3.4.2 Fluorescent Lamp

Fluorescent lamps or tube light work by ionizing mercury vapor in a glass tube. This causes electrons in the gas to emit photons at UV frequencies. The UV light is converted into standard visible light using a phosphor coating on the inside of the tube. The choke is in fact a large inductor coil and thus has a tendency to throw back stored current in it, every time power is switched through it. Choke also regulates the power to electrodes that work to ignite the inert gas in tube. Starter is used to provide an initial high current to filament for very short period of time in order to ionize the gas.

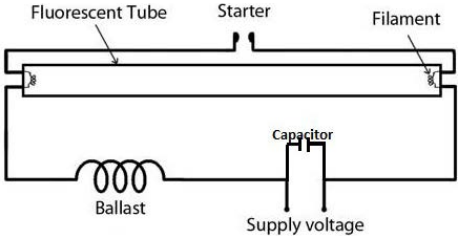


Figure 3.37: Fluorescent lamp

3.4.3 LED Lamps

Since LED lamp consists of LEDs arranged inside a diffusing glass so working of lamp is similar to single led. A light-emitting diode is a two-lead semiconductor light source. It is a p– n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with holes within the device, releasing energy in the form of photons.

Figure 3.38: LED lamp

3.5 Types of Power Socket

Socket is an electrical accessory where plugs and pins are placed into room so it is device on a wall where you can plug electrical equipment into the electricity supply. Generally there are two types of sockets namely lighting socket or normal socket and power socket.

a. Normal socket/Lighting socket

They are used for low power applications for example- lighting and fan socket. The current rating of this socket is 5A

Figure 3.39: Symbol of lighting socket

b. Power Socket

They are used for high power applications for example-Iron, washing machine heater, rice cooker etc. The current rating of this socket is 15A or 10A.

Figure 3.40:: Symbol of power socket

c. Socket With Switch Box

It is a square or rectangular box made up of wood, PVC or metal for fixing the socket or switch to protect from the electric shock and for their good look.

Figure 3.41: Lighting socket with switch

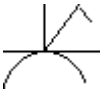


Figure 3.42: Power socket with switch

3.6 Types of Different Boxes

3.6.1 Junction Box

An electrical junction box is an enclosure housing electrical connections, to protect the connections and provide a safety barrier. It is used for connecting number of wires and taking out branches line. It is made up of wood, plastic, metal etc. which has a cover.

Figure 3.39: Junction box

3.6.2 Distribution Box

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.

Figure 3.42: Distribution box

3.6.3 Gang Box and Power Socket Box

Electrical Gang Boxes are simple enclosures that affix different switchboard accessories such as switches, socket, regulator, indicator, etc. onto it.

Figure 3.43: Gang box Figure

3.44: Power socket box

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following should be used to disconnect power to electrical equipment before servicing?

   a. Screwdriver b. Pliers c. Circuit breaker d. Hammer

2. …… all electrical equipment before use

   a. Clean b. Inspect c. Label d. Organize

3. Combination plier is used to

   a. Hold and grip the electrical component

   b. Hold and grip cylindrical shaped objects

   c. Cut wires and cables of small diameter

   d. All of the above

4. Which gas is sometimes used in filament lamps?

   a. Carbon dioxide b. Nitrogen

   c. Krypton d. Argon

5. The output of tungsten filament lamps depends on.....

   a. Size of lamp b. Size of shell

   c. Temperature of filament d. All of the above

Write short answer to the following questions.

1. Compare LED and fluorescent lamp.
2. Compare LED and Incandescent lamp.
3. Compare fluorescent and Incandescent lamp.
4. Explain types of switches with their symbol and usages.
5. List out any ten tools and describe any five of them.
6. Explain types of power circuit with their symbols.

Write long answer to the following questions.

1. Explain different types of lamps with necessary diagrams.
2. Mention any sixteen tools and describe any eight of them.
3. Explain different types of switches and holder.

Project Work

1. Collect the different tools and identify their name and function.
2. Collect the different materials and identify them and theirs uses.
3. Chart paper work(types of switches with their symbol)
4. Chart paper work(types of lamp)
5. Chart paper work(types of power socket with their symbol).
6. Identification of phase, Neutral and Earth wires for connection to domestic electrical appliances and their connections to three pin plugs.

Unit 4 Protective Devices and Earthing and Lightning Protection System

4.1 Necessity of Protective Devices

Current flow in the conductor generates heat and excessive heat can damage the electrical components. All conductors have certain current carrying capacity. The flow of current beyond the rating of equipment or ampacity of conductor heats the devices. Excessive current is referred to as overcurrent. So, protective devices for overcurrent are used to protect conductors and equipment from excessive flow of current.

Overcurrent may result from overload, short circuit or ground fault. Overload occurs when too many devices operate from single circuit or the equipment is made to work harder than it is designed for. For example- A power socket rated 16A is designed to operate at 16A but if an equipment which draws more than 16A is plugged in, the power socket is overloaded.

Short circuit occurs when there is a direct but unplanned connection between phases or phase and neutral conductors. Short circuit can rise very high current and lead to rise in temperatures melting the conductors and devices. Negligible resistances during short circuit causes a large amount of flow of current, which could lead to excessive heat and damage of devices.

Figure 4.1: Fire due to overload and short circuit

4.2. Advantages of Protective Devices

Protective devices are required because abnormal conditions like overload, short circuit, earth fault, etc. occur in electric circuits. Complete elimination of these abnormal conditions from circuits are not possible.

Protective devices are important because they protect the installation under fault conditions. Therefore, consumers are not injured or killed as a result of an electrical fault. Hence, protective devices ensure safety of electrical installation, prevention against electrical accidents and human casualties

4.3. Different Types of Fuses (Rewirable and Non-rewirable Fuses)

There are different protective devices used against overcurrent protection. Some of the common overcurrent protective devices are fuses, circuit breakers, etc. Fuse is the simplest and cheapest protective device used for protection against short circuit and overloads. It is a piece of wire which melts when excessive amount of current flows through the circuit. Here, excessive amount means the amount of current exceeding the current carrying capacity (Ampacity) of the conductor.

There are several different types of fuses depending on the construction. Following are the major types of low voltage fuses on the basis of construction:

i. Rewire able fuse

ii. Link type Cartridge or High rupturing capacity (HRC) fuse

4.3.1 Rewireable Fuse

Rewireable Fuse is the most commonly used fuse in house wiring and industries for small current appliances. This fuse is also known as rewirable fuse. Rewirable fuse consists of two basic parts- fuse element in a fuse carrier and base. The fuse element is made of tinned copper, Aluminum, Lead etc. and the base is made up of porcelain, glass or mica.

The main advantage of rewirable fuse is it can be re-wired easily once it is blown due to short circuit or overloads, but nowadays it is absolute.

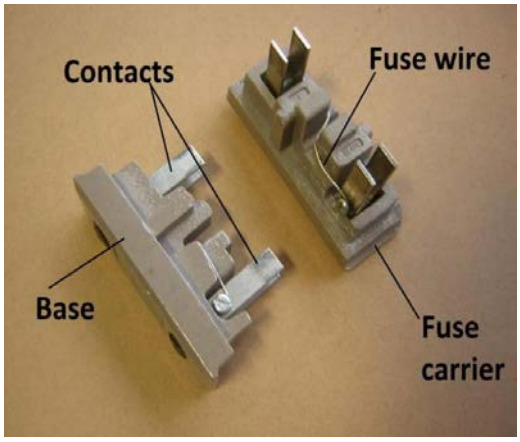


Figure 4.2: Rewire able fuse

4.3.2 Cartridge Fuse

In a cartridge type or totally enclosed fuse, the fuse element is fitted into an enclosed container. It has metal contacts on both sides. A cartridge fuse is further classified into a D-type cartridge fuse and a link type cartridge fuse.

The main parts of a D-type cartridge fuse are the base, adapter ring, cartridge and a fuse cap. The cartridge is kept in the fuse cap, and the fuse cap is fixed to the fuse base.

In a link type cartridge fuse or High Rupturing Capacity (HRC) fuse, the fuse element needs to be replaced after each operation. This fuse is maintenance free fuse. The enclosure of the HRC fuse is filled with powdered quartz, which acts as heat absorbing material. Silver or copper wire is used to make the fuse wire.

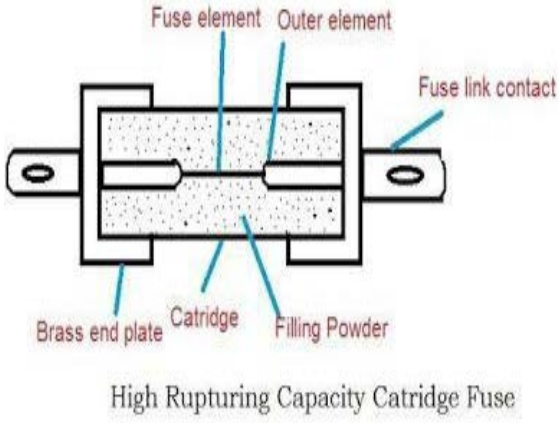


Figure 4.3: Cartridge fuse

4.4. Concept of fuse, MCB and their Functions

Fuse is an electromechanical device installed to protect the circuit against overloads and short- circuit. The heat produced by overcurrent causes the current carrying element of a fuse to melt. When the fuse melts, the load is disconnected from the source.

Construction of a Fuse

A general fuse consists of a low resistance metallic wire enclosed in a non-combustible material. The fuse consists of a fuse carrier, base body and fuse element. The base body and fuse carrier are made up of ceramic, glass, PVC or mica. Fuse is connected in series with a circuit and device.

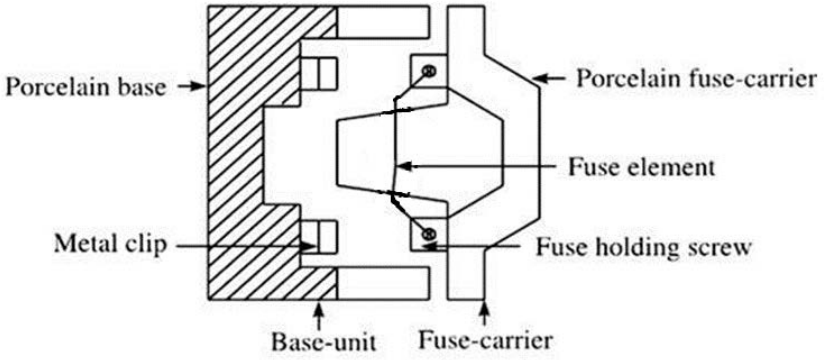


Figure 4.4: Construction diagram of rewire able fuse

Working Principle of a Fuse

The working principle of a fuse is based on the heating effect of current. Whenever overcurrent flows in a circuit, the fuse element melts from the heat generated. Therefore, it disconnects the power supply and electric circuit.

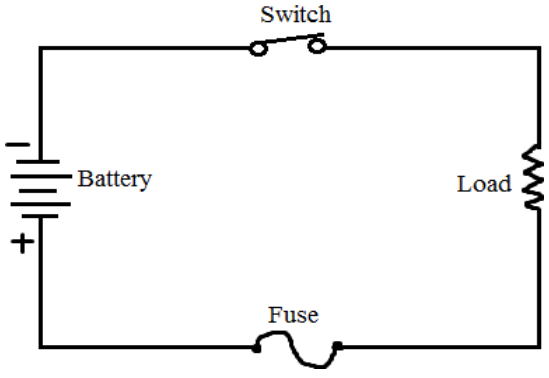


Figure 4.5: Simple circuit to study fuse principle

Miniature Circuit Breaker (MCB)

The word 'miniature' means 'very small' and 'circuit breaker' means a protective device designed to open or close a circuit. Therefore, MCB can be defined as a small device which is used for circuit protection. This device opens a circuit during short circuit and overload.

MCBs are reusable where fuses are not. They are much easier to use, with on/off switching for Circuit isolation. A circuit breaker acts as a switch, and opens when excessive current flows in a circuit. It can be reset without damage.

Construction of a MCB

Figure 4.5: Construction of MCB

MCB consists of incoming terminal, copper braid, arc chute, magnetic coil, ON/OFF Switch, bimetallic strip and outgoing terminal.

At the incoming terminal, the incoming phase is connected. Copper braid connects the moving element with the static element. Arc chute helps to confine the arc and prevent it from causing the damage. Arc chute extinguishes the arc, which is produced due to heavy current. Magnetic coil is part of the thermal tripping arrangement. During short circuit, a magnetic field is formed which attracts the plunger towards it and the switch is turned off.

Bimetallic strip uses two different metals of different thermal expansion. When overload occurs, the metals expand in a different rate and the circuit is open. Outgoing terminal is from where the phase that entered through the incoming terminal leaves the MCB.

