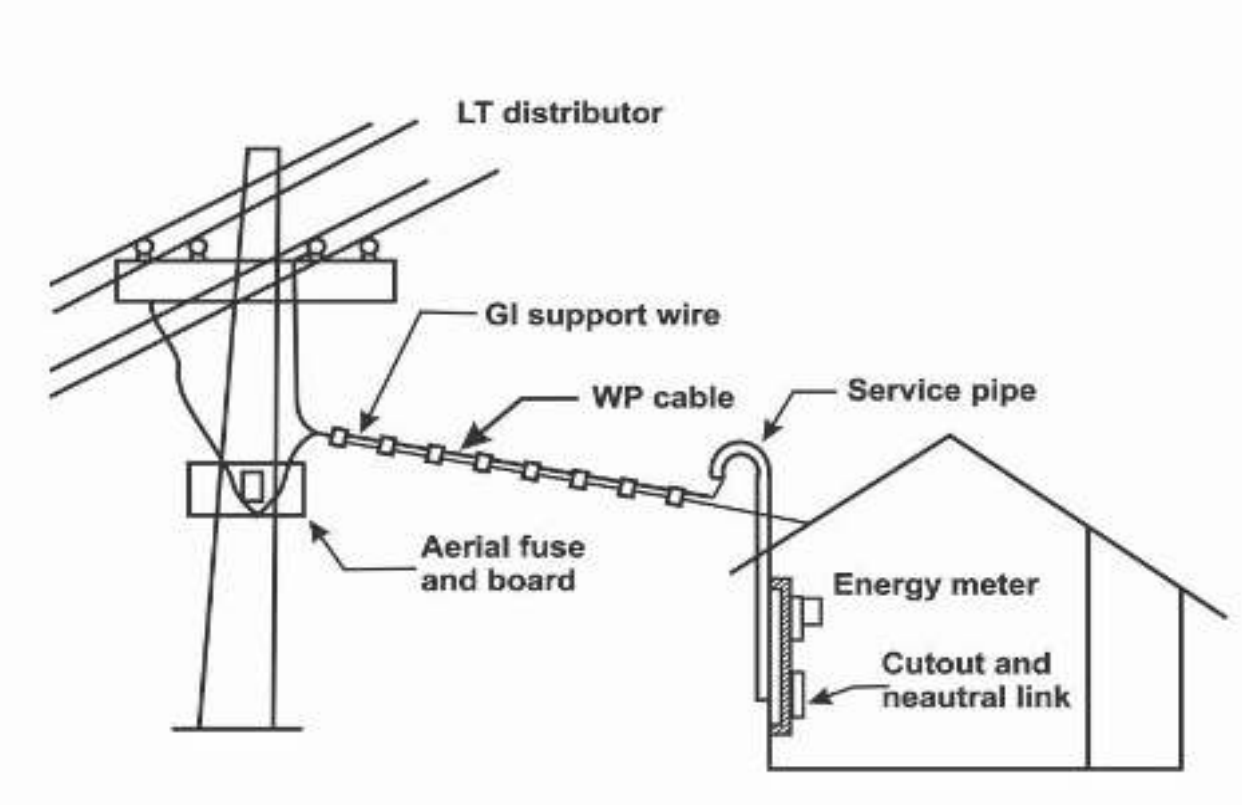
Building Electrical Installation

Level-III

Based on October 2023, Curriculum Version II



Module Title: Electrical service connection

Module code: EIS BEI3 M08 1023

Nominal duration: 100Hour

Prepared by: Ministry of Labor and Skill

October, 2023

Addis Ababa, Ethiopia

TABLE OF CONTENT

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

SLI ----------Service Line Installation

ATS ---------- Medium Voltage

SRI ----------Automatic transfer switch

SI ----------Service Installation

PVC ---------- Polyvinyl-Chloride

XLPE ----------Cross-Linked Polyethylene

RCD---------- Residual Current Device

MCB ----------Miniature Circuit Breakers

LIS ----------Line Installation Service

LRS ----------Line Restoration Service

NEC----------National Electrical Code

NM-B Cable ----------Nonmetallic-sheathed cable

BX cable----------Armored cable

Introduction to The Module

In Building Electrical installation filed provides This module covers the knowledge, skills and attitude required to perform service connection. It includes measuring distance, installing cables, main switch and energy meter, ATS, change over switch.

This module is designed to meet the industry requirement under the Building Electrical Installation occupational standard, particularly for the unit of competency: **Electrical service connection.**

This module covers the units:

- Drawings and specifications Interpreting.
- Tools and equipment's collation
- Standard distance of service line
- Cables Installation for service
- Installation of Energy meter main switch
- connection of automatic transfer switch (ATS)

Learning Objective of the Module

- Understand and Interpret drawings and specifications
- Collect tools and equipment's
- Measure the distance of service line
- Install cables for service
- Install Energy meter and main switch
- Connect Automatic transfer switch (ATS)

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

- Read the information written in each unit
- Accomplish the Self-checks at the end of each unit
- Perform Operation Sheets which were provided at the end of units
- Read the identified reference book for Examples and exercise

UNIT ONE: DRAWINGS AND SPECIFICATIONS INTERPRETING.

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Collection and interpretation drawings,
- Electrical signs and symbols
- terms and abbreviations.
- Interpret specifications

This unit will also assist you to attain the learning outcomes stated in above unit. Specifically, upon completion of this learning guide, you will be able to:

- Collect and interpret drawings,
- Identify Electrical signs and symbols
- Understand terms and abbreviations.
- Use Interpret specifications

1.1 Interpret Drawings and specifications in a workplace

- **Electrical drawings/plans:**

  An electrical drawing is a type of technical drawing that shows information about power, lighting and communication for an engineering or architectural project. Any electrical working drawing consists of lines, symbols, dimensions and notations to accurately convey an engineering's design to the workers who install the electrical system on the job.

- **Electrical plans** can include electrical outlets, telephones, communication devices and other items requiring electrical power. In small projects, these items can be shown together with the lighting. The telephone and other communication systems are also generally shown on the electrical plan.

Figure .1.1: Electrical plans

1.2 Sign and symbols:

A large part of being safe around electricity is understanding common electrical safety symbols. Electrical hazard signs help promote electrical safety and prevent accidents by warning workers and people of electrical hazards and ways to avoid them.

Figure 1.2: Electrical hazard signs

1 ***symbols associated with Electrical and maintenance under the Civil construction work place***

Electrical and maintenance symbols are used in civil construction to convey information about electrical systems and equipment. These symbols are important for ensuring the safety and reliability of electrical systems.

Figure 1.3 signs associated with Electrical and maintenance under the construction work place

- **Drawing symbols** are graphic representations of objects, ideas, or concepts. They are used in a variety of fields, including engineering, architecture, cartography, and flow diagrams. Drawing symbols can be used to communicate complex information in a clear and concise way.

SYMBOL	CHARACTERISTICS	CATEGORY
	Straightness	Form
	Flatness	
	Circularity	
	Cylindricity	
	Profile of a Line	Profile
	Profile of Surface	
	Angularity	Orientation
	Perpendicularity	
	Parallelism	
	Position	Location
	Concentricity	
	Symmetry	Runout
	Circular Runout	
	Total Runout	

Figure 1.4: Drawing symbols

- **Connection symbol** A connection symbol is a graphic representation of a connection between two or more things. It can be used to represent a physical connection, such as a bridge or a cable, or a conceptual connection, such as a relationship between two people or a logical connection between two ideas.

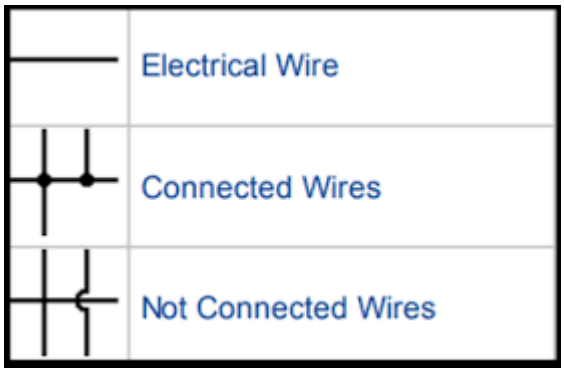


Figure 1.5: Connection Symbol

- **Load symbol:**

  An electrical load is an electrical component or portion of a circuit that consumes (active) electric power. In electric power circuits examples of loads are appliances and lights.

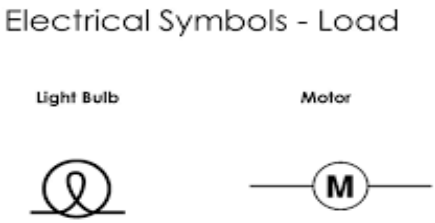


Figure 1.6: Load symbol

- **Circuit symbol:**

  The diagram below shows the standard circuit symbols generally used:

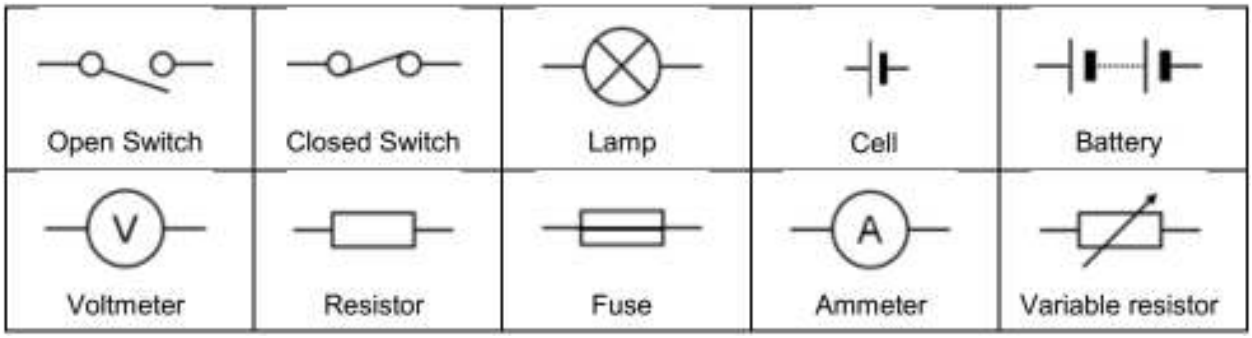
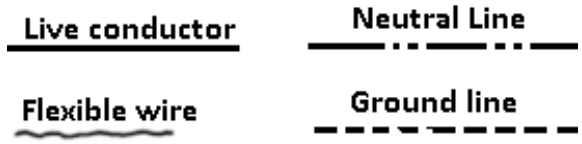
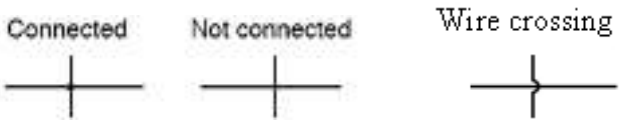
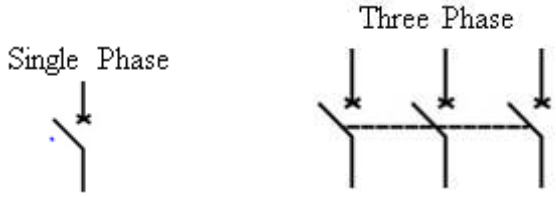
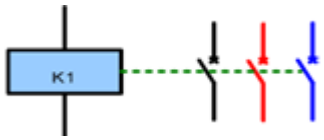
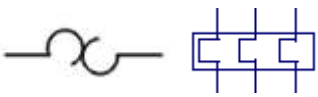
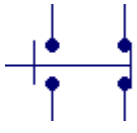
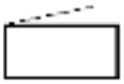
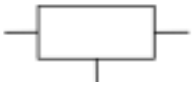
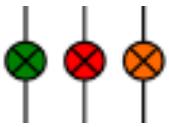
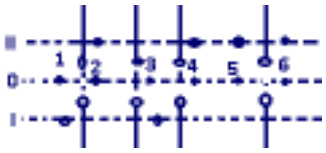


Figure 1.7: Circuit symbol

- **Electrical installation symbols** are graphical representations of electrical components and devices used in electrical drawings and diagrams. They help electricians, engineers, and technicians communicate and understand complex electrical systems, ensuring accurate installations, repairs, and designs.

No	Items	Symbol
1	wire symbol	
2	Connection symbols	
	Circuit breaker	
4	Supply symbols	
5	Isolator Switch Disconnector	
6	Fuse	
7	Contactor	
8	Overload Relay	
9	Timer	
10	Push button	

11	Danger symbols	
12	Switch board symbol	
13	Main switch symbol	
14	Regulator symbol	
15	Light indicator	
16	selector switch	
	Motor general symbol 1Ø motor 3Ø motor	

1.3 Terms and abbreviations

Electrical abbreviations are used for various circuits, conduits, sizes, standardized tools and more. The list of abbreviations used in a set of engineering drawings varies from office to office. Some basic electrical abbreviations are listed below:

Ω: Ohm	Φ: Phase	A: Amperes	AC: Alternating Current
ATS: Automatic Transfer Switch	CKT: Circuit	DC: Direct Current	ECC: Earth Continuity Conductor
F: Fuse	FLA: Full Load Amperes	HZ: Hertz	KVA: Kilovolt-Amperes
L: Line	MW: Megawatt	N: Neutral	NC: Normally Closed
NO: Normally Open	P: Pole	V: Volt	W: Watt or Wire

1.4 Specifications

A **specification** is a set of documented requirements to be satisfied by a material, design, product or service. There are different types of technical or engineering specifications and different usages of the term in different technical contexts.

- **Current carrying capacity of cables**

Cross section	No& Diameter of wire	Thickness of insulation	Outer diameter	Weight	Current rating	
					In conduit at 35*C	In cable tray at 35*C
mm2	mm	mm	mm	Kg/km	amp	Amp
1x1.5re	1/1.38	.7	3.3	22	16	20
1x1.5rm	7/.50	.7	3.4	23	16	20
1x2.5re	1/1.78	.8	3.9	32	22	28
1x2.5rm	7/.67	.8	4.2	33	22	28
1x4.0rm	7/.85	.8	4.8	51	30	37
1x6.0rm	7/1.05	.8	5.4	71	38	47
1x10.rm	7/1.35	1.0	6.8	117	52	63

Self-Check-1	Written Test

Name: _____ Date: _____

Time started: _____ Time finished: _____

Directions: Write the correct answer for the following questions.

1. What are the items/components include or shown in an electrical plan?
2. What is circuit diagram?
3. Why electrical signs and symbols are used and showed in plans?
4. What is the function of a circuit breaker?
5. Define electrical load.

UNIT TWO: TOOLS AND EQUIPMENT'S COLLATION

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Tools, equipment and materials
- motor control devices Selection and Testing

This unit will also assist you to attain the learning outcome stated in the above unit.

Specifically, upon completion of this Learning Guide, you will be able to

- Collect Tools, Equipment and materials
- selected and collected Necessary motor control devices.

2.1 Collect Tools, Equipment and Materials

Tools and equipment:

2.1.1. Hand tools: Have no power source, other than the physical force applied by the user. There are various types of hand tools. These are:

1. **Neon tester: -** It is a measuring device which measures the polarity of the wiring system.

Fig 2.1: Neon tester

2. **Fish tape**: A fish tape is used to pull stranded or solid wire conductors through metal or PVC conduit. Cable lube is available to assist you in pulling the wires through the conduit. A fish tape can also be helpful when you are pulling NM cable through wall cavities.

Fig 2.2: Fish tap

3. **Hacksaw**: a fine-tooth hand saw with a blade held under tension in a frame, used for cutting materials such as metal or plastics.

Fig 2.3: Hacksaw

4. **Pliers:** They are main essential hand **tools** for electricians. They are mainly used to cut wire, grip, twist, bend or straighten wires. Every professional technician puts a bunch of pliers in its

toolbox or truck, including crimping pliers and stripping pliers which are used to tighten locks, fittings, and caps.

A. **Lineman (combination) pliers**: It is a standard electrician's tool, featuring rubber sheathed grips and a plier head combined with a cutting blade. The blade is located in the two inner edges of the plier's head, by the pivot, and is used for stripping, twisting, cutting & pulling of wires will working.

Fig 2.4: Lineman (combination) plier

B. Diagonal Cutting Pliers: Diagonal cutting pliers, sometimes called ***side snips*** or ***dikes,*** are used to cut wires. They are specially designed with a cutting edge that goes down to the tip of the jaws, allowing you to get into tight areas to trim wires.

Fig 2.5: Diagonal cutting plier

C. **Needle-nose pliers**: Another essential specialty electrical tool is a pair of needle-nose pliers. It is used for bending and twisting wires whenever you are making screw-terminal connections. The long, narrow tip makes this a great tool for detailed work.

Fig 2.6: Needle-nose pliers

D. Snipe Nose Plier with side cutter: have jaws bent at an angle near the tip helping you reach tight spaces with ease.

Fig 2.7: Snipe-nose pliers with side cutter

E. Flat Nose Plier: it is usually used to bend the metal sheets and electric wires into the shapes you want. In repairing, they are the usual tools to install metal components and electricity and used to install and pull out the dowels and springs.