4.5. Selection and Identification of Fuse/MCB and their Ratings

Fuse is very simple in construction and cheaper in cost in comparison to MCB. An MCB is a better alternative to a fuse since it does not require replacement once an overload is detected. MCB can be easily operated and offers greater convenience and improved operational safety.

MCB is usually available in the range of 1A to 125A. Its Short Circuit rating is given in Kiloamps. The standard ratings of MCB are 1A, 2A, 3A, 4A, 6A, 10A, 13A, 16A, 20A, 25A, 32A, 40A, 50A, 63A, 100A & 125A .

Figure 4.6: SP MCB, DP MCB, TP MCB, TPN MCB and 4P MCB (from left to right)

MCB on the basis of number of poles are as follows:

Single Pole (SP) MCB

SP MCB provides switching and protection only for one phase of a circuit.

Double Pole (DP) MCB and SPN (Single pole and neutral) MCB

DP MCB provides switching and protection to DC circuit, positive and negative, and SPN MCB provides protection to phase wire and switching of both.

Triple Pole (TP) MCB

TP MCB provides switching and protection for three phases of a circuit but not to the neutral.

Three Pole with Neutral (TPN) MCB

TPN MCB provides switching and protection for three phases of a circuit and additionally Neutral is also a part of the MCB as a separate pole. Neutral pole is without any protection and can only be switched.

Four Pole (4P) MCB

4P MCB provides switching and protection for three phases and neutral of a circuit. This MCB should be used in cases where there is possibility of high neutral current flow through the circuit as in case of an unbalanced circuit.

If the proper rating is not selected on a particular circuit, there will be no proper functions of MCB at overload. Therefore it is very important to select the right rating of MCB.

4.6. Concept of Molded Case Circuit Breaker (MCCB), Residual Current Circuit Breaker (RCCB) and Residual Current Breaker with Overload Protection (RCBO)

Molded Case Circuit Breaker (MCCB)

Molded Case Circuit Breaker (MCCB) is an automatic electrical protective device used to protect the electrical equipment from short circuit and overload. It is an advanced version of MCB. It can be used for higher current rating and fault level. It is mostly used in industrial applications. It can be used for the protection of motors, capacitor banks, generator protection, etc. MCCB with adjustable overload setting are available.

Figure 4.6: MCCB

Residual Current Circuit Breaker (RCCB)

Fuses and MCBs do not protect humans against electric shocks caused by earth leakage. To obtain this safety, RCCB or RCBO are used. RCCB or RCD is designed to detect and disconnect supply in the event of earth fault, for example when a live conductor touches an earthed equipment case. It also protects against electrocution or shock caused by direct contact. This protection is achieved by monitoring the current flow in the line and neutral.

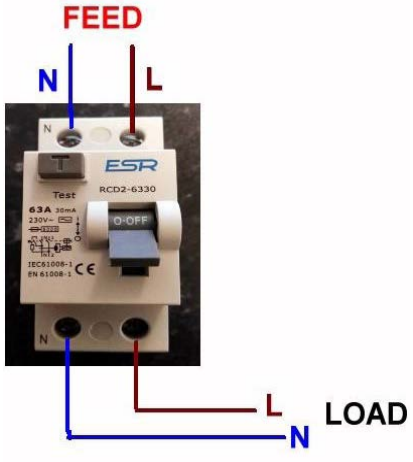


Figure 4.7: RCCB

In a healthy circuit, the current flow through the line equals the return flow through the neutral but the return flow may not be equal to the line's current flow in the event of any abnormalities. RCD will sense this and interrupt the circuit.

Figure 4.8: Residual Current Breaker with Overload Protection (RCBO)

A residual current breaker with overcurrent (RCBO) is used in applications where there is need for combined protection against both overcurrent and earth leakage faults.

The RCBO combines the functionality of an MCB and RCD/RCCB. When there is a current leakage, the RCBO trips the entire circuit. Also, internal magnetic/thermal circuit breaker components can trip the electronic device when the circuit is overloaded.

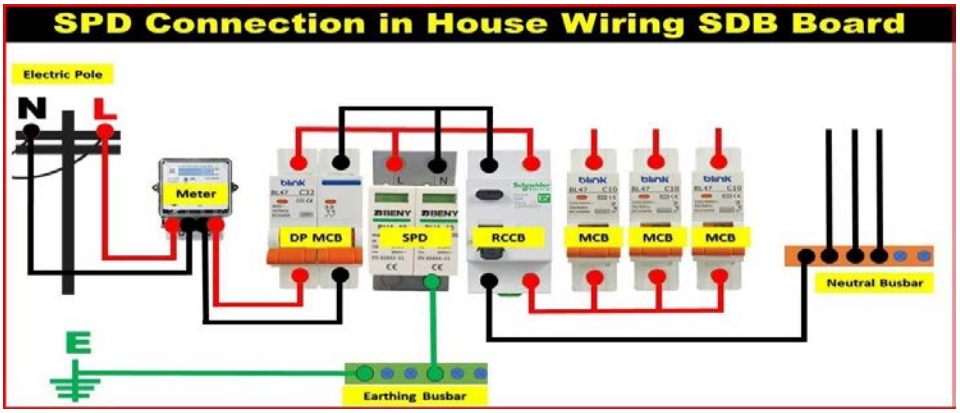
4.7 Concept of Surge Protective Devices (SPD)

Surge Protection Device (SPD) is a component of the electrical installation protection system used to protect against over voltages or electrical power surges.

Figure 4.9: SPD

It is connected in parallel on the power supply circuit of the loads that it has to protect. SPDs are also used to protect sensitive electronic equipment connected to the installation.

Equipment with sensitive electronic circuitry can be vulnerable to damage by transient over voltages. The effects of a surge can result in either instant failure or damage to the equipment.



There are three different types of SPDs:

- Type 1 SPD installed at the Main Distribution Board
- Type 2 SPD installed at the Sub-Distribution Board
- Type 3 SPD installed close to the load to be protected

4.8 Introduction to Earthing

Earthing and its Types (Equipment and System earthing)

Earthing is done by connecting an appliance or machinery to the earth using a conductor known as an earth electrode. Earthing is done to project human life from the danger of electrical shock, in case a human body comes in contact with metallic parts of machinery that are accidentally energized.

If earthing is done correctly and when the metallic part comes in contact with a live wire, it will be discharged to the earth.

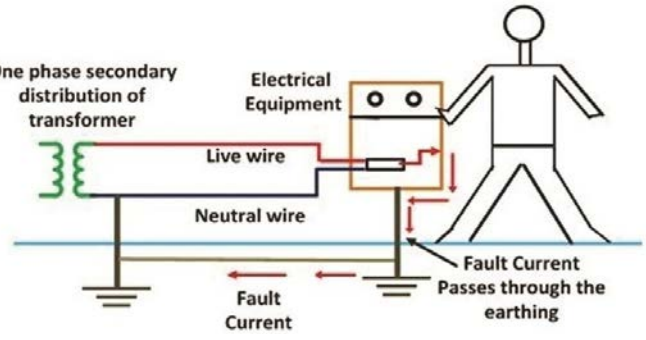


Figure 4.10: Earthing

Points to be Earthed

1. Earth pins of 3-pin and 5- pin plugs and socket
2. All metallic parts of the electric machines
3. Metallic frames of electrical machines
4. Neutral conductor of a 3-phase 4-wire system
5. Pole, towers, and cable armoring
6. Stay wires of overhead lines

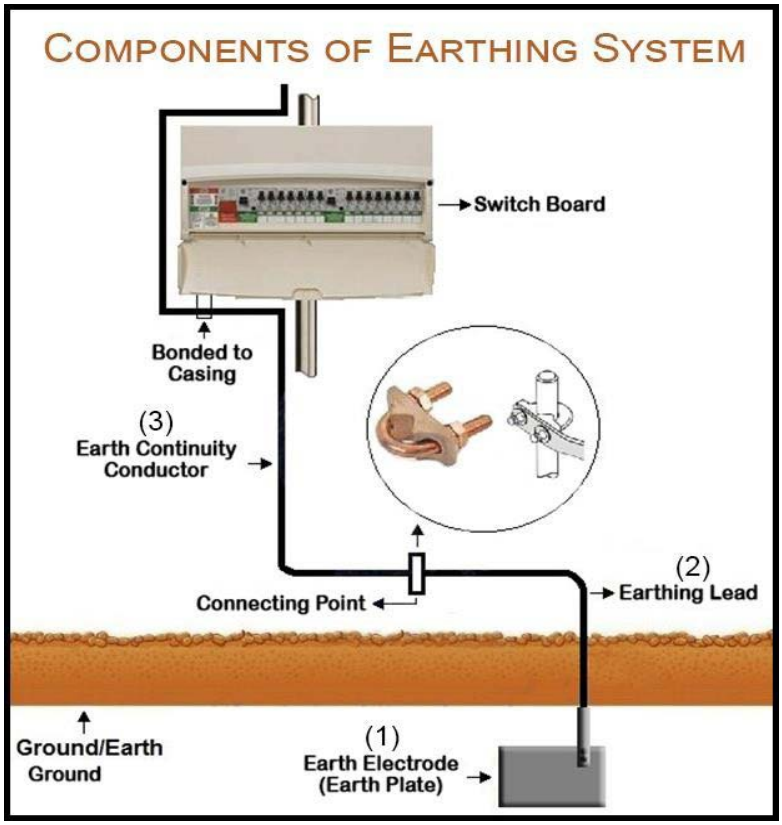


Figure 4.11: Components of earthing system

Types of Earthing

The electrical equipment mainly consists of two non- current carrying parts. They are neutral of the system and frame of the electrical equipment. Earthing can be classified into two types: Equipment earthing and neutral earthing.

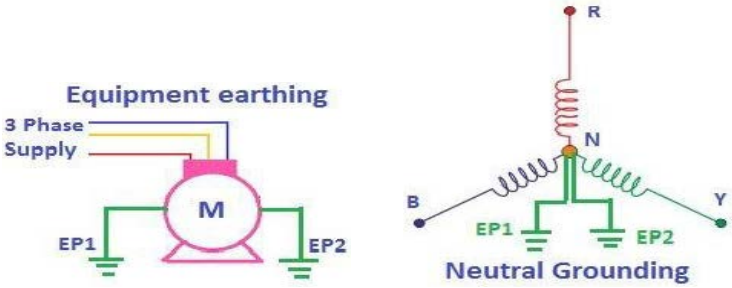


Figure 4.12: Types of earthing

Equipment or Body Earthing

The earthing in which the non-current carrying part of the equipment like their metallic frame is connected to the earth by the help of the conducting wire is called equipment earthing. If any fault occurs in the apparatus, the leakage current passes to the earth.

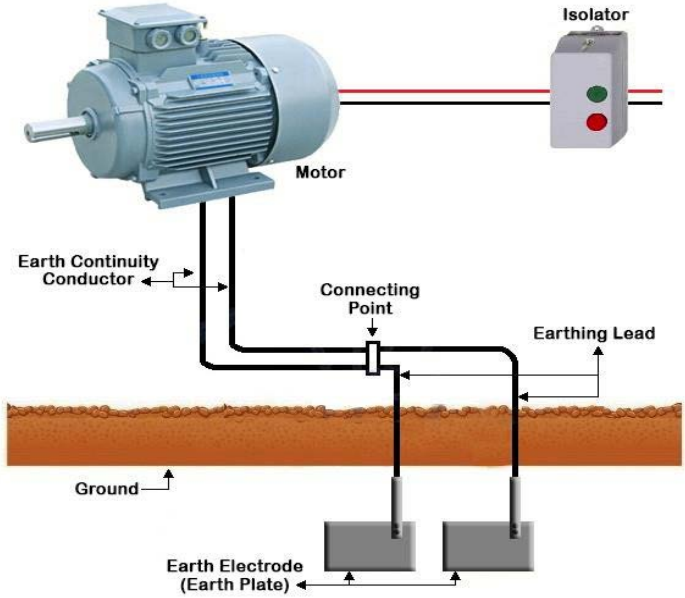


Figure 4.13: Equipment or body earthing

Equipment earthing ensure the body, structure and non-current carrying parts are held at earth potential so are safe to touch and provide path for fault current that causes MCB trip.

Neutral Earthing (System Earthing)

The earthing in which the neutral of the system is directly connected to the earth is called neutral earthing. Such kind of earthing is mostly provided to the system which has star winding. The neutral earthing is provided in the generator, transformer, etc.

System earthing ensure that the current carrying mid points of generator, transformer are held at earth potential by connecting this point to the general mass of earth "electrode" and return path is available to neutral current.