Fig 2.8: Needle-nose pliers

F. Round Nose Plier: It is usually used to bend circles of alloyed jewelry. Such as bend the pins to‘9’shapes and string beads.

Fig 2.9: Round Nose Plier

G. Vice grip (locking) plier: It can grab and move items or hold items in place like any other set of pliers, but what makes the vice grips unique is that they have a locking mechanism that can be set by the operator. Once it is set, the grips will lock in place and won’t move until they are released by the operator. This helps keep objects in place when working with them.

Fig 2.10: Vice grip (locking) plier

H. **Cable Cutter**: tools that have been designed to properly cut either wire or cable with minimal damage to the insulation or internal conductors of the wire or cable. Having a clean cut on a wire or cable can improve the quality of an electrical connection.

Fig 2.11: Cable Cutter:

5. **Plastic Pipe Cutter**: it is **used in plumbing for cutting plastic pipes**. Precision with clean cutting is important in this area of work.

Fig 2.12: Plastic Pipe Cutter:

6. **Insulation Removing tools:**

A. **Utility (Electrical) knife**: A utility knife, or *box cutter,* is handy for cutting sheathing from non-metallic (Romex) cable, to cut off electrical tape, and to open cardboard boxes.

Fig 2.13: Utility knife

B. **Wire strippers**: it has a special hole for each size of wires & it does not slow down as easily. It is suitable type, if used correctly. Do not cause the slightest damage to the metal texture of the wire & only remove the cover.

Professional **electricians** regularly place a plastic cover over the wires to keep the copper out of sight and to make connections with wiring or other components.

Fig 2.14: wire stripper

7. **Circuit tester (Voltage tick)**: Perhaps the most important specialty electrical tool you can own is a voltage tester. It is used for a quick safety check to make sure there's no voltage in an electrical wire or device before you start working on it. Non-contact voltage testers, powered by

batteries are the simplest and safest types of testers because they can detect electricity just by being near an outlet slot or wire.

Fig 2.15: circuit tester

8. **Continuity tester**: A small, battery-operated continuity tester costs less than $10. It can be used to determine whether wiring is broken and whether electrical circuits are complete.

Fig 2.16: Continuity tester

9. **Screw drivers:** Electricians keep screwdrivers with them at all times, for loosen and fasten various pieces such as cover plates, outlets, switches and many other devices. It's best to have a few different lengths of Phillips screwdrivers, as well as #1, #2, and #3 tip sizes

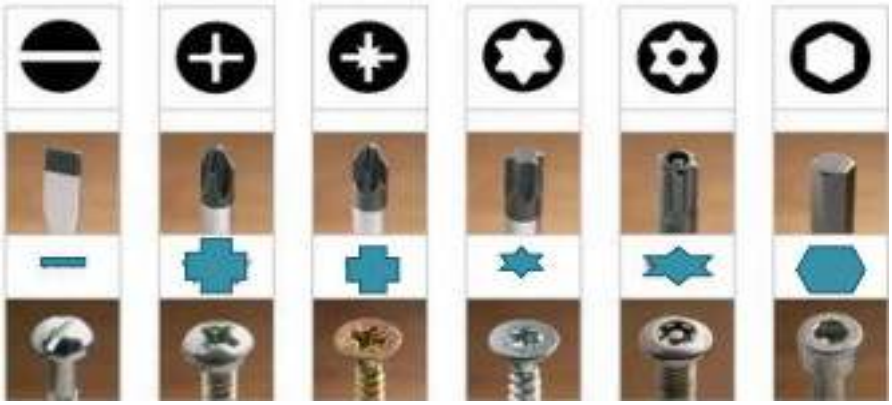


Fig 2.17: Screw drivers

- The parts of a screwdriver are the head, handle, ferrule, shank, blade, and tip. The length of the blade indicates the size of a screwdriver. Some screwdrivers may have square shanks that permit turning with a wrench when required for extra torque.

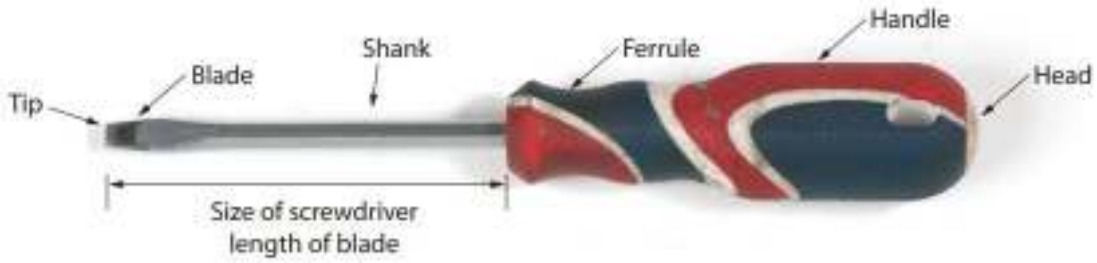


Fig 2.18: Parts of screw drivers

There are many different types of screwdrivers, identified by the type of screws they fit.

- **Some of the more common types of screwdrivers are**: -

A. ***Philips Screw Driver***. This has a cross tip resembling a positive (+) sign. This is used to drive (to tighten and loosen Phillips head screws) screws with cross slot heads. It's ranges in size from *0 to 4, 0 being the smallest.*

Fig 2.19: Philips drivers

B. ***Standard/Flat Screw Driver***. As with Phillips screwdrivers, you will likely need more than one size of straight-blade screwdrivers. If you have to choose just one, pick a medium blade; it will suit most projects. Straight-blade screwdrivers are also available with insulated handles for better safety when doing electrical work.

The blade tip is wedge-shaped and resembles a negative (-) sign. It is used to drive screws with a single slot head. It's ranges in size from*1/6 inch to 1/4 inch*.

Fig 2.20: Flat drivers

C. ***Clutch Drive Screwdriver***: - It is used to tighten and loosen clutch head screws, which are shaped like an hourglass. It has extra holding power, especially for use in cars and appliances.

Fig 2.21: Clutch dive drivers

D. TORX Screwdriver: - It is used to tighten and loosen six-point star head screws. They are used in cars, appliances and lawn and garden equipment.

Fig 2.22: Torx dive drivers

- ***Robertson Screwdriver:-*** It has a square drive that yields high torque power. It is useful to reach screws sunk below the surface of the material.

Fig 2.23: Robertson drivers

- ***Spiral Ratchet Screwdriver: -*** They are used to drive or remove small screws rapidly. The spiral ratchet screwdriver automatically drives or removes screws. It can be adjusted to turn left or right, or can be locked to act as a common screwdriver. Some spiral ratchets have a spring in the handle that automatically returns the handle for the next stroke.

Fig 2.24: spiral ratchet drivers

- ***Ratchet Multi-Bit Screwdriver/Nut Driver:***

- It provides high-torque capability and comfortable Cushion-Grip handles.
- Shaft holds 6 universal tips; converts to 3 nut driver sizes and 1 hex driver
- Strong, heat-treated nut drivers for improved torque.
- 3-way ratcheting mechanism for forward, reverse and locked positions

Fig 2.24: spiral ratchet drivers

10. ***Allen Screw Driver/Wrench***: - Allen wrenches are used to tighten hex-head screws, which are sometimes found on ceiling fans, light fixtures, and appliances. It's a good idea to own both a metric and a standard set of Allen wrenches.

    It contains several sizes that are attached to and fold into a metal carrying case. It is also known as a hex key or hex wrench and is used on screws with hexagonal slots. It is useful for recessed socket head screws.

Fig 2.25: spiral ratchet drivers

11. **Hammer:** It is a tool used to deliver an impact to an object. They are mostly used to drive nails, fit parts, or break up objects. There are many types of hammers designed for specific uses, which vary in shape and structure. Most hammers include a handle and a head, with most of the weight in the head. The two main types of hammers are claw and ball peen.

➢ **Claw Hammer:** A hammer is used to secure electrical boxes equipped with nail-on brackets to wall studs and other framing members in a home. You'll also need one to drive wire staples when anchoring new electrical cable to framing members.

Fig 2.26: Claw hammer

12. **Wrenches:** it is a tool used to provide a mechanical advantage when torque is applied to hold and turn bolts, nuts, screws, and pipes. They are divided into two categories:

➢ ***Nonadjustable***: - They are made to work on a particular size of bolt, nut, screw, or pipe.

- ***Open-End Wrench: -*** All open-end wrenches have open jaws on one or both ends of the wrench. Most jaw openings are offset from the shank portion of the wrench by 15 degrees. The wrench length is determined by the size of the jaw opening. It grips on two sides of the nut or bolt head, with an opening that can access fasteners that a closed, or box, wrench might not reach. It has

openings of different sizes on each end. The opening should fit the nut or bolt exactly to prevent mutilating the edges of the fastener.

Fig 2.27: Open end wrench

- ***Closed End Wrench: -*** it surrounds the nut, bolt head, or stud on all sides. It is available with both 6- & 12-point openings. The 12-point opening is more common because it may be used on both square and hexagonal bolt heads. Some models have ratcheting capability.

Fig 2.28: Closed end wrench

- ***Combination Wrench: -*** It has a box wrench and an open-end wrench on opposite sides of the same tool. The two ends are usually the same size.

Fig 2.29: Combination wrench

- ***Adjustable: -*** They are made to tighten or loosen a particular size of bolt, nut, screw, or pipe. It has an adjustable end opening that comes in locking and non-locking styles. The locking style can secure the jaws in the desired position, so when properly adjusted, it will not slip. The non-locking style requires frequent readjustment and is prone to slipping. The adjustable wrench is used to tighten or loosen nuts and bolts, but never on a fastener that has been rounded off.

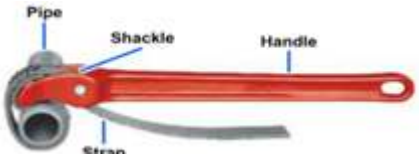
Fig 2.30: Adjustable wrench

- ***Pipe Wrenches: -*** used for turning pipe and other round objects. Teeth on the jaw will dig into the material being tightened and may damage. it does not use a pipe wrench to turn a bolt or a nut unless the components is already damaged. Do not use on hardened surfaces - may dull or

chip the jaw teeth. There are four basic types of pipe wrenches: Still son wrench, Spud wrench, Strap wrench & Chain wrench.

Still son wrench

Spud wrench



Strap wrench

Chain wrench

Fig 2.31: Pipe wrench

- **Socket Wrenches:** It has a socket that grips the nut or bolt and a ratchet (handle) that is used to turn the socket. The end of the socket that fits into the ratchet is usually square. The other end of the socket will have either 6 or 12 gripping points. The ratchet handle has a small lever that allows you to change the turning direction.

Fig 2.32: Socket wrench

- ***Special-Purpose Socket Wrenches:*** The four-way socket wrench has four non removable sockets attached to four arms. Each of the sockets is a different size. The four-way socket wrench is usually used to remove and/ or install the wheel stud nuts of a vehicle. The handle construction provides extra leverage for loosening and tightening the stud nuts.

Fig 2.33: Special-purpose socket wrench

13. **Pipe Cutting:** There are two sizes of pipe cutters. One size can cut from 1/8 to 2 inches, while the other can cut from 2 to 4 inches. The pipe cutter has a cutting blade and two pressure rollers

which are adjusted and tightened by turning the handle. Pipe cutters are used to cut steel, brass, copper, wrought iron, and lead pipe.

Fig 2.34: Pipe Cutter

2.1.2. Power Tools: A power tool is a tool that is actuated by an additional power source and mechanism other than the solely manual labor used with hand tools. The most common types of power tools use electric motors. Internal combustion engines and compressed air are also commonly used.

a. Soldering Iron: Soldering is a technique used to connect different types of pieces. Usually, it is used for making connections to electrical/electronic circuits. The tools which are required for soldering are soldering iron, de-soldering pump, holder, and soldering wire. Following points should be kept in mind when picking up soldering tools:

- The wattage of soldering iron must be checked according to the type of circuit in which it will be used.
- The soldering iron should not take a lot of time to heat up.
- Disordering pump should be able to remove soldering quickly and easily.
- Holder must withstand the weight of soldering iron

b. Portable cordless (Chargeable) drill: A cordless drill is an electric drill which uses rechargeable batteries. Primarily used for drilling circular holes in material. All cordless drills come with a battery charger, with recharge times ranging from 15 minutes to three hours. But faster isn't necessarily better. A contractor might depend on fast recharges, but slower recharging isn't usually a concern at home, especially if you have two batteries.

Fig 2.35: Cordless drill

c. **Electric portable drill:** it is a tool used for making holes in metallic sheets or other surfaces. In electrical systems, it is used during the construction of various electrical equipment. It is driven by an electric motor. to consider the following points before selecting a drill:

- There should be a wide range of speeds for drill.
- Texture and contour of the drill should be such that it is easy to grip.
- The drill should be of enough rating to work comfortably with voltage s of the working are

Fig 2.36: Corded drill

d. Electrical metering equipment

- ***Multi-meters***:- The name implies, a multimeter is designed to perform a variety of measuring tasks. With multiple inputs, settings and read the results can give accurate readings in most situations. It is either analogue or digital. Nowadays digital multi-metre is more referable than analogue. Because it's reading result is more accurate. It is used to measure electrical quantities such as voltage, current, resistance, continuity, transistor values & capacitance by rotating the knob to the labelled mark of the quantity that is to be measured.

Fig 2.37: Different types of multi-metres

- ***Megger or Digital insulation tester***: - use a high voltage, low current DC charge to measure the insulation resistance of the wires to identify current leakage and faulty or damaged insulation, which can lead to arc faults, blown circuits, and risk of electrical shock or fire.

Fig 2.38: Digital insulation tester

- **High potential tester**: It is a term used for electrical safety testing instruments used to verify electrical insulation in finished appliances, cables or other wired assemblies, printed circuit boards, electric motors, and transformers. It is the opposite of a continuity test. Continuity Test checks surety of current flows easily from one point to another point while Hi.pot Test checks surety of current would not flow from one point to another point.

Fig 2.50: High potential testor

- **Earth resistance tester**: is used to measure the resistance of the earth is called Earth Resistance Tester. All the equipment of the system is grounded through the earth electrode. Unhindered earthing protects electrical equipment and personnel from the fault current.

2.2 motor control devices Selection and Testing

2.2.1 Types of motor control devices

- Motor control devices are used to start, stop, control the speed and direction of rotation and protect electric motors.
- They can be classified into the following types:

A. Magnetic starter/contactor starter: It is a device that is used to start, stop and control electric motors. Typically, they are applicable in industrial, commercial residential applications.

Fig.2.51: contactor starter

B. Magnetic Contactors: It is an electrically controlled switch used to switch a high-current electrical power circuit. Typically, they are applicable to control electric motors, lighting, heating, capacitor banks, thermal evaporators and other electrical loads.

Fig.2.52: Magnetic Contactors

- It consists three parts. These are:
  - **Coil:** The coil is represented by a rectangle with a wavy line inside.
  - **Main contacts**: The main contacts are represented by two parallel lines with a gap between them.
  - **Auxiliary contacts**: The auxiliary contacts are represented by two smaller parallel lines with a gap between them

C. **Overload relay**: It is a device that protects electric motors from overheating. It does this by monitoring the current flowing through the motor and disconnecting the power supply if the current exceeds a certain threshold.

Fig.2.53: Overload relay

D. **Motor terminal block:** It is an electrical connector that is used to connect the wires of an electric motor to the power supply and other control devices.

Fig.2.54: Motor terminal block

E. **Timer Relay:** It is a device that combines a timer and a relay to provide automatic control of electrical circuits. Timer relays can be used to turn on or off circuits at specific times, or to delay the operation of circuits for a set period of time.

Fig.2.55: Timer Relay

- It is used to control:
  - Motor and equipment in industrial applications, such as conveyor belts pumps and automated production lines.
  - Lighting, heating and ventilation systems in buildings.
  - Lights, sprinklers, alarms, security devices and other devices in homes.

F. Industrial push button: It is a type of electrical switch that is designed for use in industrial applications.

Fig.2.56: Industrial push buttons

- They are available in a variety of different configurations, including:
  - **Normally open (NO)**: NO push button is operating when the button is pressed and breaks when the button is released.
  - **Normally closed (NC):** NC push buttons are closed when they are not pressed, and they open when they are pressed.

G. Fuse: It is an electrical safety device that protects electrical circuits from overcurrent. Fuses work by melting a thin strip of metal when the current flowing through the circuit exceeds a certain threshold. This disconnects the circuit and prevents damage to the electrical wiring and equipment.

Fig.2.57: Fuses

H. Circuit breaker: It is an automatically operated electrical switch that protects electrical circuits from damage caused by overload or short circuit. Its basic function is to disconnect the circuit when the current exceeds a certain safe value.

Fig.2.58: Circuit breaker

- Circuit breakers are used in a wide variety of applications, including:
  - Electrical panels in residential and commercial buildings
  - Industrial control systems
  - Motor control centers
  - Power distribution systems

I. Selector switch

The cam switch is also called a combination switch. It is different from the operation of the knife switch. It is a plane operation that rotates left and right. It consists of an operating mechanism, a panel, a handle, and several contact seats.

Fig.2.59: selector switch

The terminals on a selector switch are typically numbered, with each terminal corresponding to a different position of the switch. For example, a 3-position selector switch will have three terminals, numbered 1, 2, and 3. When the switch is in position 1, terminal 1 will be connected to the common terminal (C). When the switch is in position 2, terminal 2 will be connected to the common terminal. And when the switch is in position 3, terminal 3 will be connected to the common terminal.

Fig.2.60: Selector switch terminals

The common terminal is typically connected to the power source. The other terminals are connected to the devices that you want to control with the selector switch.

For example, if you have a selector switch that you want to use to control two motors, you would connect the common terminal to the power source. Then, you would connect one terminal to the first motor and the other terminal to the second motor. When you turn the selector switch to position 1, the first motor will turn on. When you turn the selector switch to position 2, the second motor will turn on.

Selector switches can be used to control a variety of different devices, such as motors, lights, and fans. They can also be used to select different modes of operation for a single device. For example, a selector switch could be used to select between different speeds for a fan or different brightness levels for a light

J. Indicator lights

The role of the indicator light:

1. Indicate the running or stopping status of the equipment.
2. Monitor whether the power supply of the control appliance is normal.
3. Use the red light to monitor whether the trip circuit is normal, and use the green light to monitor whether the closing circuit is normal.

Self-check #2

I. Choose the correct answer from the give alterative

1. Who is responsible for hand and power tool safety?

   A. the employer B) The employee C) OSH D) Both a and b

2. Which of the following basic safety rules should you follow when using hand and power tools?

   A) Keep all tools in good condition with regular maintenance

   B) Use the right tool for the job

   C) Examine each tool for damage before use and do not use damaged tools

   D) Operate tools according to the manufacturer's instructions

   E) All of the above

3. Which of the following is NOT a safe practice when working with power tools?

   A) Keeping hoses and cords away from oil, heat, and sharp edges

   B) Yanking the hose or the cord to disconnect it from the receptacle

   C) Securing work with a vice or clamps, keeping both hands free to use the tool

   D) None of the above

II. Mach column "B" to column "A"

A	B
_____ 1: Positioning of equipments	A. cordless drill
_____ 2: Chargeable drill	B. measure cross section of wire
_____ 3: Micrometer	C. Lift/tilt/turn

III. Give short ad precise answers for the following questions

1. List at 4 basic selecting criteria's of hand and power tools.
2. List the main parts of rechargeable drill?
3. Write the types & functions of hand & power tools?

Operation sheet #2

Operation Title: select the appropriate measuring hand & power tools

Instruction:

Purpose: to differentiate different types of hand & power tools

Required tools and equipment: tools from workshops like screw drivers, pliers, measuring tools,

Precautions:

- use safety personal protective equipments properly
- Follow the selection instruction of the task.
- Check tools weather it is functional or not
- Select tools properly

Procedures:

Step 1: Prepare yourself in order to perform the given task

Step 2: Visualize the type of tool

Step 3: If the tool has specification read it

Step 4: Collect the required tools from tools room

Step 5: Inspect tools for any damage prior to each use.

Step 6: Check the handle and body casing of the tool for cracks or other damage.

Step 7: If it is a power tool plug in to the appropriate power source & try check

Step 8: Select the appropriate measuring hand & power tools

Quality criteria:

LAP Test #2

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: identify the selecting criteria of hand& power tools

Task 2: select hand tools

Task 3: select power tools

Task 4: check hand & power tools for serviceability and safety.

UNIT THREE: STANDARD DISTANCE OF SERVICE LINE

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- PPEs for measuring service line
- standard distance of install cable services.

This unit will also assist you to attain the learning outcomes stated in the above unit.

Specifically, upon completion of this learning guide, you will be able to:

- Identify PPEs for measuring service line
- Obtain standard distance of install cable services.
- Measure Between distribution pole and energy meter services.
- Measure Between main switch and energy meter of service line.

3.1Personal Protective Equipment (PPE):

Where it is not possible for emissions to be controlled at their source, or removed or reduced through effective ventilation, extraction or diversion, the use of personal protective equipment (PPE) as a final measure must be considered to ensure safety.

PPE is a lower order control and can only be used where higher order controls are not possible or are not totally effective. Selection and use of PPE requires careful consideration, as there are many different types that reduce the risk of injury of contact or exposure to a hazard. Incorrect use of PPE, or purchasing inappropriate PPE, can contribute to serious workplace incidents.

PPE that is uncomfortable, restrictive or heavy may create secondary hazards, and, as a result, constant supervision may be necessary to ensure it is used effectively.

Figure 3.1: Personal Protective Equipment's

- **Types of Personal Protective Equipment**

This guideline provides information on the following types of PPE:

- ✓ Hand Protection (gloves)
- ✓ Eye Protection (goggles, safety glasses, face shields)

- ✓ Face Protection and infection prevention (eye wear, face shield, surgical mask
- ✓ Hearing Protection (ear plugs, ear muffs
- ✓ Laser Safety
- ✓ Skin Integrity and Protection (sunscreen, alcohol gel
- ✓ Protective Clothing (high visibility garments, thermal wear, overalls, aprons, lead aprons, reflective vests, impervious long-sleeve gowns)
- ✓ Footwear (enclosed shoes, safety boots)
- ✓ Head Protection (hard hats, helmets, sun hats, bike helmet)
- ✓ Falls Protection (safety harness).

- **Use of PPE**

Safety Helmet: A safety helmet is used in workplace environments to protect the head from injury due to falling objects.	
Goggles/safety glasses: Goggles are forms of protective eyewear usually enclose or protect the eye area.	
Ear plug/ear muff: This device is to be inserted in the e protect the ears from loud noises.	
Dust mask: Dust mask is necessary for dust protect workplace.	
Safety cloth/apron: Safety cloth/apron has been designed to the body from injury in the workplace.	
Safety belt/body harness: A belt/body harness is designed to sec person in case of falling while working level.	
Hand gloves: These are used to protect the hands working and safeguarding of hands.	
Safety shoes/footwear/boots: Safety shoes are used to protect the l from any harms or injuries.	

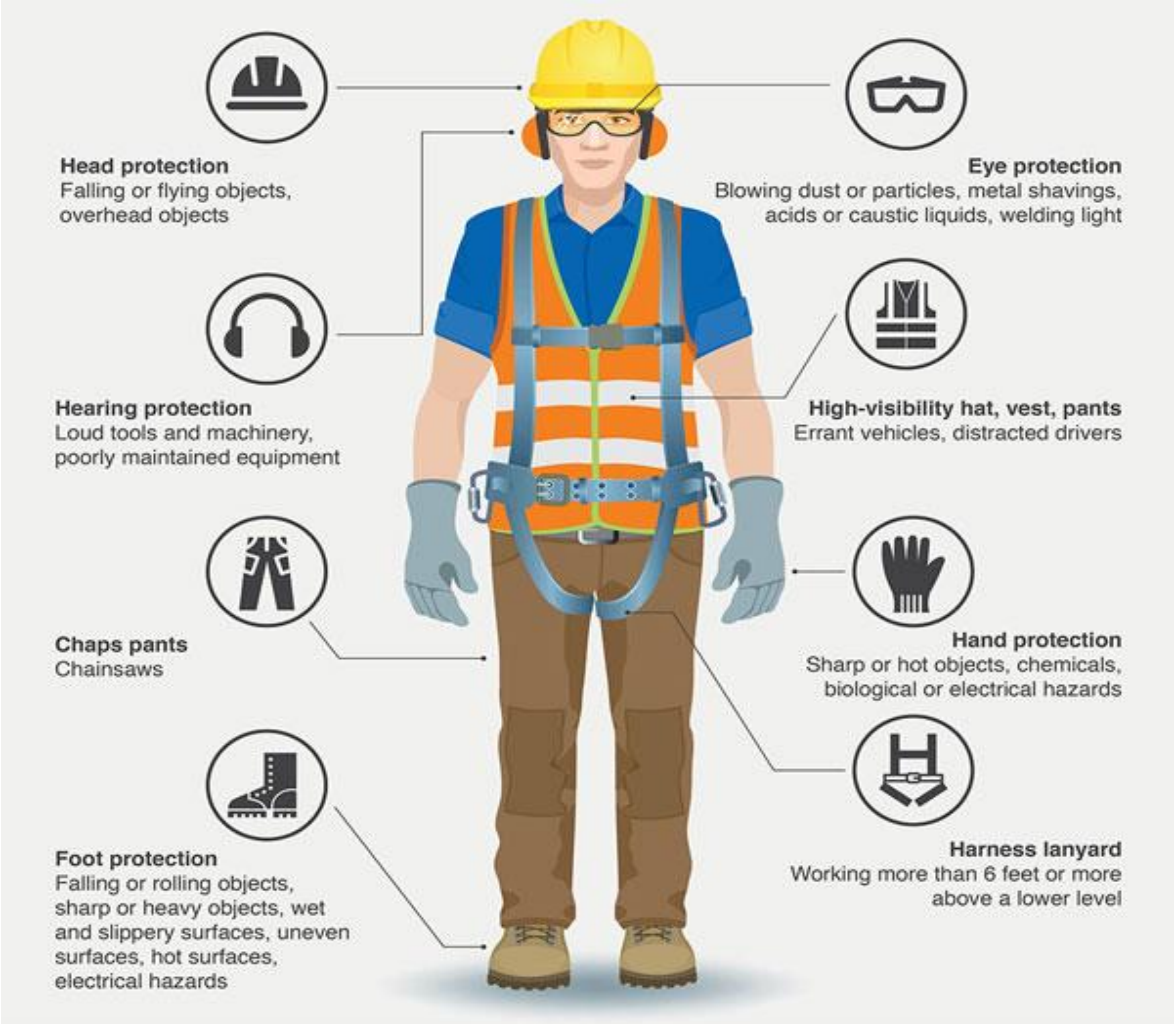


Figure 3.2: personal protective clothing

3.1Standard Distance of Install cable services line.

The standard distance for installing cable service lines can vary depending on several factors, such as local regulations, service provider policies, and the specific requirements of the installation. However, I can provide you with some general guidelines that are commonly followed.

- **Residential Installations:** In most cases, cable service lines are installed from the nearest utility pole or junction box to the customer's residence. The typical distance for a residential installation can range from ***100 to 500 feet (30 to 150 meters).*** Service providers often have a maximum distance limit beyond which they may charge an additional fee or require special arrangements.
- **Commercial Installations**: For commercial installations, the distance can vary significantly based on the size and complexity of the building or facility. It is common for service providers to work with the property owner or manager to determine the best routing and distance for the cable service lines.
- **Underground Installations**: In areas where cables are installed underground, the distance can be more challenging to estimate as it depends on the specific path and infrastructure available. Service providers usually work with local authorities and property owners to plan the underground cable routes effectively.

It's important to note that these are general guidelines, and the actual distance for cable service line installations can vary based on the unique circumstances of each situation.

3.1.1 Identify the service line and install cables for a service line in a workplace

✓ **Power line:**

▪ Power lines and equipment inside your property boundary are known as service lines or mains and are generally owned by the consumer.

✓ **Transmission and distribution lines:**

▪ Transmission lines are higher off the ground and carry higher voltage than distribution lines while distribution lines can be a lower voltage.

▪ Transmission lines run between substations and distribution lines run from the substation to the end-user location.

▪ Transformers are always connected with the distribution lines.

✓ **Distribution pole:**

▪ Distribution poles are to be used, depending on the importance of load, location and place, cost effect of such construction, including maintenance cost.

▪ There are different types of poles used in the electrical system which are made of wooden, steel, concrete and sometimes composite.

▪ In electric power distribution, a service drop is an overhead electrical line running from a utility pole, to a customer's building or other premises.

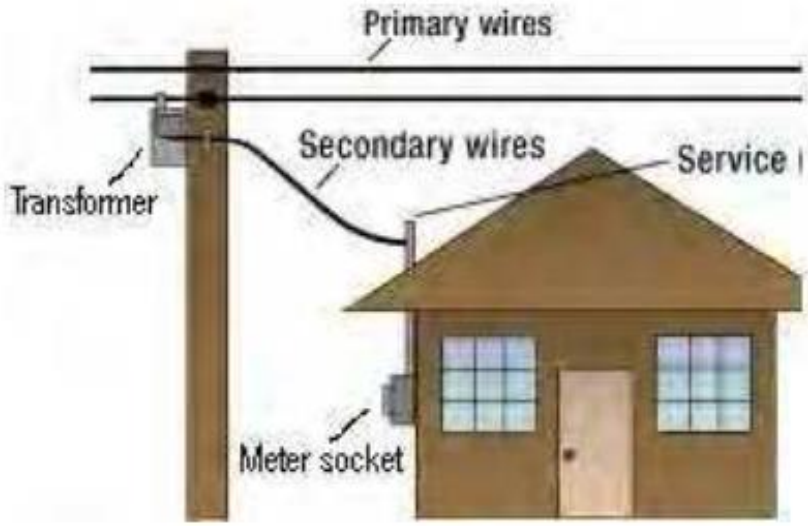


Figure 3.3: Distribution pole

- **Cable jointing methods:**

A. **Western union splices joint**: This is a straight joint used for small solid cables.

• Remove the insulation

• Bring the two conductors to a crossed position and then make a long bend or twist in each wire.

• Wrap the end of one of the wires around the straight portion of the other wire and then do the same for the other wire. Repeat this for about four or five times.

• Press ends of the wires down close to the straight portions of the wire to prevent the ends from piecing through the insulation tape.

•Insulate the joint using the tape.

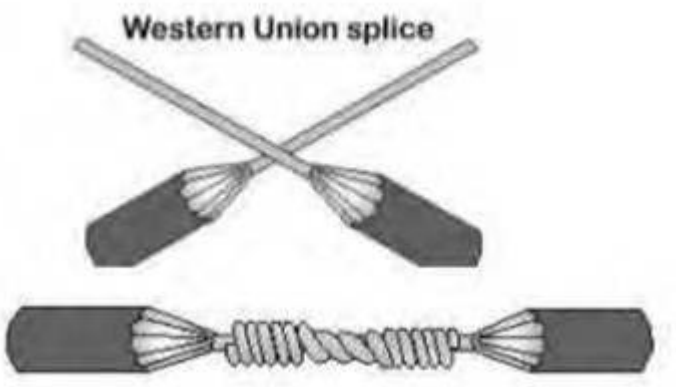


Figure 3.4: Western union splices

B. **Rattail joint:** The rattail joint is usually used in the junction boxes. It allows the connection of branch or multiple circuits in buildings. To create the joint, follow the steps:

- Strip the insulation off the ends of the cable to be joined
- Twist the wires to create the rattail effect.

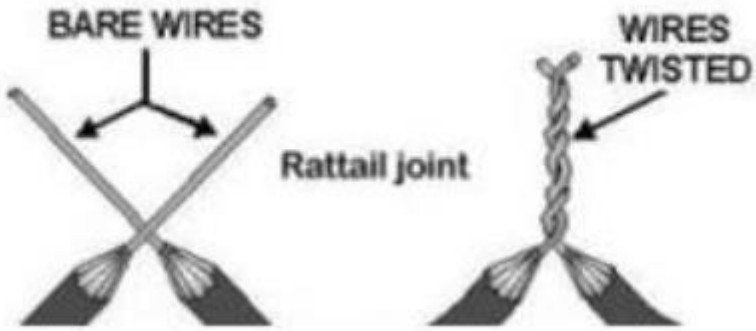


Figure 3.5: Rattail joint

C. **Fixture joint**: This is a type of branch joint connecting a small-diameter wire to the large diameter conductor, such as those used in lighting fixtures.

- Remove the insulation
- Wrap the fixture wire around the branch wire
- Bend the branch wire over the completed turns
- Wrap the remaining fixture wire over the bent branch wire
- This can be followed by soldering and taping, or simply taping of the joint.

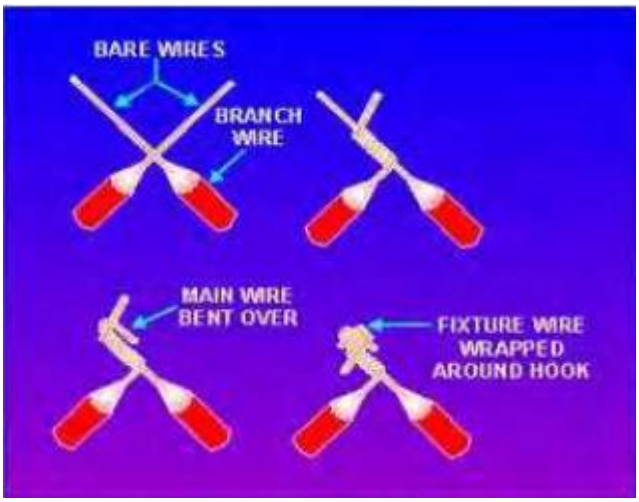


Figure 3.6: Fixture joint

D. **Knotted tap joint:** The knotted tap joint is used to for branch joints to connect a branch wire to a continuous wire.