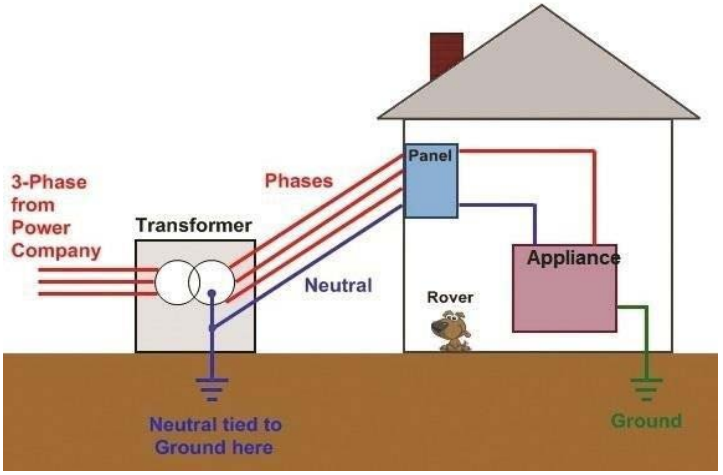


Figure 4.14: Neutral earthing

Methods of Earthing (Rod, Pipe, Strip and Plate)

Earthing can be done using several kinds of low-resistance earth electrode. On the basis of construction of earth electrode, the methods of earthing are as follows:

1. Strip Earthing

In this type of earthing, galvanized iron strip or copper strip are laid in horizontal trenches at a certain depth. This type of earthing is used in place where the land is rocky and digging is difficult. Generally, GI strip should not be of size less than 25mm X 4 mm or copper strip of 25mm X 1.6mm are laid in horizontal trenches of minimum depth of 0.5 meter.

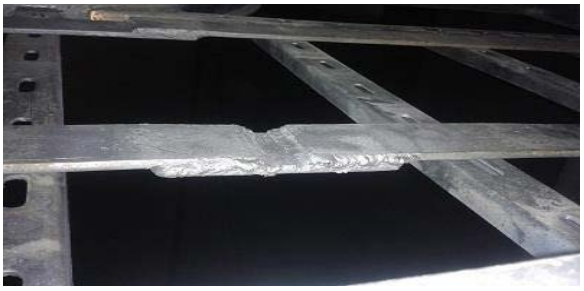


Figure 4.15: Strip earthing

2. Rod Earthing

In this type of earthing, a solid rod of copper or galvanized irons are fitted vertically into the earth not less than 2.5 meter on earth surface. This type of earthing is used in

places where there is less moisture in the earth and have to dig a deep hole.

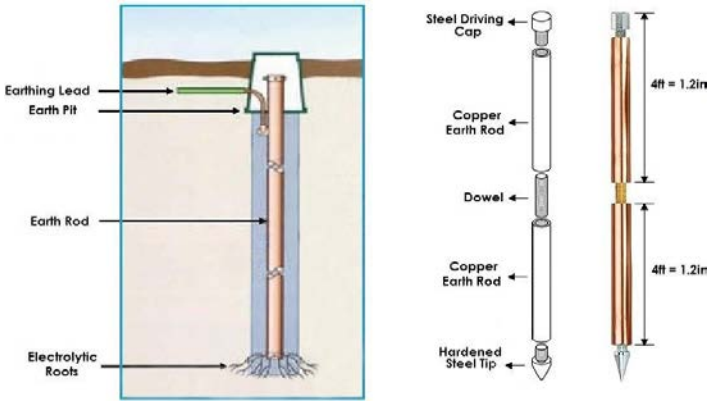


Figure 4.16: Rod earthing

3. Pipe Earthing

In this type of earthing, a hollow pipe of about 2.5 metres long is placed underground. This is a cheaper method of earthing.

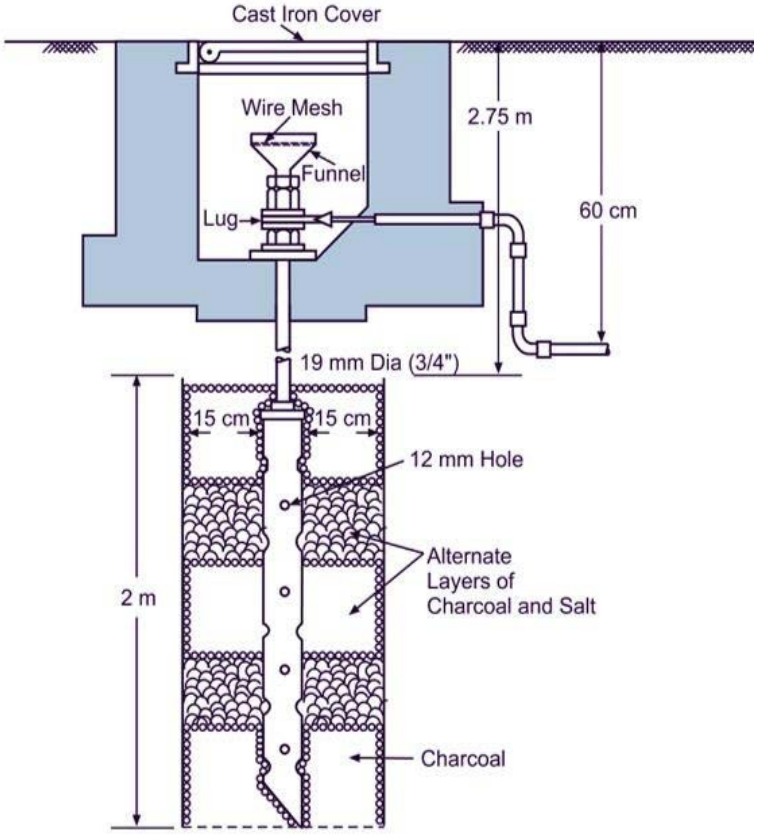


Figure 4.17: Pipe earthing

4. Plate Earthing

In this type of earthing, a plate of either copper or galvanized iron is buried vertically in the earth pit. This type of earthing is mostly used in commercial and industrial buildings.

Generally a plate of either copper with dimensions 60cm X 60cm X 3.18mm or galvanized iron of dimensions 60cm X 60cm X 6.35mm is buried vertical in the earth pit, which should not be less than 3 meters from the surface of ground.

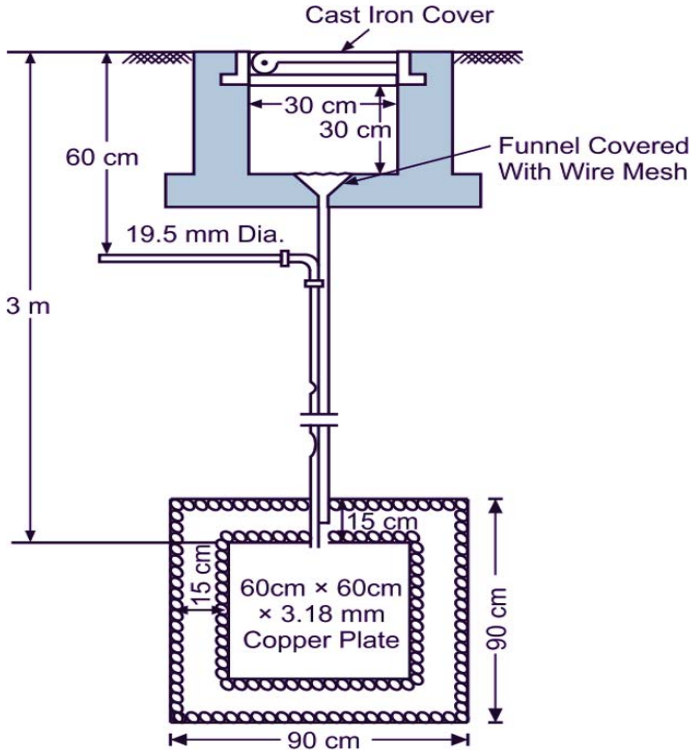


Figure 4.18: Plate earthing

Types of Earthing Materials

Earthing materials may be made up of Copper, Aluminum or Galvanized Iron (GI). Main earthing terminals the main protective conductor, and the earthing conductor are essential Earthing materials. Besides these materials, chemicals to reduce earthing resistance are also required in some cases.

Main Earthing Terminals

A terminal or bar provided for the connection of protective conductors, main equipotential bonding conductors and conductors for functional earthing to the earthing. Main protective

conductor: A conductor that connects the main earthing terminal or bar to the supply neutral.

Earthing conductor: A conductor connecting the main earthing terminal or bar to the earth electrode.

Importance of Earthing

1. It saves human life from the danger of shock from leakage current.
2. It maintains the line voltage constant.
3. It protects buildings/ machines from atmospheric lightning.
4. It avoids the risk of accidents.

4.9 Lightning Protection System (LPS) in Buildings

Atmospheric lightning is a form of visible discharge of electricity between clouds or cloud and the earth. The electric discharge is seen in the form of an arc between cloud and earth surface. When the electrical potential between two clouds, or a cloud and the earth reaches a sufficiently high value the air becomes ionized along a narrow path and results in lightning flashes.

The possibility of lightning is more on tall trees and buildings rather than the ground. Buildings are protected from lightning by the following ways:

1. Lightning rod
2. Lightning rod with taut wires
3. Lightning conductor with meshed cage

4.9.1 Lightning Rod (Spike)

The lightning rod is a metallic rod placed at the highest part of the roof and it is extended to ground through conductor/s. The conductor is a thick copper or GI strip which runs down the building. The lower edge of the strip is connected to the earth.

When lightning strikes on the rod, the current flows down through the strip. The rod provides a low- resistance path for the lightning discharge and prevents it from travelling through the structure of a building itself.

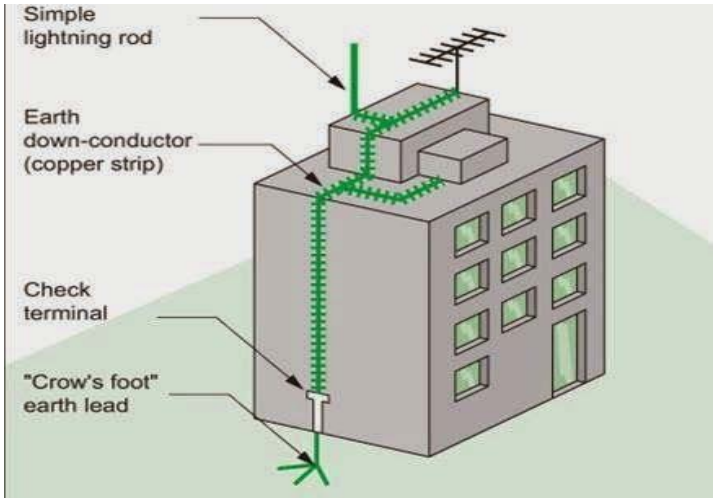


Figure 4.19: Lightning rod

4.9.2 Lightning Rod with Taut Wires

The taut wires are stretched above the building to be protected with the help of metal post. The metal posts are earthed by connecting them together.

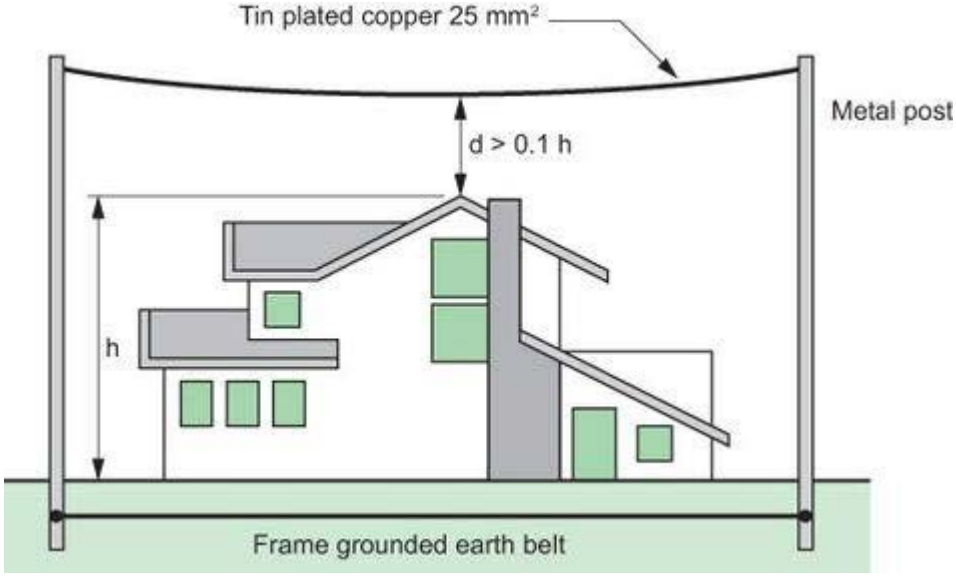


Figure 4.20: Lightning rod with taut wire

4.9.3 Lightning Conductor with Meshed Cage

In this kind of protection, the protection involves air terminations connected to roof, placing numerous down conductors symmetrically all around the building and is terminated in earth electrodes. All metallic projections, vent pipes, fan housings, etc.

above the main surface of the roof structure shall be bonded to and form part of the air termination network.