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

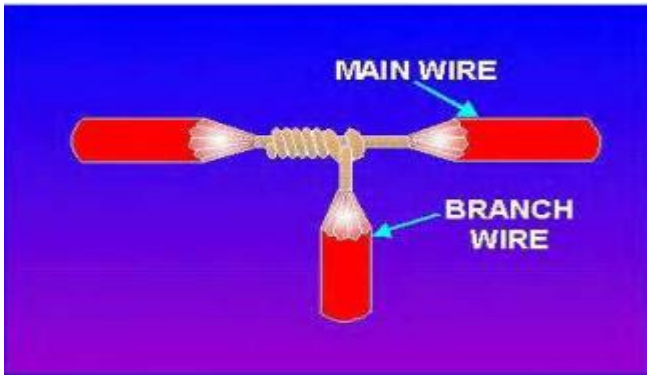


Figure 3.6: knotted tap

E. **Joints using wire nut and split bolt:** The wire nut replaces the rattail joint splice. The nut is usually housed in a plastic insulating casing. To make a joint,

- Strip the conductors
- Place the two to be joined into the wire nut
- Twist the nut.

- **Split bolt connector:**

▪ The split bolt is mainly used to joint large conductors.

▪ This replaces the knotted tap joint and can be used to join three ends or join a branch wire to a continuous conductor.

▪ The bare wires are placed through the space between the two bolts, after which the nut is tightened to ensure a sound joint.

Figure 3.6: split bolt

3.2.1 The Distance Between distribution pole and energy meter services.

- **World common Standard**

he distances between a distribution pole and energy meter services typically ***ranges from 10 to 100 feet (3 to 30 meters).*** This distance can vary depending on a number of factors, including the type of electrical service, the location of the building, and the terrain.

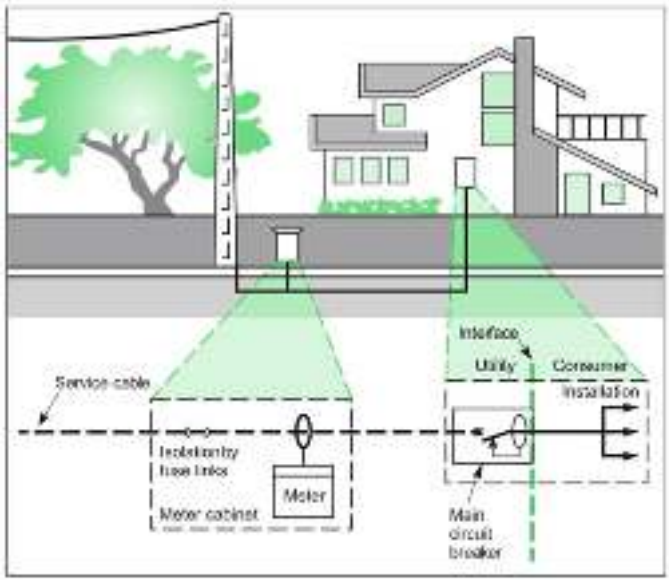


Figure 3.6: pole and energy meter services

Distribution pole and energy meter service in general, the distance between the distribution pole and energy meter services should be as short as possible. This is because longer distances can lead to voltage drop and other problems.

- **(EEPCo)standard**

he Ethiopian Electric Power Corporation (EEPCo) has a set of technical guidelines for the installation of electrical services, including the distance between the distribution pole and the energy meter.

According to the EEPCo guidelines, the minimum distance between the distribution pole and the energy meter is **2 meters (6.56 feet).** This distance is necessary to ensure that there is enough space for the electrician to safely work on the installation and to protect the electrical equipment from damage.

However, the distance between the distribution pole and the energy meter can be greater than ***2 meters***, depending on the specific needs of the property. For example, if the building is located far from the distribution pole or if there are obstacles in the way, it may be necessary to have a longer distance.

Here are some additional factors that may affect the distance between the distribution pole and the energy meter in Ethiopia:

- ***The type of electrical service:*** For example, three-phase electrical service typically requires a longer distance than single-phase electrical service.
- ***The location of the building***: If the building is located in a rural area or in an area with difficult terrain, it may be necessary to have a longer distance.
- ***The presence of obstacles***: If there are obstacles in the way, such as trees or buildings, it may be necessary to have a longer distance.
- ***The budget***: The cost of installing electrical service can increase depending on the distance between the distribution pole and the energy meter.

If you have any questions or concerns about the distance between the distribution pole and the energy meter for your specific property, please contact EEPCo or a qualified electrician.

3.2.2 The Distance Between Main Switch and Energy Meter of Service Line

The distance between the main switch and energy meter of a service line should be as short as possible, but typically not more than 1 meter (3.28 feet). This is because longer distances can lead to voltage drop and other problems.

- **Main switch and energy meter of service line**

The main switch is a device that allows you to disconnect the power to your entire building. It is important to have the main switch located close to the energy meter so that you can easily disconnect the power in an emergency.

The energy meter is a device that measures the amount of electricity that you use. It is important to have the energy meter located close to the main switch so that it can accurately measure the amount of electricity that is being used.

In some cases, it may be necessary to have a longer distance between the main switch and energy meter. For example, if the main switch is located indoors and the energy meter is located outdoors, it may be necessary to have a longer distance. However, it is important to consult with a qualified electrician to determine the best way to install your electrical service.

Self-Check –

3Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Fill in the blanks with the correct answer:

1. _____ is used to protect the head from injury due to falling objects.
2. _____ is used to protect eyes from flying particles which may to the cause worker injury.
3. _____ is essential for a worker while working in construction site at high level.
4. _____ is used to protect the hands when working.
5. _____ is used to protect one's feet from sharp object to fall.

Operation sheet #3

Operation Title: select the appropriate Cable jointing methods

Instruction:

Purpose: to different types of Cable jointing methods

Required tools and equipment: tools from workshops like screw drivers, pliers, measuring tools,

Precautions:

- use safety personal protective equipments properly
- Follow the selection instruction of the task.
- Check tools weather it is functional or not
- Select tools properly

Procedures:

Step 1: Prepare yourself in order to perform the given task

Step 2: Visualize the type of tool

Step 3: If the tool has specification read it

Step 4: Collect the required tools from tools room

Step 5: Inspect tools for any damage prior to each use.

Step 6: Check the handle and body casing of the tool for cracks or other damage.

Step 7: If it is a power tool plug in to the appropriate power source & try check

Step 8: Select the appropriate measuring hand & power tools

Quality criteria:

LAP Test #3

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, Cable jointing methods you are required to perform the following tasks within 1 hours.

Task 1: identify the selecting criteria of Cable jointing methods

UNIT FOUR: CABLES INSTALLATION FOR SERVICE

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- quality cables Selection
- proper cables collection
- Hold and clamp cables with distribution pole of service line
- Joint and connect cables with pole and energy meter of service line

This unit will also assist you to attain the learning outcomes stated in the above unit.
Specifically, upon completion of this learning guide, you will be able to:

- Select quality of cables
- Perform proper cables collection
- perform Hold and clamp cables with distribution pole of service line
- Carryout Joint and connect cables with pole and energy meter of service line

4.1 Quality cables Selection and collection

To select and collect quality cables for service line connection, you should consider the following factors:

- **Cable type:** The type of cable you need will depend on the type of service you are connecting. For example, if you are connecting a new electrical service, you will need to use electrical cable. If you are connecting a new telephone or data service, you will need to use telephone or data cable.
- **Cable size**: The size of the cable you need will depend on the amount of current or data that needs to be carried. For example, a larger cable will be needed for a high-amp electrical service than for a low-amp service.
- **Cable insulation**: The insulation of the cable should be appropriate for the environment in which it will be used. For example, if the cable will be installed outdoors, it will need to have UV-resistant insulation.
- **Cable quality:** It is important to select cables from a reputable manufacturer. This will help to ensure that the cables are made to high quality standards and that they are safe to use.

  Once you have selected the appropriate cables, you should collect them carefully. Avoid bending or kinking the cables, and be careful not to damage the insulation.

  Here are some additional tips for selecting and collecting quality cables for service line connection:

  - ✓ Inspect the cables carefully. Look for any signs of damage, such as cuts, nicks, or kinks.
  - ✓ Make sure that the cables are the correct type and size for your needs.
  - ✓ Verify that the cables have the appropriate insulation for the environment in which they will be used.
  - ✓ Purchase cables from a reputable manufacturer.
  - ✓ Collect the cables carefully to avoid damaging them.

  Once you have collected the cables, you are ready to install them. Be sure to follow the instructions provided by your service provider.

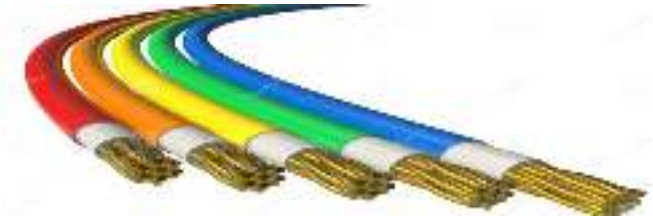


Figure 4.1: Cables

4.2 Cut and set collected cables

To cut and set collected cables for service line connection, follow these steps:

Figure 4.2 Cut and set collected cables

Stripping the insulation off the ends of the cables

1. Inspect the cables carefully. Look for any signs of damage, such as cuts, nicks, or kinks. If you find any damaged cables, do not use them.
2. Measure the length of cable you need. Add some extra length to allow for stripping the insulation off the ends of the cables.
3. Cut the cables to the desired length. Use a sharp cable cutter to make clean cuts.
4. Strip the insulation off the ends of the cables. Be careful not to damage the copper wires inside the cables. You can use a wire stripper or a utility knife to strip the insulation.
5. Set the cables aside in a safe place. Avoid bending or kinking the cables.

Once you have cut and set the cables, you are ready to install them. Be sure to follow the instructions provided by your service provider.

To cut and set collected cables for service line connection, follow these steps:

1. Inspect the cables carefully. Look for any signs of damage, such as cuts, nicks, or kinks. If you find any damaged cables, do not use them.
2. Measure the length of cable you need. Add some extra length to allow for stripping the insulation off the ends of the cables.
3. Cut the cables to the desired length. Use a sharp cable cutter to make clean cuts.
4. Strip the insulation off the ends of the cables. Be careful not to damage the copper wires inside the cables.
5. Set the cables aside in a safe place. Avoid bending or kinking the cables.

Once you have cut and set the cables, you are ready to install them. Be sure to follow the instructions provided by your service provider.

Here are some additional safety tips for cutting and setting cables:

- Wear safety glasses and gloves when cutting and stripping cables. This will help to protect you from flying debris and sharp edges.
- Be careful not to cut yourself on the sharp edges of the cables.
- Do not cut or strip cables that are energized.
- Store the cables in a safe place where they cannot be damaged.

Figure 4.3 Aluminum cables

4.3 Hold and clamp cables with distribution pole of service line To hold and clamp cables with the distribution pole of a service line, you will need to use a pole clamp. Pole clamps are specifically designed to secure cables to poles, and they come in a variety of sizes and styles to accommodate different types of cables and poles.

Figure 4.4 Pole clamps

To install a pole clamp, follow these steps:

1. Choose the appropriate pole clamp for the type of cable and pole you are using.
2. Position the pole clamp on the pole where you want to secure the cable.
3. Tighten the bolts on the pole clamp to secure it to the pole.
4. Wrap the cable around the pole clamp and tighten the bolts on the pole clamp to secure the cable.

It is important to note that pole clamps should be inspected regularly to ensure that they are tight and secure. Pole clamps should also be replaced if they are damaged or corroded.

Here are some additional tips for holding and clamping cables with a distribution pole:

- Use the correct size pole clamp for the type of cable and pole you are using.
- Position the pole clamp so that the cable is centered in the clamp.
- Tighten the bolts on the pole clamp evenly to avoid overtightening.
- Use a torque wrench to ensure that the bolts are torqued to the manufacturer's specifications.
- Inspect the pole clamp and cable regularly to ensure that they are tight and secure.

4.4 Joint and connect cables with pole and energy meter of service line

To joint and connect cables with a pole and energy meter for a service line, you'll need to follow proper electrical installation procedures. Here's a general outline of the steps involved:

- **Safety first:** Before starting any electrical work, ensure that you have the necessary safety equipment such as gloves, safety goggles, and insulated tools. Make sure the power supply to the area is switched off to prevent any accidents.
- **Prepare the pole:** Install a suitable pole or use an existing one to mount the energy meter. Ensure that the pole is securely anchored and meets the required height and clearance regulations set by your local electrical authority.
- **Mount the energy meter:** Fix the energy meter onto the pole using appropriate brackets and fasteners. The energy meter should be positioned at a suitable height for easy reading and accessibility.
- **Prepare the cables**: Strip the insulation from the ends of the service cables using a wire stripper, exposing the conductors. Ensure that the cable ends are clean and free from any dirt or corrosion.
- **Connect the cables to the energy meter**: Follow the manufacturer's instructions for your specific energy meter. Generally, you'll have terminals or connectors on the meter for the incoming and

outgoing cables. Connect the appropriate cables securely to their respective terminals. Use suitable connectors, such as cable lugs, and tighten them properly.

Secure the cables to the pole: Use cable clamps or suitable fasteners to secure the cables along the pole at regular intervals. This helps to protect the cables from damage and ensures a neat installation. Insulate the connections: Once the cables are connected to the energy meter, insulate the connections using electrical tape or heat shrink tubing. This helps to protect against moisture and prevents accidental contact with live parts.

- **Perform a visual inspection:** Double-check all the connections and ensure that they are secure and properly insulated. Verify that there are no loose or exposed wires and that everything is in compliance with electrical codes and regulations.
- **Test the installation:** Once the connections are completed, you should contact a qualified electrician or your local electrical authority to perform the necessary tests to ensure the installation is functioning correctly and safely.

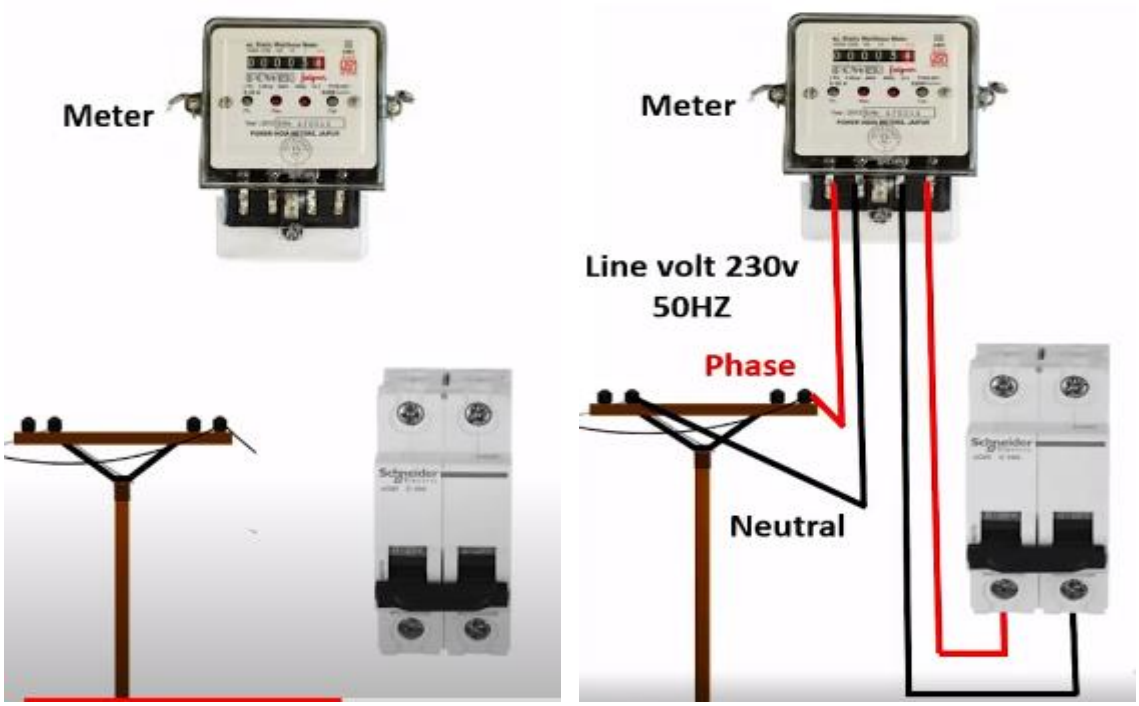


Figure 4.5 connect cables with a pole and energy meter

Self-Check -4

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Wright the following questions listed below

1: What is the most important factor to consider when selecting cables for service line connection?

(A) Cable type

(B) Cable size

(C) Cable insulation

(D) Cable quality

2: When cutting cables, what is the best way to avoid damaging the copper wires inside?

(A) Use a sharp cable cutter to make clean cuts.

(B) Use a utility knife to strip the insulation off the ends of the cables.

(C) Be careful not to overtighten the cable clamps.

(D) Inspect the pole clamp and cable regularly to ensure that they are tight and secure.

3: What is the best way to secure cables to a distribution pole?

(A) Use a pole clamp.

(B) Use electrical tape.

(C) Use heat shrink tubing.

(D) All of the above.

4: When connecting cables to an energy meter, what is the most important safety precaution to take?

(A) Ensure that the power supply to the area is switched off.

(B) Use insulated tools.

(C) Connect the appropriate cables securely to their respective terminals.

(D) Insulate the connections using electrical tape or heat shrink tubing.

Answers: 1. (D), 2. (A), 3. (D), 4. (A),

Operation sheet #4

Operation Title: perform the appropriate connect cables with a pole and energy meter

Instruction:

Purpose: Identify of connect cables with a pole and energy meter

Required tools and equipment: tools from workshops like screw drivers, pliers, measuring tools,

Precautions:

- use safety personal protective equipments properly
- Follow the selection instruction of the task.
- Check tools weather it is functional or not
- Select tools properly

Procedures:

Step 1: Prepare yourself in order to perform the given task

Step 2: Visualize the type of tool

Step 3: If the tool has specification read it

Step 4: Collect the required tools from tools room

Step 5: Inspect tools for any damage prior to each use.

Step 6: Check the handle and body casing of the tool for cracks or other damage.

Step 7: If it is a power tool plug in to the appropriate power source & try check

Step 8: Select the appropriate measuring hand & power tools

Quality criteria:

LAP Test #4

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, connect cables with a pole and energy meter you are required to perform the following tasks within 1 hours.

Task 1: perform the appropriate connect cables with a pole and energy meter

UNIT FIVE: INSTALLATION OF ENERGY METER MAIN SWITCH

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Energy meter and main switch setting on the board
- Measurement and sizing cables
- Laying cable in to the conduits
- Connect energy meter and main switch
- Connect energy meter with service line

This unit will also assist you to attain the learning outcomes stated in the above unit.

Specifically, upon completion of this learning guide, you will be able to:

- Install energy meter and main switch on the board.
- Measure and size cables.
- Lay cable in the conduits.
- Connect energy meter and main switch.
- Connect energy meter with service line.

5.1Energy meter and main switch setting on the board

- **Energy meter:** is an instrument which measures amount of electrical energy used by the consumers. An energy meter is a device that measures the amount of electrical energy consumed by a building or other facility. It is typically installed by the utility company that provides electricity to the building. Energy meters are used to bill customers for their electricity usage.

  There are two main types of energy meters: mechanical and electronic. Mechanical energy meters use a rotating disc to measure the amount of electricity consumed. Electronic energy meters use digital components to measure electricity usage.

  Most energy meters' measure electricity consumption in kilowatt-hours (kWh). A kWh is a unit of energy equal to 1,000 watts of power used for one hour.

  Energy meters are an important part of the electrical grid. They help utility companies to track electricity usage and to bill customers accurately. They also help customers to manage their energy consumption and to save money.

  Here are some of the benefits of using an energy meter:

  - **Accurate billing**: Energy meters provide an accurate measure of electricity consumption, which helps utility companies to bill customers accurately.
  - **Energy management:** Energy meters can help customers to track their energy consumption and to identify areas where they can save energy.
  - **Cost savings:** By managing their energy consumption, customers can save money on their electricity bills.
  - **Environmental benefits**: Reducing energy consumption helps to reduce greenhouse gas emissions and other environmental impacts.

Watt (W) meter	• Measures active electrical power, • normally displayed as kW. • Reactive Volt-Ampere (VAR) meter:
Measures reactive electrical power	• normally displayed as kVAR. • Volt-Ampere (VA) meter • Measures apparent electrical power, • normally displayed as kVA.
Energy Meters	• Watt hour (Wh) meter:

	• Measures active electrical energy, integrating active power • with respect to time, • normally displayed as kWh
VAR hour (VARh) meter:	• Measures reactive electrical energy, integrating reactive • power with respect to time, normally displayed as kVARh
VA hour (VAh) meter	• Measures apparent electrical energy, integrating apparent • power with respect to time, normally displayed as kVAh

Electrical Power and Energy

Power - the rate of energy output or transfer

Energy - capacity to do work- integration of power over time

The methods for calculation of these values will be covered in more detail later in the course.

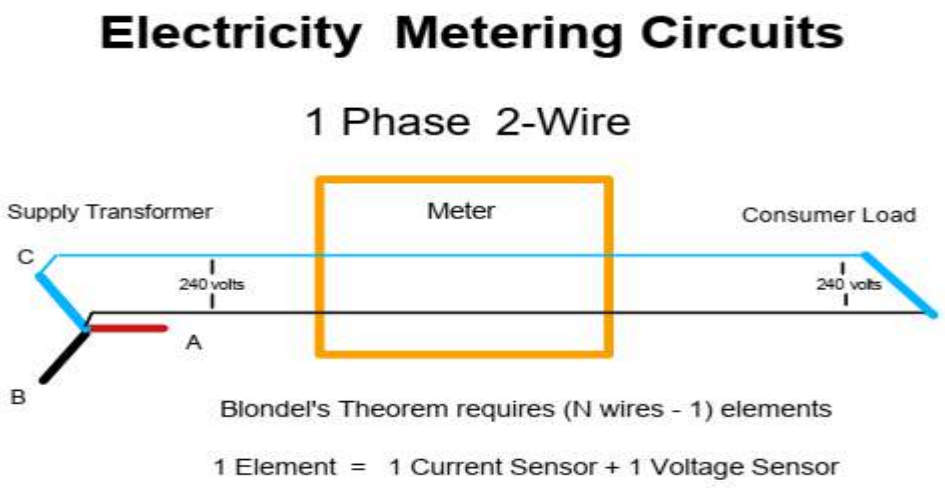


Figure 5.1 Metering ckt

Measurement Concepts

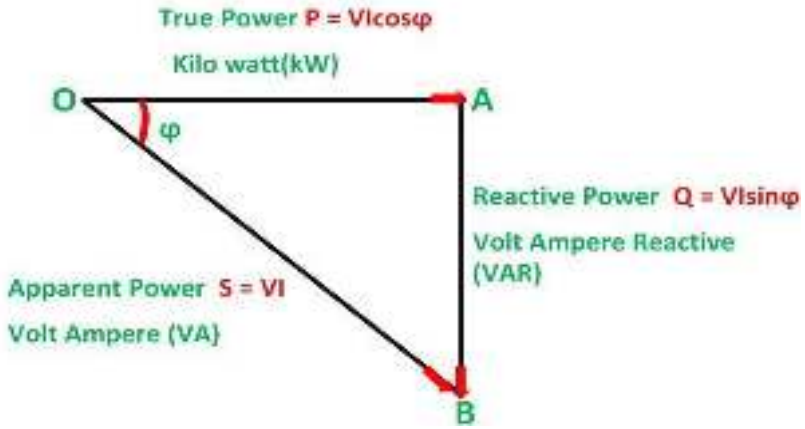
Quadrant Measurement

- ✓ Watts hours, (Wh)
- ✓ Reactive Volt-Ampere hours (VARh)
- ✓ Volt-Ampere hours (VAh)

Power Triangle

Power Triangle is the representation of a right angle triangle showing the relation between active power, reactive power and apparent power.

When each component of the current that is the active component (Icosϕ) or the reactive component (Isinϕ) is multiplied by the voltage V, a power triangle is obtained shown in the figure below:



- ✓ The power which is actually consumed or utilized in an AC Circuit is called True power or **Active Power** or real power. It is measured in kilowatt (kW) or MW.
- ✓ The power which flows back and forth that means it moves in both the direction in the circuit or reacts upon it, is called **Reactive Power**. The reactive power is measured in kilovolt-ampere reactive (kVAR) or MVAR.
- ✓ The product of root mean square (RMS) value of voltage and current is known as **Apparent Power**. This power is measured in KVA or MVA.

The following point shows the relationship between the following quantities and is explained by graphical representation called Power Triangle shown above.

$$\text{Power factor Cos}\varphi = \frac{\text{Active power}}{\text{Apparent power}} = \frac{\text{KW}}{\text{KVA}}$$

- **Power Calculation Triangle with Example**

The power calculation triangle is a right triangle that represents the relationship between the three types of power in an electrical circuit:

Real power (P)

Reactive power (Q)

Apparent power (S)

The three sides of the triangle are related by the following equation:

$$S^2 = P^2 + Q^2$$

Where:

S is the apparent power in VA

P is the real power in W

Q is the reactive power in VAr

The power factor (PF) of a circuit is a measure of how efficiently the circuit is using real power. It is defined as the ratio of real power to apparent power:

$$PF = P / S$$

A power factor of **1** indicates that the circuit is using all of its apparent power efficiently. A power factor of less than **1** indicates that the circuit is using some of its apparent power inefficiently.

Example:1

A circuit has an apparent power of 100 VA and a power factor of 0.8. What is the real power and reactive power in the circuit?

- ✓ Real power (P) = S * PF = 100 VA * 0.8 = 80 W
- ✓ Reactive power (Q) = √ (S^2 - P^2) = √ (100^2 - 80^2) = 60 VAr

Therefore, the real power in the circuit is **80 W** and the reactive power is **60 VAr.**

Example:2

A circuit has a real power of **50 W** and a power factor of **0.7**. What is the apparent power and reactive power in the circuit?

- ✓ Apparent power (S) = P / PF = 50 W / 0.7 = 71.43 VA
- ✓ Reactive power (Q) = √(S^2 - P^2) = √(71.43^2 - 50^2) = 45.9 VAr

Therefore, the apparent power in the circuit is **71.43 VA** and the reactive power is **45.9 VAr**.

The power calculation triangle is a valuable tool for understanding and managing power consumption in electrical circuits. It can be used to calculate any of the three types of power in a circuit if two of the other types of power are known.

Unit of energy:

- 1 Joule (J) is the MKS unit of energy, equal to the force of one Newton acting through one meter.
- 1 Watt is the power from a current of 1 Ampere flowing through 1 Volt.
- 1 kilowatt-hour is the energy of one kilowatt power flowing for one hour.

Types of energy meters

1. **Electromechanical Energy Meters:** The electromechanical induction meter operates by counting the revolutions of a nonmagnetic, but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number of revolutions is thus proportional to the energy usage	
2. Electronic Energy Meters: Electronic meters display the energy used on an LCD or LED display and some can also transmit readings to remote places. In addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc.	
3**. Smart Energy Meters:** These are capable of communicating in both directions. They can transmit the data to the utilities like energy consumption, parameter values, alarms etc. and also can receive information from utilities such as automatic meter reading system, reconnect/disconnect instructions, upgrading of meter software's and other important messages. Advantage of smart metering is complete avoidance of tampering of energy meter where there is scope of using power in an illegal way.	

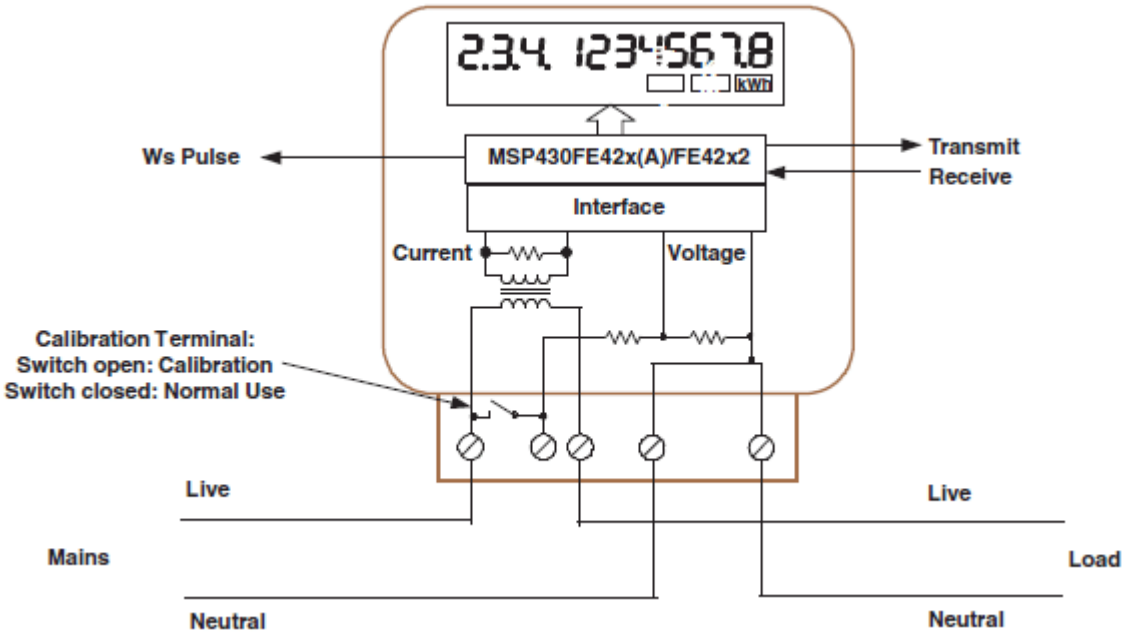


Figure 5.2 Energy Meter Connection

- **How to install a new energy meter?**

The energy meter shall be located in places readily accessible to authorized organization representatives for installation, maintenance, reading or removal.

To complete the task, you should follow the steps given below:

1. Collect all necessary tools, equipment and accessories to install an energy meter.
2. Identify and select usable tools & equipment to install an energy meter.
3. Collect an energy meter from the house owner for installation.
4. Install the energy meter in accordance with standard requirements.
5. Check the installation and test continuity using appropriate tools & equipment.
6. While working you should use personal protective equipment for safety.
7. Clean the workplace and restore the tools, equipment and excess materials.

➢ **Main switch:** is an intermediate installation in the power distribution circuit connecting the power generators and power consumers.

- ✓ Main switch allows to disconnect all electricity coming into the home.
- ✓ Main switch is a central cut-off switch that controls the smaller cut-off switches and machines of a building.
- ✓ Main switch can be cut off by a human or a computerized system to control the flow of power in the building.

Figure 5.3 Main switch

How to install and connect main switch?

The main switch shall be located in places readily accessible to power users or consumers for installation, operation and maintenance.

To complete the task, you should follow the steps given below:

1. Collect all necessary tools, equipment and accessories to install and connect main switch.
2. Identify and select usable tools & equipment to install and connect main switch.
3. Collect a main switch from the house owner for installation and connection.
4. Install and connect main switch in accordance with standard requirements.
5. Check the installation and test continuity using appropriate tools & equipment.
6. While working you should use personal protective equipment for safety.
7. Clean the workplace and restore the tools, equipment and excess materials.

The energy meter and main switch are typically located on the same board, which is usually installed in a cupboard or closet. The energy meter is used to measure the amount of electricity that is used in a property, while the main switch is used to turn the power on and off.

The energy meter is usually a digital display that shows the electricity consumption in kilowatt-hours (kWh). The main switch is usually a large lever or button. To turn the power on, flick the lever up or press the button. To turn the power off, flick the lever down or press the button again.

It is important to note that the main switch should only be turned off in an emergency, such as if there is a fire or a flood. It is also important to note that the main switch should not be turned off while appliances are in use, as this can damage them.