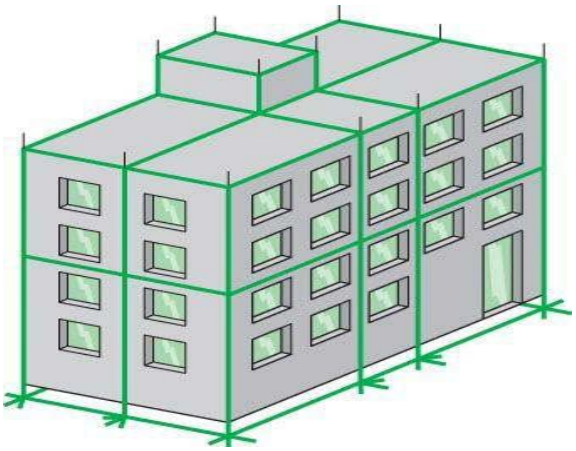


Figure 4.21: Lightning conductor with meshed cage

Exercise

Choose the correct answer from the given alternatives.

1. HRC fuse is employed for protection against.....

a. Sparking b. Lighting c. Short circuit d. All of above

2. A fuse is.....

a. Normally inserted in phase wire

b. Normally inserted in neutral wire

c. Never inserted in neutral wire

d. Never inserted in phase wire

3. The rating of a fuse wire is always expressed in.....

a. Volts b. Amperes c. Amperes volts d. Ampere hour

4. Overload currents occur when.....

a. Equipment is overloaded b. Installation is abused

c. Installation has been badly designed d. All of the above

5. One of the devices is not used for protection.....

a. RCB b. MCB c. Fuse d. Socket

Write short answer to the following questions.

1. Write Differences between Rewireable and non-rewireable fuse.
2. Explain fuse and MCB with their functions.
3. Define earthing. Why is it done? What are the importances of earthing?
4. List out the methods of earthing. Explain any one of them in detail.
5. Explain lightning protection system in buildings.
6. Write short notes:

a. MCCB b. RCCB c. RCBO d. SPD

Write long answer to the following questions.

1. Explain different types of methods of earthing.
2. Explain fuse, MCB, MCCB, RCBO, RCCB.
3. What are the necessity and advantages of protective devices? Explain lightning protection system.

Project Work

1. Demonstrate them types of fuses.(rewire able and non re wire able)
2. Demonstrate the function of fuse and MCB.
3. Identify fuse/MCB and their ratings
4. Familiarization with MCCB,RCCB,RCBO,SPD.
5. Methods of earthing system (videos)
6. Lightning protection related videos

Electrical wiring system

Unit 5

5.1 Introduction to Wiring System

A network of wires from the supplier meter board to the numerous electrical energy consuming devices such as lamps, fans and other domestic appliances through controlling and safety devices is known as a wiring system. The network of wires connects various accessories for distribution of electrical energy.

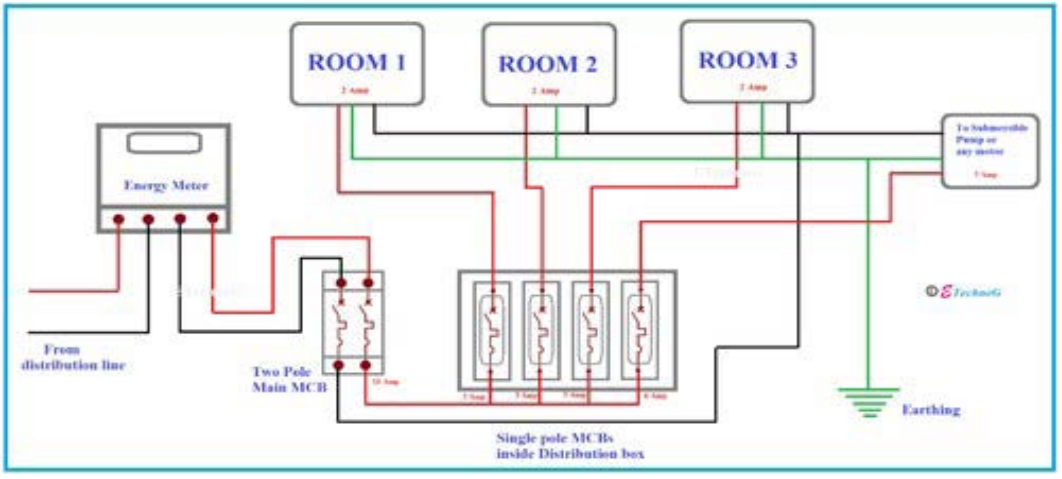


Figure 5.1: Single phase wiring system

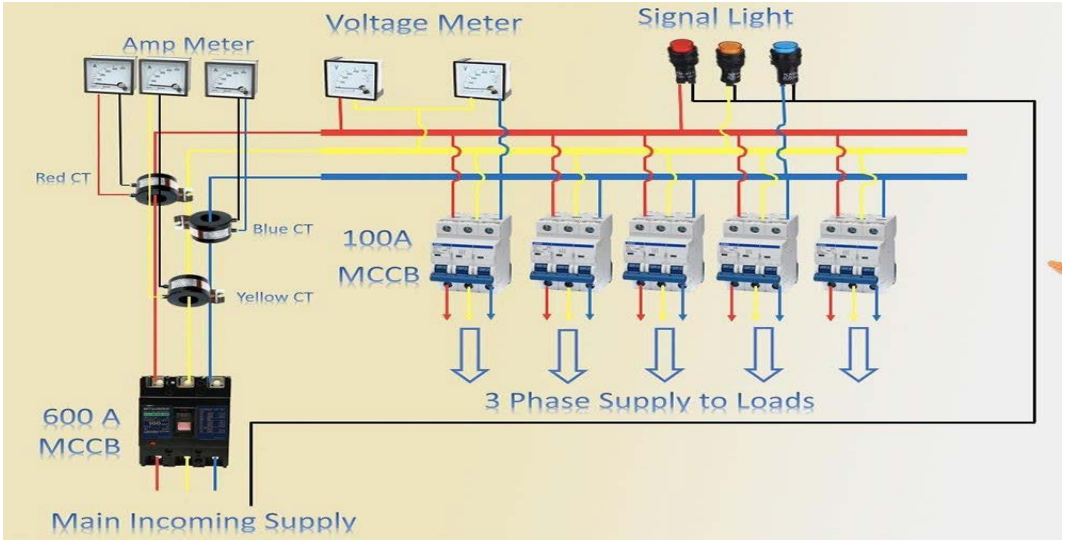


Figure 5.2: Three phase wiring system

Wiring system are mainly classified into following two types:

- Tree System
- Distribution system

Tree System

In this system smaller branches are taken from the main branch and the wiring system resembles a tree. As each branch is taken off, a fuse is inserted. This system used to be employed in early days. Now a days it is no more adopted because of several drawbacks.

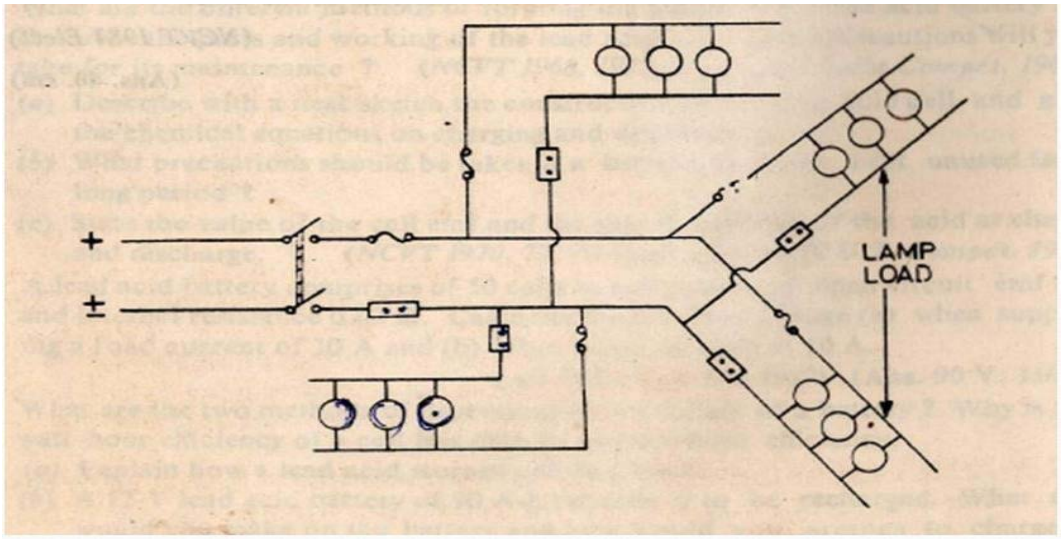


Figure 5.3: Tree system

Disadvantages of Tree Wire System

(i) The voltage across all the lamps does not remain the same. The lamps in the last branch will have the least voltage across them on account of voltage drop in leads.

(ii) A number of joints are involved in every circuit.

(iii) Fuses are scattered.

(iv) In case of occurrence of faults, all the joints have to be located. Hence it is difficult to find out every joints.

All these disadvantages of Tree Wire System are solved in Distribution board Wire system.

Distribution Board System

In distribution board system, the fuses/MCBs of various circuits are grouped together on

a distribution board. It is the most commonly adopted method for distribution of electrical in a building.

The two copper strips known as bus bars fixed in a distribution board of PVC or metal case are connected to the supply mains through a double pole iron clad (DPIC) switch or double pole isolator so that the installation can be switched off. A fuse or Single pole MCB is inserted in the phase of each circuit so that each circuit is connected up through its own protective device. The number of circuits and sub-circuits is decided as per number of points to be wired and load to be connected to the supply system.

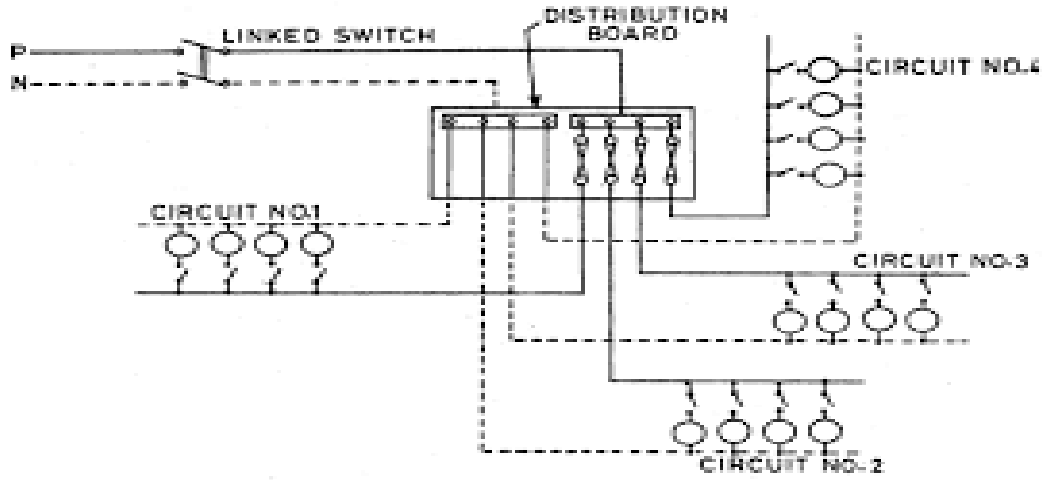


Figure 5.4: Distribution system

5.2 Type of Wiring, Accessories, Advantages and Disadvantages

The wiring that are into practices these days are PVC casing capping, Conduit wiring and Trunking wiring.

• PVC casing and capping system

In this system of wiring, PVC wires are carried through the PVC casing enclosure and capping is used to cover the casing.