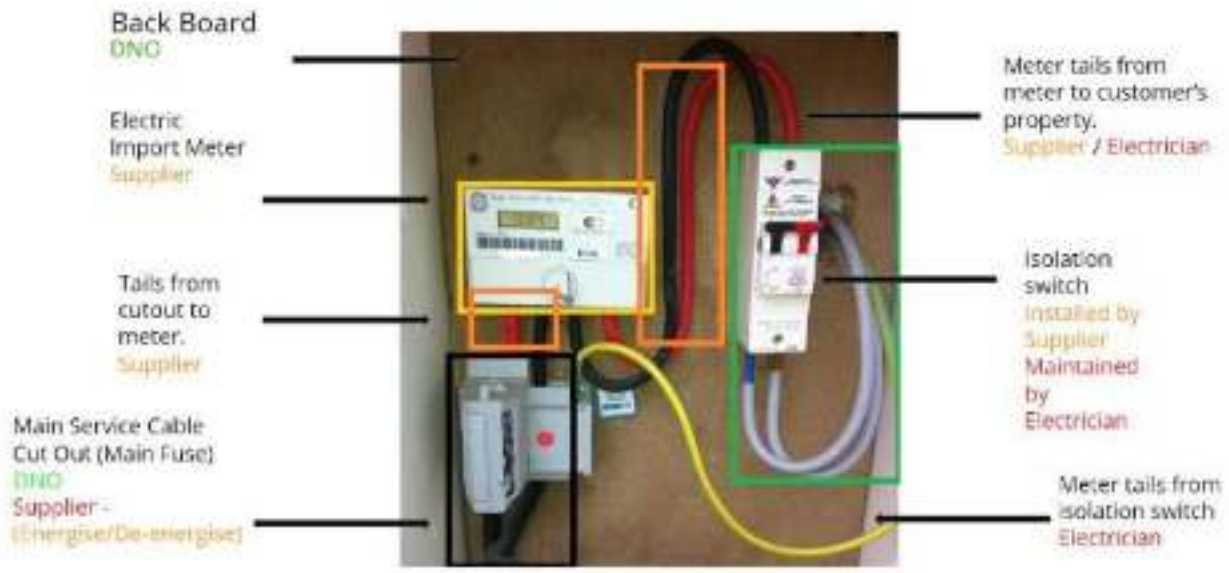


Figure 5.4 Main switch connection with KWHM on the board

If you need to turn off the power to your property for a longer period of time, such as when you are going on vacation, you should contact your electricity supplier. They will be able to send an engineer to disconnect your supply at the meter.

- ✓ **Setting the main switch**

The main switch should be set to the 'ON' position unless there is an emergency. If you need to turn the main switch off, be sure to turn it back on as soon as possible.

- ✓ **Setting the energy meter**

The energy meter is usually set to the 'AUTO' position. This means that it will automatically record your electricity consumption. If you need to reset the energy meter, you can usually do this by pressing a small button on the meter.

Safety tips

- Always be careful when working with electricity.
- Never touch the main switch or the energy meter while the power is on.

5.2 Energy meter is connected with service line

➢ **Service Line**

➢ **A service line can be defined as follows;**

1). A L.T (low tension) line which is used to provide electricity from an electric pole up to the energy meter installed on the premises, is called a service line.

2). A-line, which is mounted between an electric pole and a consumer's energy meter, is called a service line

3). Service line is a type of line, which supplies electric energy from the supplier's lines to the consumer's premises.

4). A-line through which a consumer's installations are connected directly to the distribution lines is called a service line

5). A-line or cable which connects a supplier's (e.g., WAPDA) distribution lines to the consumer's wiring system via an energy meter, is called a service line.

The electrical power is supplied through the transmission lines from the generating stations or sub-stations to different cities and from there to the consumers for ordinary applications via the distributors or distribution lines. The consumers receive this power through a service line from the distribution lines (i.e., the consumer's wiring or installations are connected directly with the distribution line through a service line). For domestic loads, a single-phase supply (220 – 250 volts) whereas for the industrial loads, a three-phase supply (380 – 440 volts), is provided. The service line used to get a single-phase connection tends to be a 2-core cable (one core for phase while the other for neutral), above which there is insulation covering of PVC (Poly Vinyl Chloride) or T.R.S (Tough Rubber Sheath). As a three-phase supply is normally provided to huge buildings or industries through a service line, therefore a four-core cable or service line is used at such places instead of a two-core cable. This four-core service line consists of red, yellow, blue, and black colors insulated covers, wherein red, yellow, and blue colored covers are used for the three supply phases, whereas the black color insulation cover functions as a neutral. It must be remembered that the service line should always be used according to the load requirements of the building.

➢ **Types of Service Lines**

The following two types of service lines are used in a single- story and multi-storeyed buildings;

1). Overhead Service Line

2). Underground service Line

- **Overhead Service Line**

If an overhead conductor has been used as a service line, this type of service line is called an overhead service line. In other words, if the supply line leading from an electric pole to the energy meter fitted in a building for providing electricity to a consumer's installations, is set at a specific or a proper height, such a line is termed an overhead service line. The overhead service line or cable is tied with the L.T conductor of the pole through a clamp. Then this cable is fastened above a metallic wire and brought to the entrance passage of the consumer's building. The purpose of a fastening cable above a metallic wire is to provide support against an expected sagging of the cable. Another advantage of a metallic wire is that in the case of a road crossing, a cable can be put at a reasonable height through it to avoid traffic disruption. Then, the cable is passed through a galvanized iron (G.I) pipe having a reasonable diameter and brought up to the energy meter fitted in the building. In figure 5.5, an overhead service connection has been illustrated.

To get overhead service connection, different sized all-aluminum stranded conductors (AAC), aluminum conductor steel reinforced (ACSR), or hard-drawn copper conductor (its application is very low nowadays due to being costly) are used according to the load of the consumer. In the case of copper conductor, the minimum size that tends to be used is 10SWG, provided the load does not exceed 1-kilo watt (1KW). If the load does not exceed 2.5 KW, then households, as well as commercial consumers, are supplied through an 8SWG copper conductor or 13.9 square millimeter size AAC or ACSR conductor. To connect a power load of up to 12 KW with the supply, a 6SWG copper conductor or 19.4 square millimeter AAC or ACSR conductor is used. The aluminum core PVC cables or weather-proof cables are used for cable service connection.

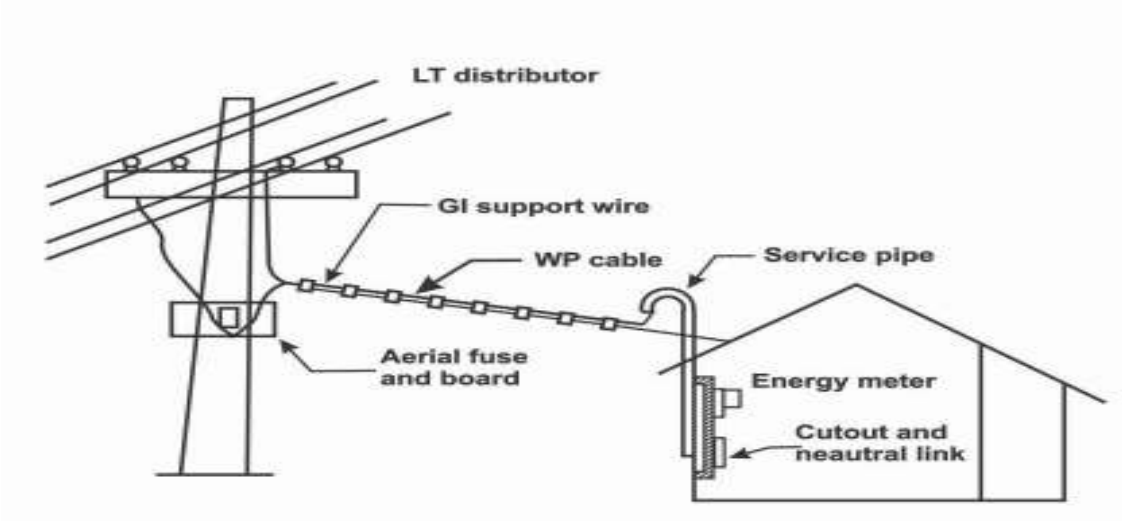


Figure 5.5 – Overhead service connections

- **Methods of Installation of Overhead Service Lines**

The following methods are adopted for the installation of overhead service lines;

- **For High Roof Building or Multi-Storey Building**

If the roof of any building is very high or if a building consists of more than two storeys, for this purpose a service bracket is firmly fixed onto the wall at a suitable height for installation of the service wire. On this service bracket, shackle style or pin type insulators are then mounted, the number of which depends on the number of incoming wires (an iron piece made of mild steel, which has been bent at a certain angle, is called a steel bracket). In the case of a common service connection or a single-phase connection, their number uses to be two, whereas, in a situation of power service connection or a three-phase connection, their numbers tend to be four. According to the rules, the vertical distance between the insulators must be 35 centimeters while the distance from the side should be 30 centimeters. The phase and neutral wire are always fetched from the nearest service pole and these are connected to the insulators fitted on the service bracket. The earth wire is joined with angle iron through an eye bolt. Thereafter, a weatherproof or PVC cable (which is known as a service cable) is tightly annexed to the conductors (i.e., overhead service line) through the connectors. Then, this cable is passed into an appropriately sized galvanized iron (G.I) pipe or conduit and carried to the service board. This has been illustrated in figure 2.2. The open-top mouth of the G.I pipe should be bent slightly so that rainwater does not enter the pipe. In figure 2.3, an alternative method for providing service mains has also been illustrated, wherein shackle insulators have directly been installed on walls instead of the service bracket.

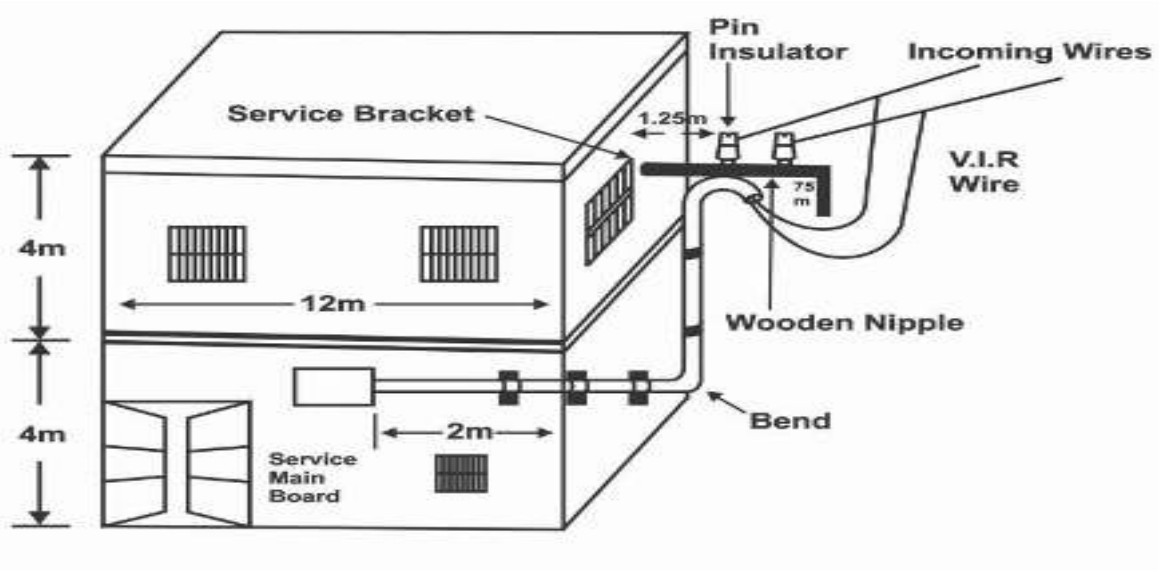


Figure 5.6 – Service line connection with angle iron bracket for a double-story building

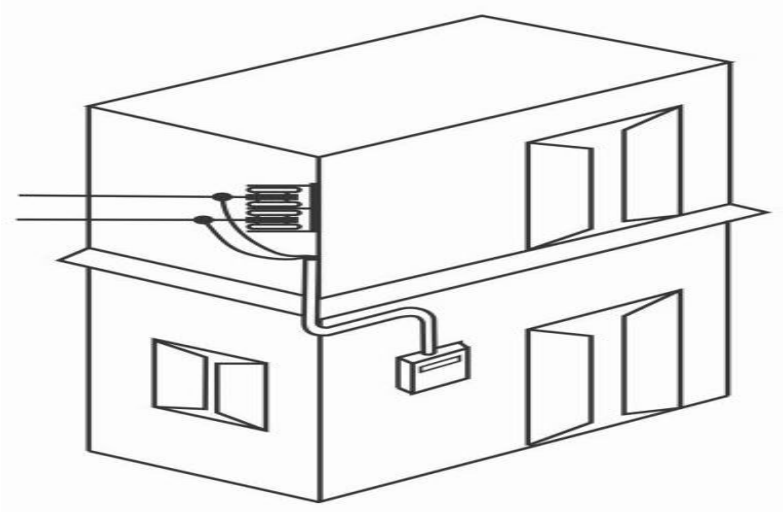


Figure 5.7 – represents an alternative method of providing service mains

For low Roof or Single Storey Building

If the roof of a building is low or the height of any building is substantially low, then the service bracket is not fitted directly onto the wall, because by doing so, the difference between the power conductors and earth will not be according to the electricity rules. Under such a situation, roof pole connection or G.I pipe connection are done. In the case of a roof pole connection, an appropriately sized strong steel tube, which is called a pole, is fitted. This has been illustrated in figure 5.8.

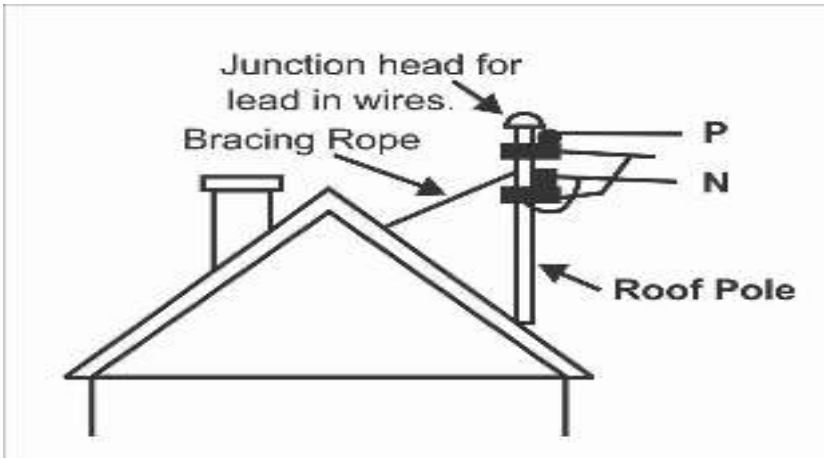


figure 5.8. Roof pole

Alongside a steel pole or roof pole, arms are fitted length-wise, on which insulators have been mounted. The height of the roof pole should not exceed 3 meters otherwise tensile strength of the wires tied along with it, will increase. To reduce the power of this tensile strength, this pole is tied to the roof through a steel rope for providing it strong support.

In the case of the G.I pipe connection, the lower end of a suitably heightened galvanized iron (G.I) pipe is installed on the wall through clamps. As such, a pipe is thrust above the roof surface to a

reasonable extent. However, the height of the pipe from the roof should not exceed 3 meters. So that tensile strength on G.I pipe, resulting from wires, does not cross a safe limit.

In order to provide support to a G.I pipe, a stay wire is also fastened with it, the other end of which is installed within the roof. In figure 2.5, the service line connection for a one-story building with a G.I pipe has been illustrated. A G.I wire has been tied between the top end of the G.I pipe and pole through an eye thimble, along which ring insulators are fitted at equal distances. The bare conductors of a service line are joined with these insulators. One end of the PVC pipe is connected to this service line, while its other end is carried up to the service board through the G.I pipe.

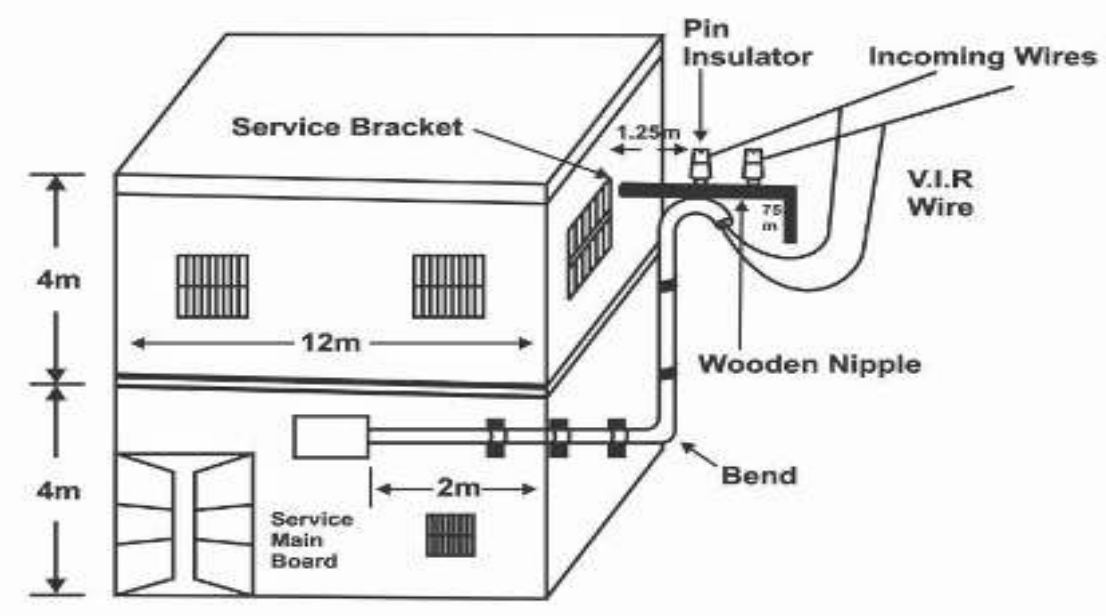


Figure 5.9 – Service line construction with G.I pipe to a single-story building

- **Underground Service Line**

If an underground cable has been used as a service line, such a service line is called an underground service line. In other words, if the supply line from an electric pole through an energy meter in a building for the supply of electricity to the consumer's installations, is spread underground, such a service cable line is called an underground service line. In figure 2.6, an underground service cable has been illustrated.

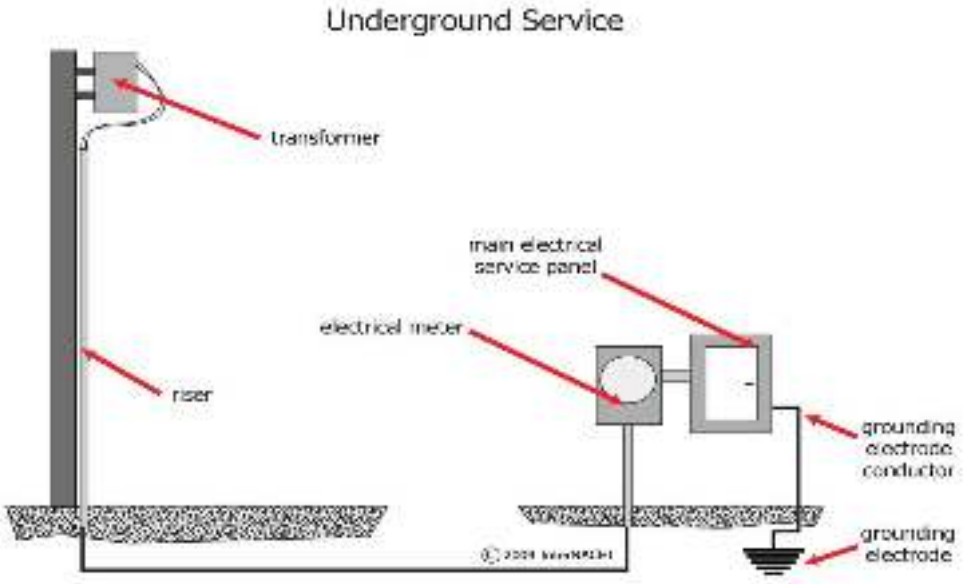


Figure 5.10 – service main by underground cable

The importance of underground mains increases at a time when the owner of a building fears that the beautification of his building could be at risk through the supply of an overhead service connection. Moreover, if several buildings are constructed side by side, it is always convenient to provide service connections to all these buildings in such a fashion that the service main is carried underground through a service pole to the main board of the building and then the main board of the second building is provided supply from the main board of the first building. Similarly, the main board of the third building is looped with the main board of the second building, as has been illustrated in the figure

- **The Underground Cable Service Connection**

The underground cable is generally used when the consumer is required to be supplied more than 25KW of power. For spreading the underground service line, an appropriate size cable box is installed on the service pole. For carrying cable from this cable box to another cable box fitted on the service board, the first cable is fetched onto the earth by passing it through the G.I pipe, which has been fitted on the pole with the help of clamps. Then, the cable is stretched into a one-meter trench dug into the ground from the pole base up to the building. After stretching the cable in the trench, it is filled up with sand and then the trench is closed from above through bricks. Sometimes, this service cable is passed in the underground trench inside G.I pipes, so that cable remains protected against mechanical shocks.

Remember that for spreading underground cable, a sound-insulated typed cable should be used, so that it does not get out of order soon. After stretching the cable underground, this cable is carried inside an appropriately sized G.I pipe up to the service board, so that cable remains shielded against external perils. In figure 5.11, the installation of an underground service cable has been illustrated.

Material Required for Overhead Service Line

S. No	Nomenclatures	S. No	Nomenclatures
1.	Connector	9.	Single-Phase or Three-phase Service Mast Pipe
2.	Eye Screw Bolt	10.	Wall Clamp
3.	Weather Proof PVC Insulated Twin or Four Core Aluminum Cable	11.	Reg Bolts for Clamp Fitting
4.	Tie Wire	12.	Hook
5.	Steel Clips	13.	Wooden or Plastic Dowels
6.	Pole Clamp with Thimble	14.	Screws for Meter Board
7.	Bush for G.I Pipe	15.	Single-phase or Three-phase Energy Meter
8.	Pipe Clamp	16.	Meter Board

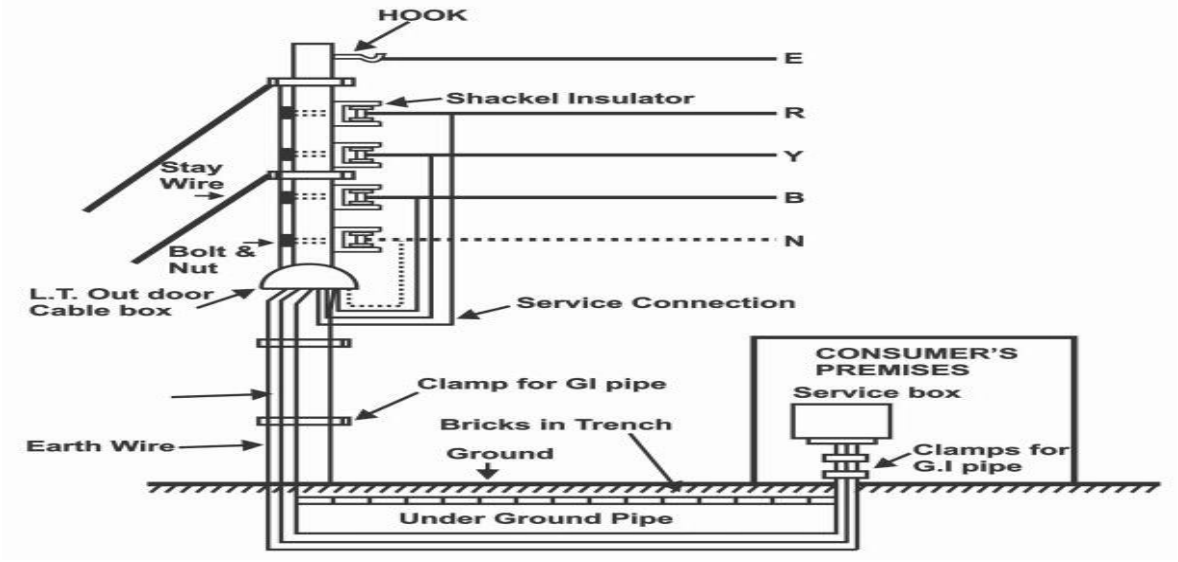


Figure 5.11 the installation of an underground service cable has been illustrated.

The connetion of Energy meter with service line

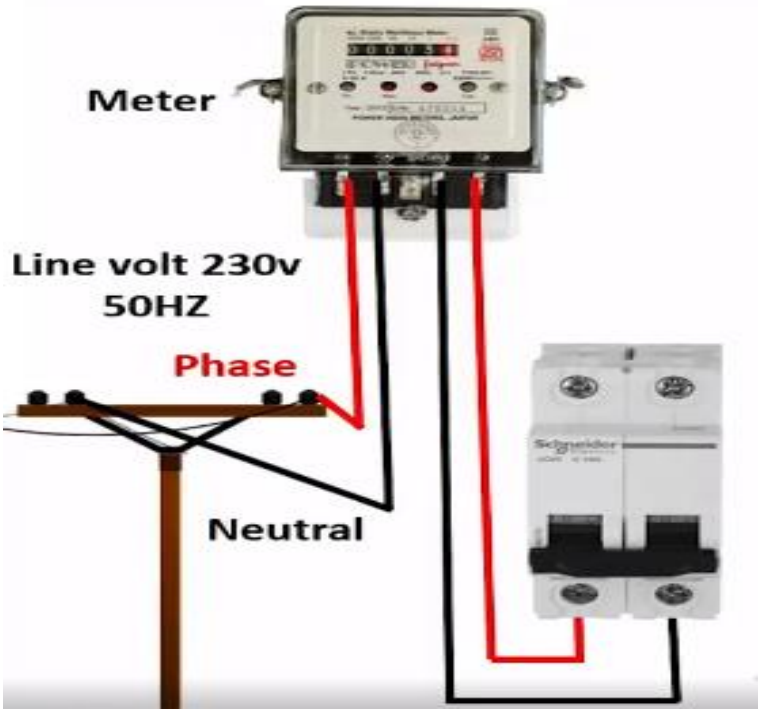


Figure 5.12 Connecting the Energy Meters

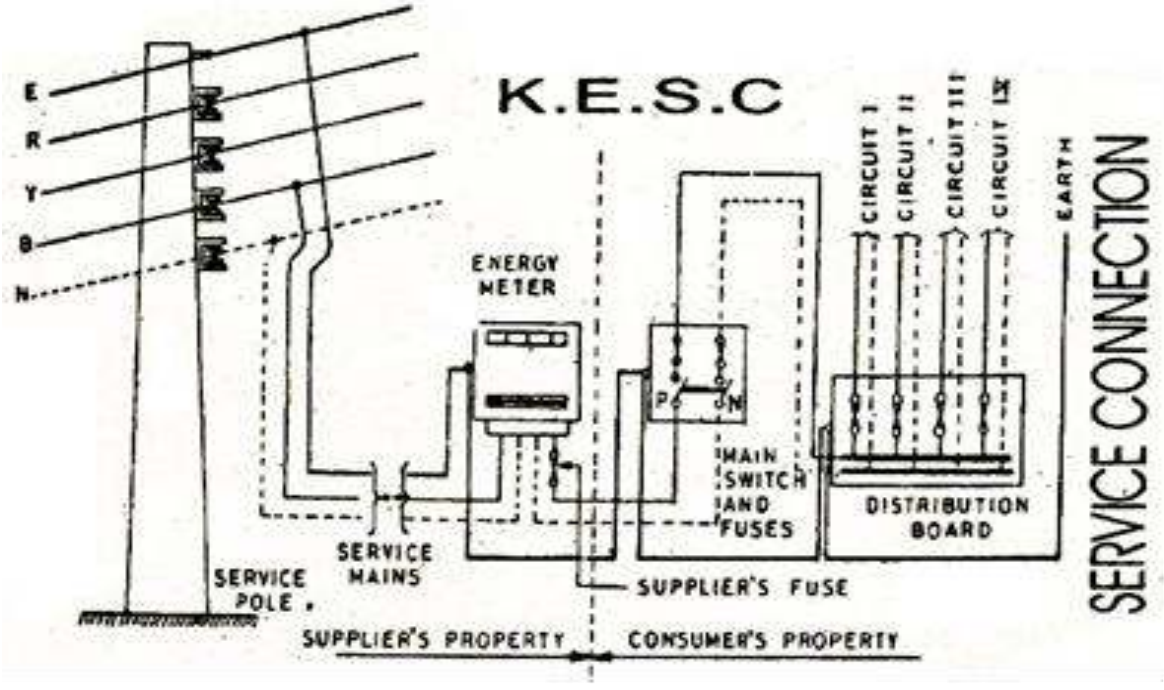


Figure 5.13 Connecting the Energy Meters with service connection

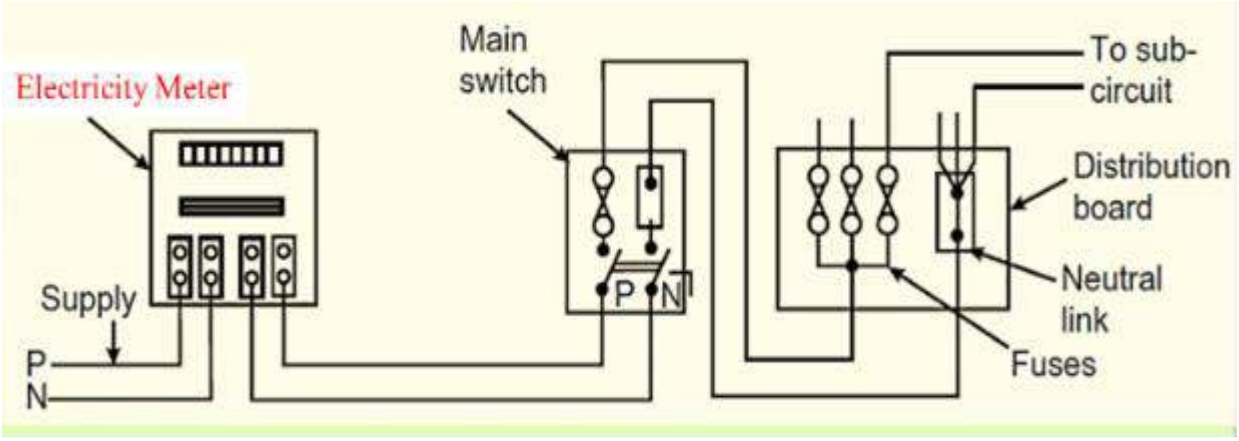


Figure 5.14 single phase Connecting the Energy Meters with service connection

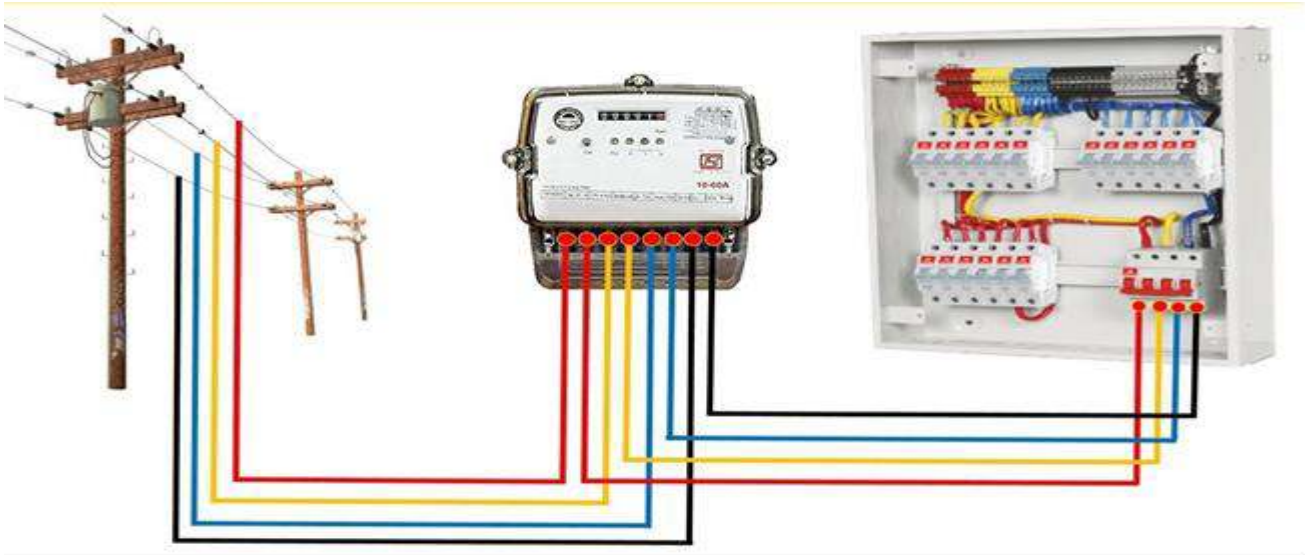


Figure 5.15 three phase Connecting the Energy Meters with service connection

5.3 Measurement and sizing cables

➢ **Measurement and cables size a service line to energy meter**

The standard cable size for the installation of a service line to an energy meter can vary depending on several factors, including the electrical load requirements and the local electrical code regulations. Typically, the size of the cable is determined based on the anticipated maximum current that will flow through it.

In many residential and commercial installations, the most common cable sizes for service lines are 10 AWG (American Wire Gauge) and 8 AWG copper conductors. These sizes are suitable for typical loads and are commonly used for 100-amp and 200-amp service entrances, respectively.

However, it's important to note that cable sizing should be done by a qualified electrician or electrical engineer who can consider all the relevant factors specific to your installation, such as the length of the service line, the voltage drop requirements, and any local code requirements.

Therefore, it is highly recommended to consult with a licensed electrician or electrical engineer who can assess your specific needs and comply with the local regulations and electrical codes applicable in your area.

he standard cable size for installation of a service line to an energy meter will vary depending on the following factors:

- The amperage of the service
- The length of the service line
- The type of cable being used
- The local electrical code requirements

In general, the following cable sizes are commonly used for service line installations:

Amperage	Cable Size
100 amps	#4 AWG copper or 250 MCM aluminum
150 amps	#2 AWG copper or 350 MCM aluminum
200 amps	2/0 AWG copper or 500 MCM aluminum

If the service line is longer than 100 feet, it may be necessary to use a larger cable size to compensate for the voltage drop. It is important to consult with a qualified electrician to determine the correct cable size for your specific installation.

Additional notes:

- The cable should be installed in a conduit to protect it from damage.
- The cable should be buried at least 18 inches deep.
- The cable should be connected to the energy meter using a weatherproof enclosure.