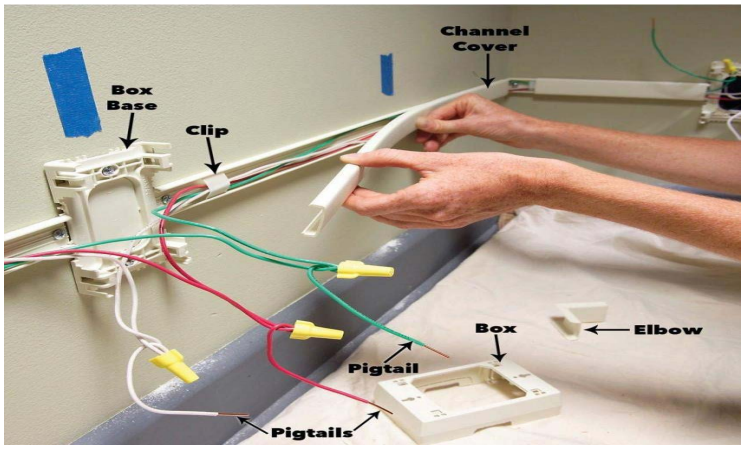


Figure 5.5: PVC casing and capping system

Advantages

1. It is cheaper and easier to install
2. It is strong and durable wiring
3. There are no risks of electric shock.
4. It is safe from smoke, dust, rain etc.

Disadvantages

1. It is not suitable for weather with high humidity and acidic conditions
2. There is risk of fire.

Conduit Wiring System

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 fiber and can be rigid or flexible.

Conduit wiring is safe, aesthetically good, no risk of shock, no risks of fire and damage to cable insulation, long lasing etc.

The conduit wiring system consists various accessories and fittings. The accessories used are:

1. **Conduits Coupler:** Used to join two lengths of conduits
2. **Bends, Elbows and Tees:** Bends are used for change in direction of conduits, Elbows are used where sudden right turn is required Conduit Bushings

3. **Conduit Bushings:** Used when the rigid conduit enters the conduit box or a hole which is not threaded

4. **Conduit Reducers:** Used when the size conduit changes

Figure 5.6: Conduit coupler

For fitting of conduits, lock nuts or check nuts, conduit nipples and conduit boxes are used.

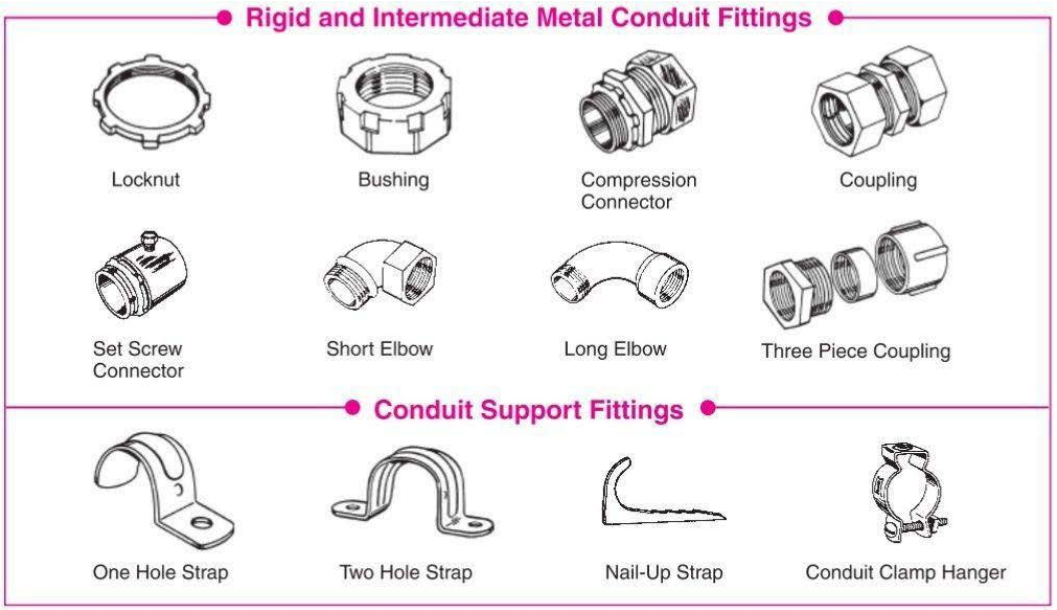


Figure 5.7: Conduit accessories

Conduit Wiring are of Two Types

1. Surface Conduit wiring
2. Concealed Conduit wiring

Surface Conduit Wiring is done on the outside of the wall. It is not easy to customize for future. Also it is not hard to detect the faults by visual inspection in this kind of wiring.

Figure 5.8: Surface conduit wiring

Concealed wiring is done under the plaster of the wall of the building. Conduit pipes are buried under the plaster of the wall with the help of GI wires.

Figure 5.9: Concealed conduit wiring

The advantages and disadvantages of conduit wiring are as follows:-

Advantages

1. It is the safest wiring system (Concealed conduit wring)
2. Appearance is very beautiful (in case of concealed conduit wiring)
3. No risk of mechanical wear & tear and fire in case of metallic pipe
4. Customization can be easily done according to the future needs
5. There is no risk of damage the cables insulation

6. It is safe from corrosion (in case of PVC conduit) and risk of fire
7. It can be used even in humidity, chemical effect and smoky areas
8. No risk of electric shock (In case of proper earthing and grounding of metallic pipes)
9. It is reliable and popular wiring system
10. Sustainable and long-lasting wiring system

Disadvantages

1. It is expensive wiring system (Due to PVC and Metallic pipes, Additional earthing for metallic pipes etc.
2. Very hard to find the defects in the wiring
3. Installation is not easy and simple
4. Risk of electric shock (In case of metallic pipes without proper earthing system)
5. Very complicated to manage additional connection in the future

Trunking Wiring System

Trunking wiring system is often used in place of the larger sizes of conduit. A trunking is an enclosure that provides for the protection of cables. It is normally square or rectangular in cross section, and has a removable lid.

Trunking forms the backbone or framework of an installation. Conduits run from the trunking to accessory outlet boxes.

Figure 5.10 : Trunking wiring system

Advantages

1. No risk of damage of cable insulation as the cables are enclosed in trunking.

2. Cables are safe against dust and humidity.
3. Longer life of cables

Disadvantages

1. Expensive as compared to other wiring system
2. Good workmanship required to ensure a successful installation

5.3 Selection of Wiring

The choice of wiring system is affected by many factors such as the type of building, temperature, safety, cost etc. The factors affecting the selection of wiring are as follows:

1. Current carrying capacity and voltage drop
2. Type of Building construction – to decide the routing, fixing and terminations
3. Flexibility of the system – change of location of equipment such as in machine shops and temporary buildings.
4. Installation conditions – protection against mechanical damage requirements and working heights.
5. Appearance of the finished installation –surface or concealed
6. Durability – life of the installation.
7. Economics – cost of the installation and money available.
8. Safety aspect

5.4 General Rules of Wiring

1. Every installation is to be properly protected near the point of entry of supply cables by a two –pole linked isolator and a MCB or fuse.
2. In a two-wire installation, in neutral conductor no fuse, switch or CB is to be inserted.
3. The conductor used is to be of such a size that it may carry load current safely.
4. Every sub-circuit is to be connected to a distribution board.
5. Every phase is to be protected by an overcurrent device of suitable rating as per requirements.
6. All plugs and socket outlets are to be 3 pin type, the appropriate pin of socket being connected permanently to the earthing system.
7. Adequate number of socket outlets are to be provided.
8. In metal conduit wiring, metal conduit pipe is to be earthed.

9. In any building, there must be separate sub-circuits for light/ fan and power sockets for power loads.

10. The earthed terminals of all 3 pin socket outlets and plugs should be permanently connected to the earth wire.

5.5 Types and Sizes of Wire in Metric Unit

For wiring, 250/440 Volts and insulation level 1kV grade wires are normally used. The wires available in the market are usually denoted by cross sectional area in square mm. Multistranded wires are predominantly used these days. There are different sizes available in multi strand flexible wire with 1 sq. mm, 1.5 sq. mm, 2.5 sq. mm and 4 sq. mm.

5.6 Technical Drawings and Specifications as Per Standards Related to Wiring

Technical drawings contain all the information necessary for the installation contractor to bid on and install a particular project. The preparation of technical drawings provides a detailed record of the design and installation requirements of the works.

Technical drawings may include design drawings and installation drawings.

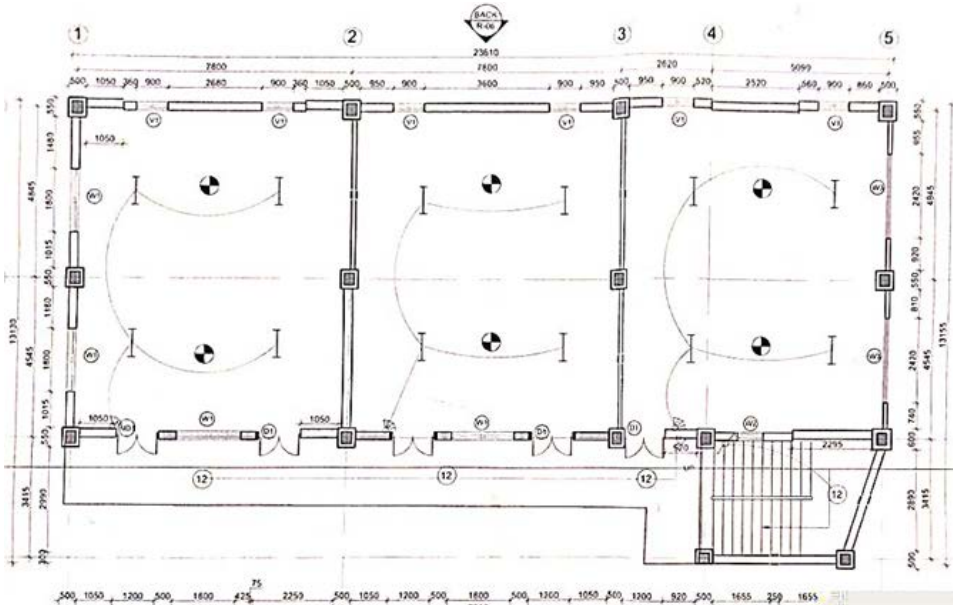
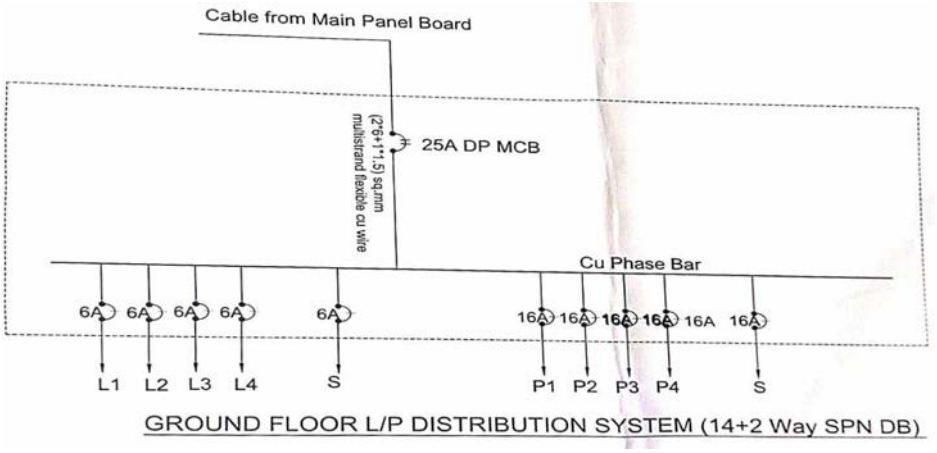


Figure 5.11: Electrical plan for ground floor



Electrical works are carried out in accordance with the drawings. All wiring diagrams are called drawings. They indicate the main switch board, distribution boards, runs of various mains and sub mains and the position of all points with their controls.

All electrical works are carried out in accordance with the provisions of Electricity Act, Electricity Rules and standards.

Technical Specifications

A contract or tender document references technical specifications about the specific requirements and installation standards for various elements of a project. Technical specifications include the specifications of different components, how the installation is to be done, the quality of workmanship and methods of testing.

Electrical works may require technical specifications for HT/LT Power and Control cables, cable trays, earthing materials, lightning protection system, Panel boards etc.

Exercise

Choose the correct answer from the given alternatives.

1. Which size of copper wire is used for lighting circuit?

   a. 1sq.mm b. 1.5 sq.mm

   c. 2.5sq.mm d. 4sq.mm

2. PVC wires are usually used for.....

   a. Internal wiring of building and workshops

   b. 6.6kV c. 11kV d. 33kV

3. Which type of wiring is preferred for workshop lighting?

   a. Casing capping wiring b. Batten wiring

   c. Concealed conduit wiring d. Surface conduit wiring

4. Highly skilled labour is required in.....

   a. TRS wiring b. Casing capping wiring

   c. Conduit wiring d. Both conduit and casing and capping wiring

5. The cheapest system of internal wiring is.....

   a. Cleat wiring b. Casing capping c. CTS or TRS d. Conduit

Write short answer to the following questions.

1. Explain the wiring system and distribution system along with their advantages and disadvantages.
2. What are the type of wiring? Explain any one of them in detail.
3. What are the points to be consider for the selection of wiring?
4. Write down any eight rules of wiring.
5. Explain the types and sizes of wiring.

Write long answer to the following questions.

1. What are the types of wiring? Explain any two of them with their advantages and disadvantages.
2. Explain the selection of wiring system and write down the rules of wiring.

Project Work

1. Demonstrate types of wiring. (In group)
2. Familiarization with the different accessories used in wiring installation. (In group)
3. How to read technical drawing with their specification.
4. Identify types and sizes of wire (1.5 sq mm, 2.5 sq mm, 4 sq mm)

Installation of wiring system

Unit 6

6.1 Electric Diagram and Electric Symbol of Accessories used in Domestic Wiring System

In electrical drawings, the symbols are used in layouts and wiring circuits to represent the electrical parts or the function of the circuit. The symbols are not actual drawings but they represent the electrical components or devices. With the help of symbols, an electric circuit can be represented easily and can be described precisely as well. Symbols differ from the standards we follow. Following are some of the examples of BIS symbols used for wiring:

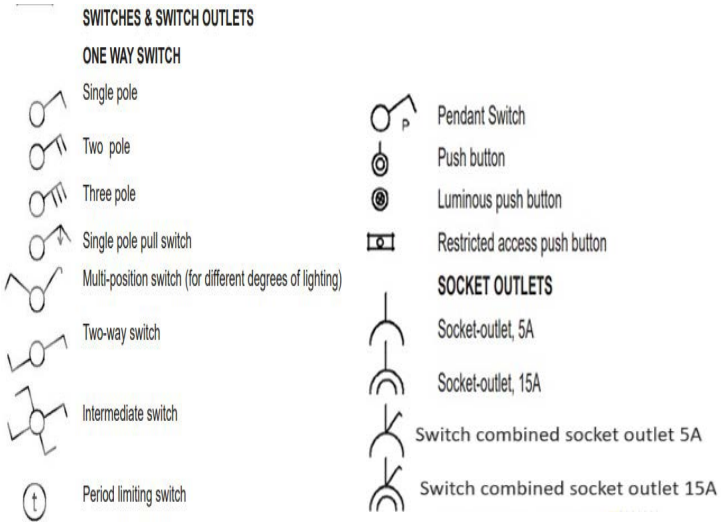


Figure 6.1: Symbols of switches

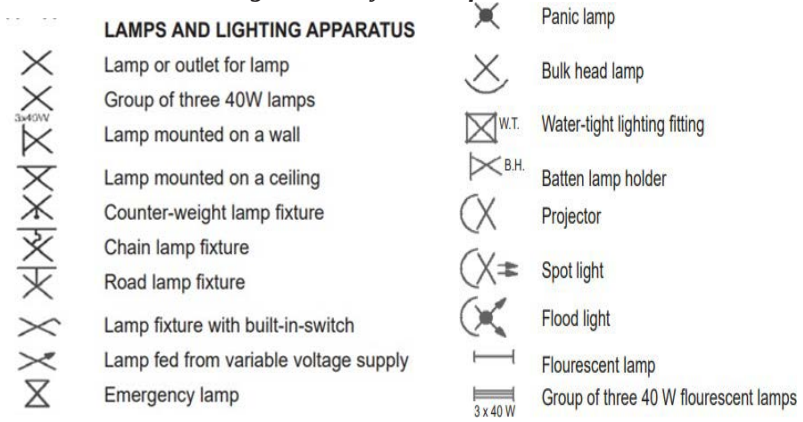


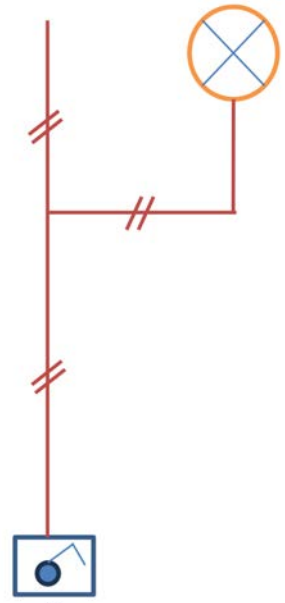
Figure 6.2: Symbols of lamps and lighting apparatus

6.2 Concept of Electrical Diagram and Symbol

In electrical engineering, we use different kinds of drawings or diagrams to represent a certain electrical system or circuit. There are mainly two ways to show electrical circuits in buildings. They are layout and wiring diagrams.

Layout Diagram

This type of diagram represent the electrical connections of devices using single lines. This diagram is also called line diagram and with slashes indicating the number of conductors in the line.



Layout Diagram

Wiring Diagram

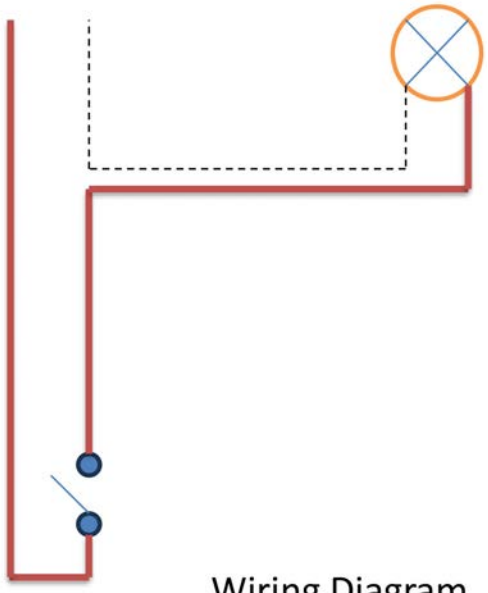
This type of diagram represents the actual connections of electrical devices in a circuit. This uses electrical symbols which is more detail because it shows the wire terminations and connections.

6.3 Installation of Conduits and Draw Wire (use of fish wires)

The following steps are followed for installation of conduits.

Step1: Make a plan

Step2: Cutting



Wiring Diagram

Step 3: Bending

Step 4: Install the fittings

Step 5: Solvent welding joints and cementing

Step 6: Supporting with straps

Step 7: Connect the conduit and the box

Generally, fish wire or GI wire is used for drawing wires and it is made up of steel to pull wire through metal or PVC conduit by twisting and locking its end to the conductor.

Figure 6.4: Fish wire

6.4 Installation of Energy Metering System (Analog, Digital, Smart and Dual Source Energy Meter)

Energy meter is a device used for measuring, indicating and recording consumption of electricity. It is also known as Kilowatt-hour meter because consumption of one kilowatt in one hour is considered as one unit of energy.

Energy meter is classified in accordance with several factors, such as

1. Type of display like analog or digital
2. Type of metering point like grid, primary and secondary distribution
3. End applications like domestic, commercial and industrial load
4. Number of phases like single phase and three phase meter

Electromechanical Induction Type Energy Meter

This meter consists of a rotating aluminum disc mounted on a spindle between two electromagnets. The speed of rotation of disc is proportional to the power and this power is integrated by the use of counter mechanism and gear trains.

This type of meter is simple in construction and accuracy is somewhat less due to creeping and other external fields.

Electronic Energy Meter

Electronic energy meter is accurate, high procession and reliable type of measuring instrument as compared to electromechanical energy meter. It consumes less power and start instantaneously when load current flows. This meter may be analog or digital.

Smart Energy Meter

It is advanced metering technology involving placing intelligent meters to read, process and provide feedback to customers. It measures energy consumption, remotely switches the supply to customers and remotely control the maximum electricity consumption.

This meter can transmit data to the utilities and receive information from utilities. This meter reduces the need to visit for taking or reading monthly bill. This meter is installed in big installations like cinema halls, showrooms, industries etc.

Single Phase Meter

Single phase meter are directly connected to the mains. These meters are used to measure

energy consumed by single phase loads.

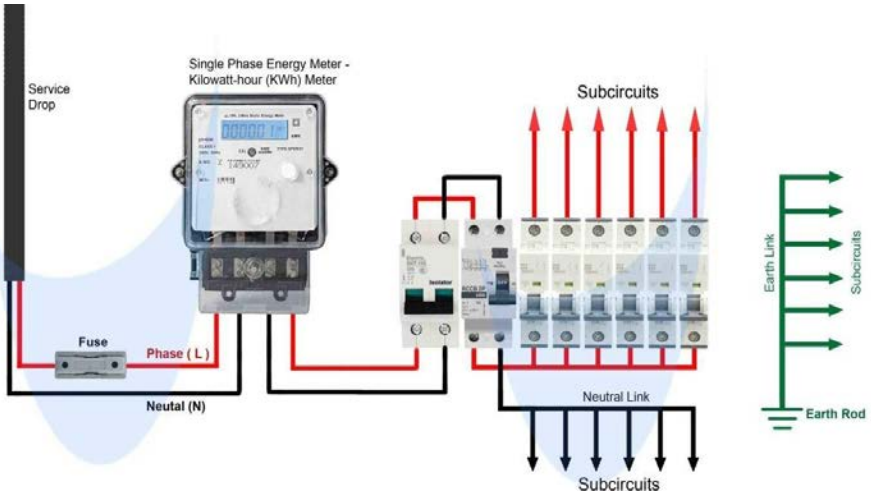


Figure 6.5: Single phase meter supply system

Three Phase Meter

It is a combination of three single phase meters. The entire load current passes through the meter itself. Three phase meter is connected to the supply is a three phase four wire meter.

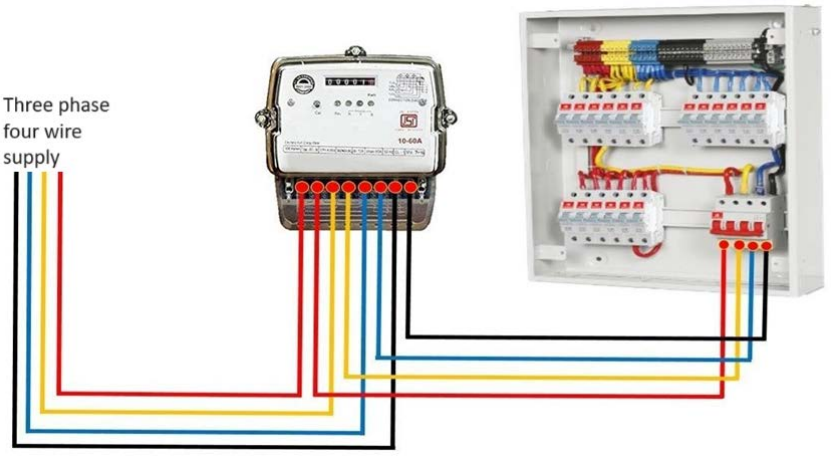


Figure 6.6: Three phase supply system

Dual Source Energy Meter

Dual source energy meter is a digital dual meter used for the measurement of electrical energy for the dual source energy Utility (U) and Generator (G).

Figure 6.7: Dual source energy meter

Location and Installation of Meters

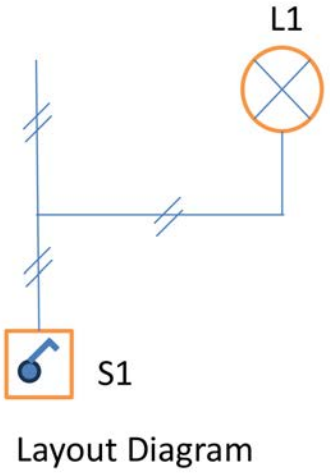
The installation of meters includes the steps given below:

1. Distribution Company shall examine, test and regulate all meters before installation.
2. The meter shall be installed at locations, which are easily accessible for installation, testing, commissioning, reading and maintenance.
3. In case of single phase meters, the consumer shall ensure that there is no common neutral or phase or looping of neutral or phase of two or more consumers on consumer's side wiring.

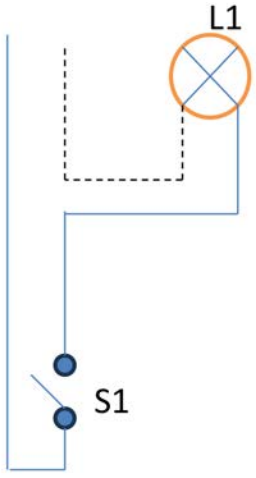
Example of house wiring

1. Draw a wiring diagram and list out the required material for casing and capping wiring system as per given layout diagram below.

Solution



Layout Diagram

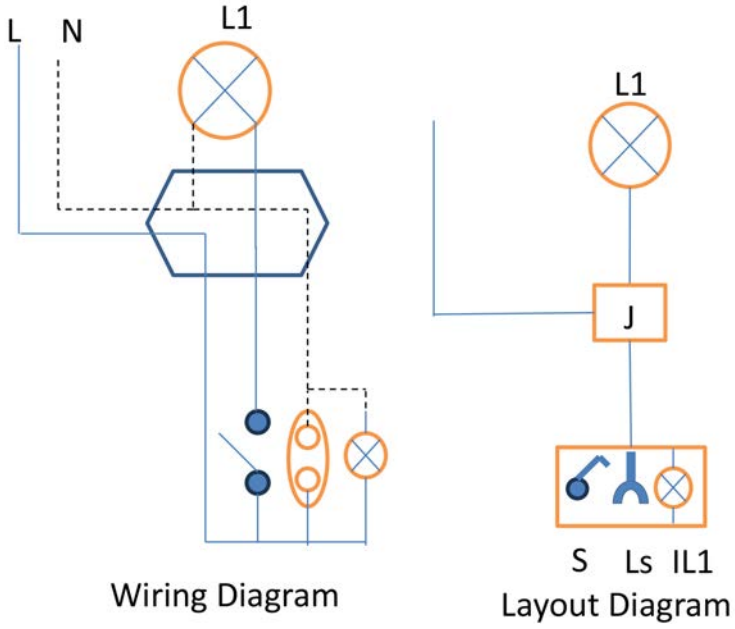


Wiring Diagram

S.N	Materials	Quantity
1	Bulb	1
2	Bulb holder	1
3	One way switch	1
4	One way switch box	1
5	Casing capping	APR
6	Insulation tape	1
7	Screw	APR
8	Wires	APR
9	Grips	APR
APR- As per requirement		

2. Draw a layout diagram from given wiring diagram and list out the required material for casing and capping wiring system.

Soluliton

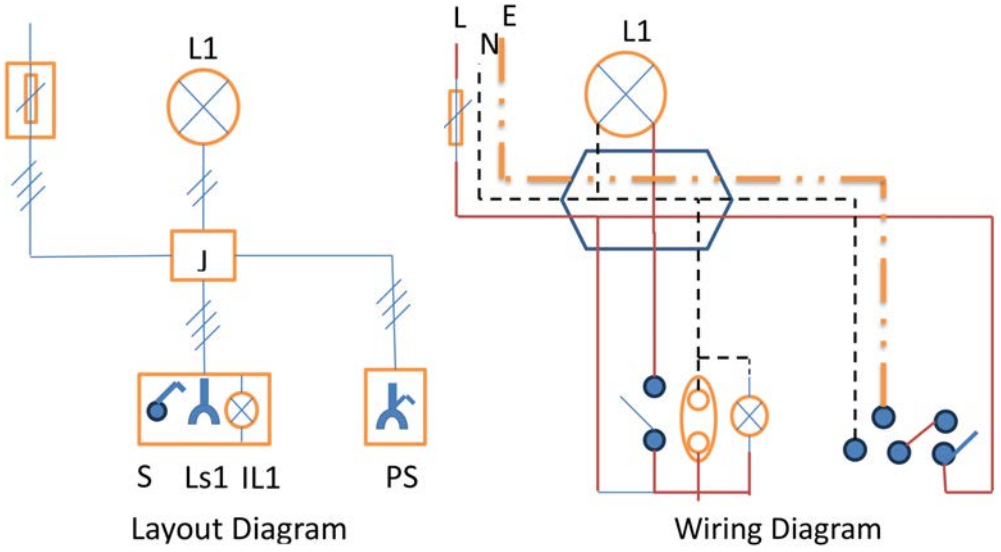


S.N	Materials	Quantity

1	Bulb	1
2	Bulb holder	1
3	One way switch	1
4	Two pin socket	1
5	Indicator	1
6	3 way gang plate	1
7	3 way gang box	1
8	Join box	1
9	Casing capping	APR
10	Insulation tape	1
11	Screw	APR
12	Wires	APR
13	Grips	APR
APR- As per requirement		

3. Draw a wiring diagram and list out the required material for casing and capping wiring system as per given layout diagram below.

Solution:



Required material can be listed as in previous example.

Exercise

Choose the correct answer from the given alternatives.

1. How many light, fan and 6A socket outlet points are recommended for a sub circuit?

   a. 7 b. 10 c. 12 d. 14

2. What is the name of wire used to install conductors in conduit installation?

   a. PVC wire b. Normal wire c. Draw wire d. Soft wire

3. What is the name of wiring if one lamp controlled from two different places?

   a. Go down wiring b. Tunnel wiring

   c. Stair case wiring d. Hostel wiring

4. What type of switch is used in stair case wiring?

   a. One way switch b. Alternate switch

   c. Timer switch d. All of the above

5. Which diagram shows the real location of the material?

   a. Layout diagram b. Schematic diagram

   c. Wiring diagram d. None of the above

Write short answer to the following questions.

1. Explain different types of energy meter.
2. Draw the layout and wiring diagram of one bulb control by one way switch.
3. Draw the wiring diagram of stair case wiring.
4. Draw the wiring diagram of go down wiring.
5. Draw the wiring diagram of tunnel wiring.

Write long answer to the following questions.

1. Draw the layout and wiring diagram for connecting one lamp, one bell and a fan in a gang plate and also connect power socket 3 pin/ 15 A separately.
2. Draw the layout and wiring diagram for connecting two lamps in parallel control by a simple one-way switch and third lamp by another switch in a 2-way gang plate.

Project Work

1. Demonstrate different kinds of wiring system
2. Connect 3 pin 15 amp switches/socket.
3. Connect single lamp control by single 5 amp switch.
4. Connect single bell control by single push button switch.
5. Connect two lamp in parallel control by simple one way switch.
6. Connect one lamp by using one way switch. Also connect two pin socket and indicator in 3 gang plate.
7. Connect a lamp control separately by two simple switches.(two way switching)
8. Connect two lamp in parallel control by a simple one way switch and third lamp by another switch in a 2 way gang plate.
9. Connect one lamp, one bell and a fan in a gang plate and also connect power socket 3-pin/15-A separately.
10. Connect two or more lamp in parallel and control from three or more places. (intermediate switches)

    Note: All the practical works should be done in LAB.

7.1. Familiarization with Test Instruments

On completion of a wiring installation, a number of tests on the installation have to be conducted to ascertain that the wiring circuits and connected appliances are safe for use. Prior to carrying out the tests, an inspection has to be done.

The following tests shall be conducted:

a. Continuity Test;

b. Insulation Resistance Test;

c. Polarity Test;

d. Earth Electrode Resistance test; and

e. Residual Current Device Test.

The commonly used instruments used for testing and maintenance of wiring are Insulation tester, Earth Resistance tester, Neon Lamp Tester/Continuity tester.

- **Continuity Test Instruments (AVO or multi Meter):**

  The instrument which is used to measure resistance and detect whether it is open circuit or short-circuit is known as continuity test instrument. Generally Ampere Volt Ohm(AVO) meter or multimeter is used as continuity test instrument.

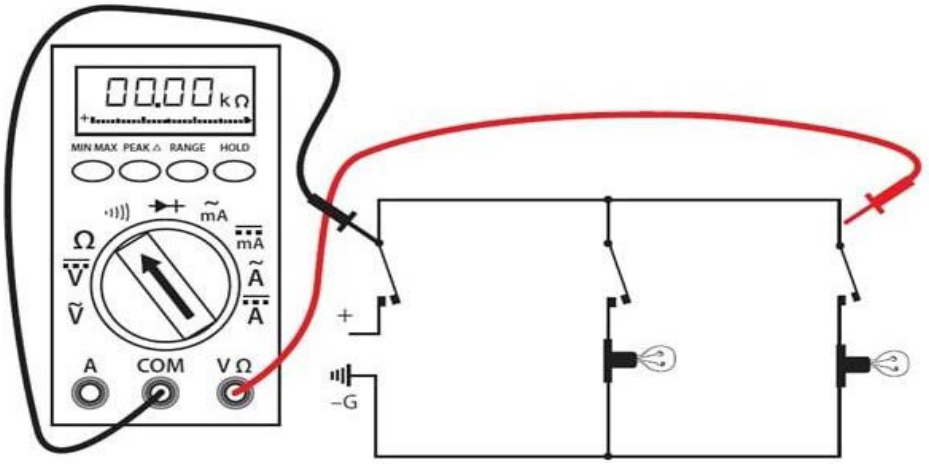


Figure 7.1: Continuity test

- **Earth Electrode Test Instruments**

  The instrument which is used to test the earth resistance is known as earth resistance test instrument. This instrument is required to test resistance around the earth electrode.

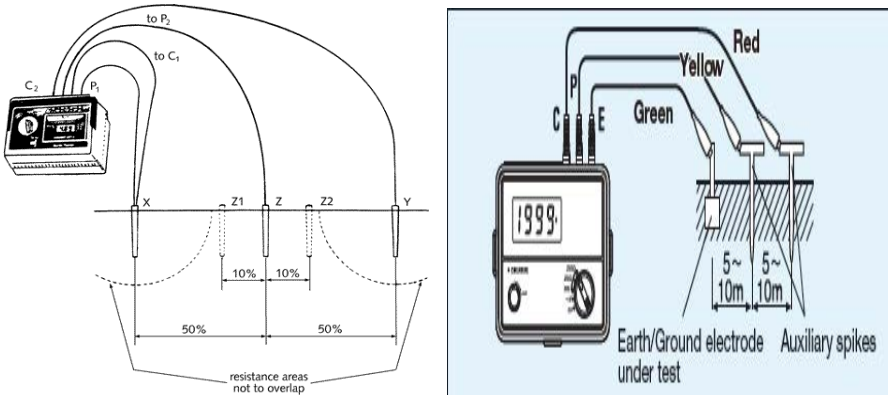


Figure 7.2: Earth electrode test instrument

- **Insulation test Instruments**

  The instrument which is used to measure high resistance between conductors or conductor and earth is known as insulation test instrument. This instrument helps in detecting the insulation leakage between the conductors in a cable, conductor and earth etc.

  This instrument must be capable of producing high DC voltages like 500V, 1000V, 2000V etc. to measure the insulation resistance. Generally double off the installation.

Figure 7.3: Insulation test instrument

The tests that should be made on a new electrical installation before it is switched on to the mains are as follows:

1. Insulation resistance test between conductors while load is connected
2. Insulation resistance test between conductors and earth
3. Polarity Test
4. Testing of Earth continuity paths
5. Earth Resistance Tests

7.2. Familiarization with Test Methods

Insulation Resistance Test between the Wiring and Earth

The test performed to know whether the cables or wires used in the wiring system are sufficiently insulated is called Insulation Resistance Test between the Wiring and Earth. The values of insulation resistance are measured in terms of Mega ohms (MΩ).

Insulation Resistance Tester, also known as Megger, having working voltage of not more than 500V DC is used to test the insulation resistance. Before making an insulation test, following things should be taken into consideration:-

i. Main switch is in OFF position.
ii. Main fuse has to be taken out or main MCB has to be made in OFF position.
iii. All other fuses are in position.
iv. All the switches are in ON position.
v. All the lamps are in their positions or the lamp holders are short circuited
vi. Line and neutral terminals are shorted on the installation side.

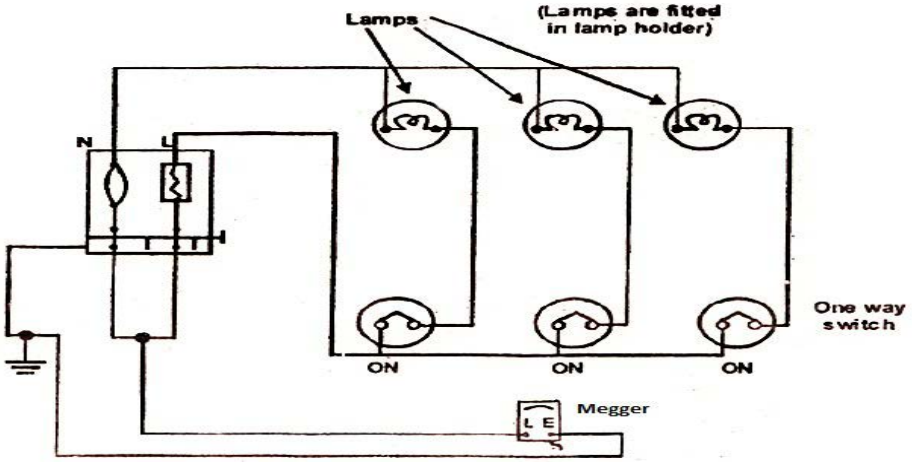


Figure 7.4: Insulation Resistance Test between the Wiring and Earth

Procedure

The line terminal of the megger is connected to the point where the conductors have been shorted at the main switch and the earth terminal is connected to the earth. The handle of the megger is then rotated if it is analog hand driven megger. Then the readings are noted. The measured insulation resistance should not be less than 50 Mega Ohms (MΩ) divided by the number of outlets. If the ration is 1MΩ is more than unity, insulation resistance is considered sufficient but the insulation resistance should not be less than 0.5 MΩ. If the reading is zero, it means that there is short circuit in wiring which should be removed.

Insulation Resistance Test Between the Conductors

This test is conducted to ensure that the insulation between the conductors is sound so that there is no leakage between them. In this test, megger is used to find out the insulation resistance between the conductors.

Before making an insulation test, following things should be taken into consideration:

i. Main switch is in OFF position.

ii. Main fuse has to be taken out or main MCB has to be made in OFF position.

iii. All other fuses are in position.

iv. All the switches are in ON position.

v. All the lamps are removed.

In this case, all the things to be considered are same as above except the loop at the main switch is removed and the all the lamps and all metallic connections are removed from the lamp holders.

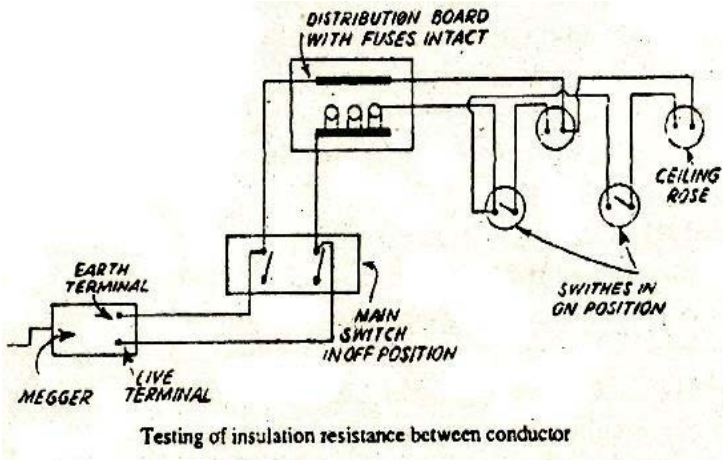


Figure 7.5: Insulation Resistance Test between the conductors

Procedure

The terminals of the megger are connected to the two poles or lines of the installation and insulation resistance is measured between two conductors (i.e phase and neutral). The insulation resistance so measured should not be less than 0.5 MΩ and need not be more than 1MΩ.

Polarity Test of Single Pole Switches

This test is performed to ensure that all the switches are placed in phase or live conductors and not in neutral conductor. It is necessary that single pole switches are placed in live wire so that the lamp can be made quite dead when switched off. If switch is provided on neutral wire, the wiring will remain alive even when the single pole switch is turned off. The person who is working with this circuit might get injured when replacing the lamps if s/he comes in contact with the line terminal of the lamp holder. Hence single pole switches should be kept in live wire, never in neutral wire.

There are two methods of testing of polarity of single pole switches which are as follows:

- Using test lamp
- Using neon tube tester

Using Test Lamp

In this method, all the lamps are removed, main switch is ON position and main fuse is inserted. Then, one end of test lamp is connected to Earth and the other end is tapped to each contact of each switch in turn. If the test lamp lights on one of the two contacts, it indicates that switch is on the live wire. If the test lamp doesn't give light on either contact of the switch, it indicates that the switch is on neutral wire.

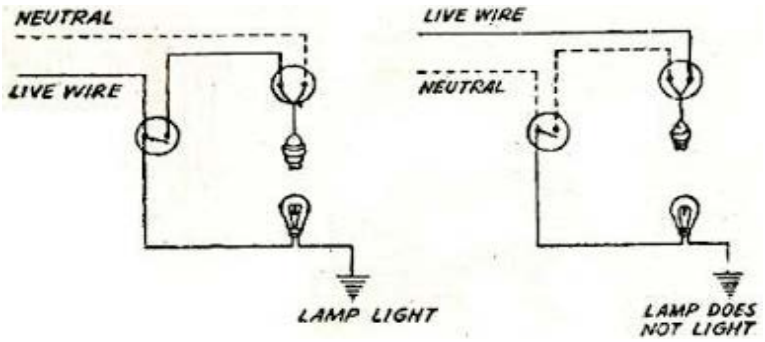


Figure 7.6: Polarity test using test lamp

Using Neon Tester

While performing polarity test by means of neon tester, one terminal of it is held in the hand

and the other against the feed terminal of the switch. If the switch is in live wire, the neon lamp will glow otherwise not.

Earth Continuity Test

Earth continuity test is carried out to check that the resistance of the earth continuity conductor between its connection to the earth electrode and any other metal pieces in the installations does not exceed 1Ω. In a properly designed wiring system, there are number of earth points located different positions throughout the wiring. For example each plug socket will have a third earthing point. The metallic body of each electrical appliance is connected to the earth through an earth points. This test ensures the continuity between an earth point and the actual earth.

In this test, main switch should be opened, main fuse withdrawn, all other switches in ON position and lamps in their respective holders. One terminal of Earth Resistance tester is connected to the earth point whose continuity is to be checked and other terminal of the tester is connected to the main earthing system of the building. The pointer of earth continuity tester will give the resistive value between the said earth point and actual earth. In any case, the value must not be greater than 1 ohm. If it is greater than 1 ohm, then the earthing connection should be physically rechecked and properly rectified to achieve desired minimum earth resistance.

Earth Resistance Test

Earth resistance test is carried out to check that the earth resistance is within permissible limits. The permissible earth resistance of domestic purpose is 5Ω. Earth resistance is checked by using an instrument called Earth Resistance Tester.

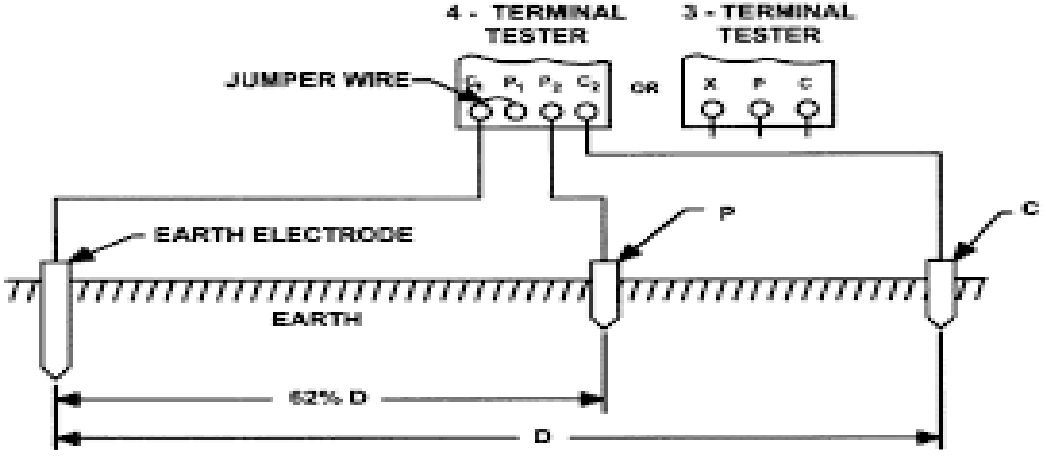


Figure 7.7: Earth Resistance Test

Earth resistance tester is used as a test instrument. Terminal 'E' is connected to the electrode to be tested. Terminal 'P' is connected to the potential electrode at a certain distance as instructed by the instrument manual from the earth electrode. Terminal 'C' is connected to the current electrode at a distance twice the distance between terminal E and P from the earth electrode. Then the test button is pressed to get the value of earth resistance.

This test must be repeated at least three times and the value of earth resistance is obtained by the average value of the tested earth electrode resistance.

Continuity Tests

This test is conducted to ensure that each conductor in the circuit has continuity. Multimeter or Ohmmeter is used to perform continuity tests.

Method

- Switch off the main switch and MCB.
- Disconnect all loads
- Switch on all switches in the circuit
- Disconnect the fuses/ circuit breakers and close the circuit
- Carry out the test

7.3. Continuity Test of Fuses, MCB, Wires

Continuity Test

Continuity test is done to check the continuity of a circuit i.e. if it is broken or not. It gives idea about continuity of any circuit, fuses, etc. This can be done by measuring resistance of the wire whose continuity is to be checked and then comparing this resistance value with the standard value. Generally it should be very less value.

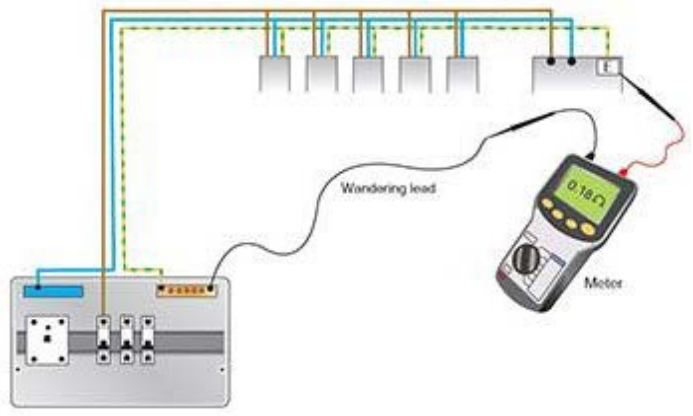


Figure 7.8: Continuity test

Continuity test can be done by multimeter or AVO meter.

Figure 7.9: Continuity test

If the component or circuit has very low resistance, then it is continuous and if very high resistance almost infinity, then it is discontinuous.

Exercise

Choose the correct answer from the given alternatives.

1. Which among these tests are to be conducted on wiring installation?
   a. Testing of polarity of non-linked single pole switches
   b. Testing of earth continuity path
   c. Testing of earth resistance
   d. All of the above

2. Megger is an instrument for.....
   a. Measuring current
   b. Measuring voltage
   c. Testing insulation
   d. Measuring power

3. Megger is exclusively designed for measuring.....
   a. Very low resistance
   b. Very high resistance
   c. Ground fault
   d. Over load in dc motor

4. What is the reason for excess reading of the energy meter?
   a. Defective wiring
   b. Meter defects
   c. Both a and b
   d. None of above

5. The leakage current must not be more than……. Of maximum supply current.
   a. 1/1000 b. 1/100 c. 1/5000 d. 1/500

Write short answer to the following questions.

1. Explain, how to perform continuity and discontinuity test of fuses, MCB and wires.
2. Write down the steps to be allowed while performing continuity test.
3. Describe the produce of earth resistance test.
4. Explain polarity test by using test lamp and neon tube tests.
5. Explain insulation resistance test between wiring and earth.
6. Explain insulation test between the conductors.
7. Describe continuity test.

Write long answer to the following questions.

1. Explain the continuity and discontinuity test of fuses, MCB and wires.
2. Explain the different test methods with necessary diagram.

Project Works

a. Demonstrate test instruments

b. Perform polarity test of single pole switches, SPMCB, fuse etc.

c. Perform continuity test of switches, fuses, MCB etc.

d. Perform insulation test between conductors of wiring system

e. Show earth continuity test by videos

Video URL

Unit 1:

https://www.youtube.com/watch?v=kcM9u4heDVk

https://www.youtube.com/watch?v=YEsQ36KeETo

Unit 3:

https://www.youtube.com/watch?v=jovscTSq-mg

https://www.youtube.com/watch?v=OIO3hKyN7ko

https://www.youtube.com/watch?v=hQA0dd_0rq8

Unit 4:

https://www.youtube.com/watch?v=BLIYsRwKrkE

https://www.youtube.com/watch?v=Unh99Qn7CmI

Unit 5:

https://www.youtube.com/watch?v=BIRS34UnsCo

Unit 6:

https://www.youtube.com/watch?v=S7dQRU95Cnw

https://www.youtube.com/watch?v=lm5zUCca7jM

Unit 7:

https://www.youtube.com/watch?v=_-n6BiFJy8w

References

Theraja, B. (2006). A Textbook of Electrical Technology - Volume IV. S. Chand Publishing.

Scaddan, B. (2011). Electrical installation work. Routledge.

A Textbook of Electrical Technology (MDU). (n.d.). Goodreads. https://www.goodreads.com/book/show/28718165-a-textbook-of-electrical-technology

Linsley, T. (2013). Basic electrical installation work. Routledge.

Chapman, W. (2019). Workshop Technology Part 1. Routledge.

D, A. K. P. (2020). Symplified Wiring System Book Guide: A Profound Guide to Designing, Wiring and Installation.

Alonzo, R. J. (2009). Electrical codes, standards, recommended practices and regulations: An Examination of Relevant Safety Considerations. William Andrew.

https://www.nea.org.np/admin/assets/uploads/supportive_docs/Electricity_Regulation_2050-english.pdf

https://www.electrical4u.com/

https://www.electricaltechnology.org/

https://electrical-engineering-portal.com/

https://energyeducation.ca/

https://www.allaboutcircuits.com/

https://safetyculture.com/