- **Measurement and cables energy meter to main switch**

  The measurement and cable size of the main switch will depend on the specific electrical system and load requirements of the installation. The main switch, also known as the main circuit breaker or main disconnect, is typically located at the service entrance panel or main distribution board.

  Here are some general guidelines regarding the measurement and cable size for the main switch:

- **Measurement:** The measurement or rating of the main switch is typically determined based on the maximum anticipated electrical load of the installation. It is usually expressed in terms of amperes (A). Common main switch ratings for residential installations are 100A, 200A, or 400A, but larger installations may require higher ratings.

- **Cable Size:** The cable size for the main switch is determined by several factors, including the maximum current expected to flow through it, the length of the cable run, and the voltage drop limitations. The cable size is typically specified in terms of the cross-sectional area of the conductors, measured in American Wire Gauge (AWG) or square millimeters (mm²).

  To determine the appropriate cable size, it is important to consult with a qualified electrician or electrical engineer who can perform a load calculation and consider all relevant factors specific to your installation. They will take into account the electrical code requirements, voltage drop considerations, and the specific characteristics of the electrical system to determine the correct cable size. It is important to note that electrical installations should be performed by licensed professionals who are familiar with local regulations and codes to ensure safety and compliance.

5.4. Laying cable in to the conduits

Laying of Underground Cables

The reliability of underground cable network highly depends upon proper laying of cables, quality of cable joints and branch connections etc. There are three main **methods of laying underground cables**, which are - (i) direct laying, (ii) draw-in system and (iii) solid system. These three methods are explained below with their advantages and drawbacks.

This method is the most popular as it is simple and cheap. The cables to be laid using this method must have the serving of bituminized paper and hessian tape so as to provide protection against corrosion and electrolysis.

The **direct laying procedure** is as follows.

Figure 5.16 Direct Laying of Underground Cables

- **Laying Procedure**
  - ✓ A trench of about 1.5 meters deep and 45 cm wide is dug.
  - ✓ Then the trench is covered with a 10 cm thick layer of fine sand.
  - ✓ The cable is laid over the sand bed. The sand bed protects the cable from the moisture from the ground.
  - ✓ Then the laid cable is again covered with a layer of sand of about 10 cm thick.
  - ✓ When multiple cables are to be laid in the same trench, a horizontal or verticle spacing of about 30 cm is provided to reduce the effect of mutual heating. Spacing between the cables also ensures a fault occurring on one cable does not damage the adjacent cable.
  - ✓ The trench is then covered with bricks and soil to protect the cable from mechanical injury.
- **Electrical Conduits**

In this article, we discussed the importance of Electrical conduits, different types of electrical conduits, Maximum no. of cables in electrical conduits 20mm, 25mm, 32mm. The minimum distance between saddle clips for a conduit. Why some LED light works even when the switch is OFF. This may be due to the electrical induction from another cable in the same conduit. Avoid it draw less than the maximum allowed cables in the conduit.

- **pull cable is the type of conduit**

One of the important things to consider when preparing to pull cable is the type of conduit you'll be working with. The thickness of the conduit, as well as the texture, will help determine the best method for pulling wire through the conduit. Thinner conduits may not allow for the use of fishing weights or conduit mice, while larger conduits may support these methods.

Some common types of conduit include the following:

- Divisible conduits
- Fiber optic conduits
- Jumbo conduits
- Metallic braided conduits
- Plastic conduits
- Polyamide conduits
- Retrofit table conduits
- Specialty polymer conduits

Whatever type of conduit you're working with, ETHIOPIAN can provide high-quality versions at excellent prices.

Nominal cross sectional area conductors mm^2	Size of Conduit in mm		
	20	25	32
	Maximum number of cables draw		
1.5	7	12	
2.5	5	9	12
4	3	6	9
6		5	8
10		3	6
16			4
25			3

Tabel 5.1 Electrical Coundiut Size With Conductors Cross sectional Area

5.4 Connect energy meter and main switch

A main switch is a device that is used to turn on and off the electrical power to a building or other structure. It is typically located in the main electrical panel, which is often located in the basement or garage. Main switches are typically rated for high currents and voltages, and they are designed to be operated manually.

Figure 5.1 main switch

Main switches are used for a variety of purposes, including:

- To turn off the power to a building or structure for maintenance or repairs.
- To isolate a building or structure from the electrical grid in the event of an emergency.
- To control the power to specific circuits or areas of a building or structure.

Main switches are an important safety feature in any electrical system, and they should be inspected and tested regularly by a qualified electrician.

Here are some of the different types of main switches:

- Circuit breakers: Circuit breakers are the most common type of main switch. They are designed to automatically trip and turn off the power in the event of a short circuit or overload.
- Disconnections: Disconnections are manual switches that are used to isolate a building or structure from the electrical grid. They are not designed to protect against short circuits or overloads.
- Fuses: Fuses are manual switches that contain a thin strip of metal that melts and breaks the circuit in the event of a short circuit or overload. Fuses are less common than circuit breakers today, but they are still used in some applications.

The type of main switch that is best for a particular application will depend on a number of factors, such as the size and type of electrical load, the budget, and the desired level of safety. It is always

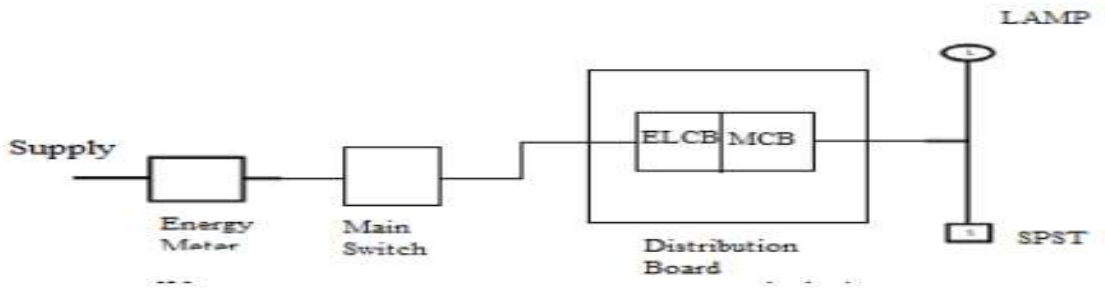
best to consult with a qualified electrician to determine the best type of main switch for a particular application.

- **Procedures**

1. Turn off the power at the main breaker. This is usually located outside your home, near the meter.
2. Connect the incoming power wires to the energy meter. The incoming power wires are usually black and red, and they are connected to the meter terminals labeled "Line In" or "L1" and "L2."
3. Connect the outgoing power wires to the main switch. The outgoing power wires are usually black and white, and they are connected to the switch terminals labeled "Line Out" or "L1" and "L2."
4. Connect the ground wire to the energy meter and main switch. The ground wire is usually green or bare copper, and it is connected to the meter and switch terminals labeled "Ground."
5. Turn on the power at the main breaker.

   Once the power is turned on, the energy meter will begin recording the amount of electricity that is used in your home. The main switch can be used to turn off all of the power to your home, if necessary.

LAY OUT :



CIRCUIT DIAGRAM :

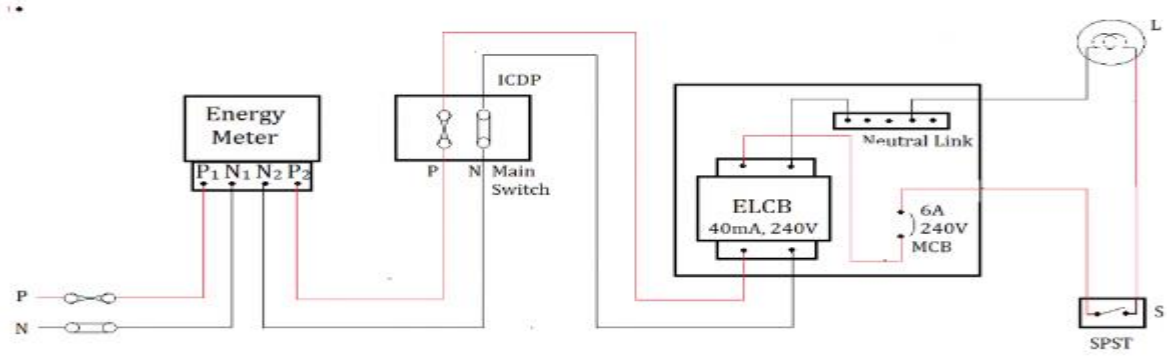


Figure 5.17 Connect energy meter and main switch

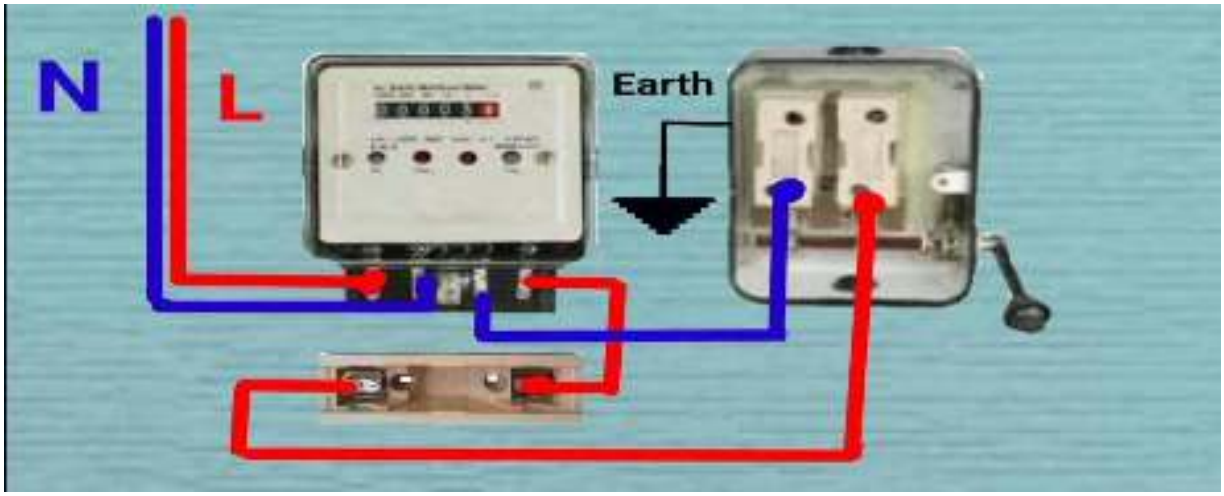


Figure 5.18 Connect energy meter and main switch

Self-Check -5

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Wright the following questions listed below

Part 1: Energy meter

1. What is the unit of measurement for energy consumption on an energy meter?
2. What are the two main types of energy meters?
3. What are the benefits of using an energy meter?
4. What is a smart energy meter?
5. How do you install a new energy meter?

Part 2: Main switch

1. What is a main switch?
2. What is the purpose of a main switch?
3. Where is the main switch typically located?
4. How do you turn the main switch on and off?
5. When should you turn off the main switch?

Operation sheet #5

Operation Title: select the appropriate Measurement and cables size

Instruction:

Purpose: selact of Measurement and cables size

Required tools and equipment: tools from workshops like screw drivers, pliers, measuring tools,

Precautions:

- use safety personal protective equipments properly
- Follow the selection instruction of the task.
- Check tools weather it is functional or not
- Select tools properly

Procedures:

Step 1: Prepare yourself in order to perform the given task

Step 2: Visualize the type of tool

Step 3: If the tool has specification read it

Step 4: Collect the required tools from tools room

Step 5: Inspect tools for any damage prior to each use.

Step 6: Check the handle and body casing of the tool for cracks or other damage.

Step 7: If it is a power tool plug in to the appropriate power source & try check

Step 8: Select the appropriate measuring hand & power tools

Quality criteria:

LAP Test #5

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, connect cables with a pole and energy meter you are required to perform the following tasks within 1 hours.

Task 1: select the appropriate Measurement and cables size

Task 2: perform the appropriate Connect energy meter and main switch

Task 3: perform the appropriate mean service and main switch

Unit Six: Connection of Automatic Transfer switch (ATS)

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Basic concept of ATS
- Selection of tools and equipment
- Connection of ATS with stand by generator
- Clean the work place

This unit will also assist you to attain the learning outcomes stated in the above unit.

Specifically, upon completion of this learning guide, you will be able to:

- Understand the Basic concept of ATS
- Select tools and equipment
- Install of ATS with stand by generator
- Clean the work place

6.1 Basic concept of ATS

- **How does an automatic transfer switch work?**

An automatic transfer switch (ATS) is a self-acting, intelligent power switching device governed by dedicated control logic. The principal purpose of an ATS is to ensure the continuous delivery of electrical power from one of two power sources to a connected load circuit (electrical equipment – lights, motors, computers, etc.).

The control logic or automatic controller is typically microprocessor-based and constantly monitors the electrical parameters (voltage, frequency) of primary and alternate power sources. Upon failure of the connected power source, the ATS will automatically transfer (switch) the load circuit to the other power source (if it is available). As a general rule, most automatic transfer switches seek connection to the primary power source (utility) by default and will only connect to the alternate power source (engine-generator, backup utility) when required (primary source failure) or requested to do so (operator command).

A typical transfer sequence includes:

1. The normal utility power source fails.
2. The transfer switch shifts the load to the emergency power source when power from the generator or backup utility feed is stable and within prescribed voltage and frequency tolerances. Depending on a facility's needs and preferences, the transfer process is self-acting or manually-initiated.
3. The transfer switch returns the load from the emergency power source to the normal power source when utility power is restored. The retransfer process is self-acting or manually-initiated.

- **Basic concept of ATS operation:**

1. The ATS continuously monitors the primary power source for voltage and frequency.
2. If the primary power source fails, the ATS will automatically switch to the backup power source.
3. The ATS will also switch back to the primary power source once it has been restored.

- **Benefits of using an ATS:**

- Uninterrupted power supply: ATSs can ensure that critical loads continue to receive power even during a primary power outage.
- Reduced downtime: ATSs can help to reduce downtime for businesses and industries that rely on critical loads.

- Increased reliability: ATSs can help to improve the reliability of power systems by providing a backup source of power.
- Enhanced safety: ATSs can help to enhance safety by ensuring that critical systems, such as fire alarms and security systems, continue to operate during a power outage.

ATSs are an important part of many power systems, and they play a vital role in ensuring the reliability and continuity of power supply.

- **What ATS arrangements are available?**

A variety of arrangements are available utilizing two power sources and three power sources.

Two power sources

- **Utility-Generator**

The standard transfer switch configuration includes an electric utility service and a generator for normal and emergency power sources. This system arrangement is typically referred to as an emergency standby generator system. The single generator shown may be several engine-generator sets operating in parallel.

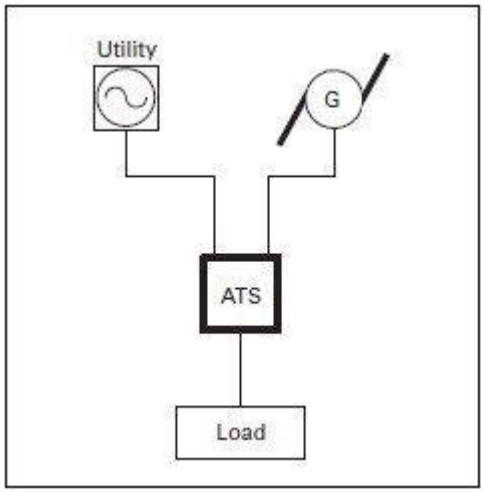


Figure 6.1 Utility-Generator

- **Utility-Utility**

This use case employs two utility sources that provide redundancy in the distribution system and allows for quick restoration of service to the load if an upstream equipment failure occurs. The two sources can be independent of each other, requiring the public utility company to provide dual electric services, or they can originate from a single electric service that is distributed through redundant paths within the facility.

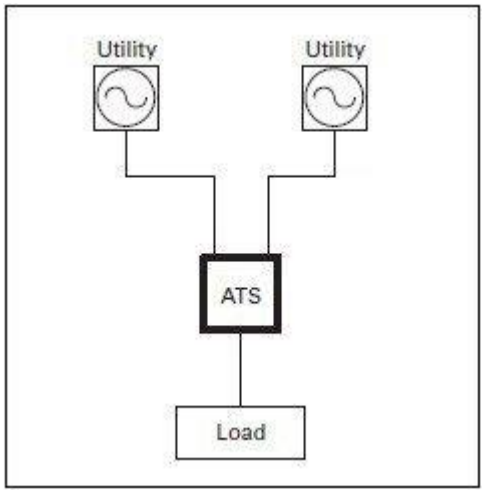


Figure 6.2 Utility-Utility

Generator-Generator

Transfer switches, at times, are applied between two generator sets for prime power use, often at remote installations. In such cases, the generator may be required to provide continuous power 24/7. To equally share run-time, source power is periodically alternated between the generator sets.

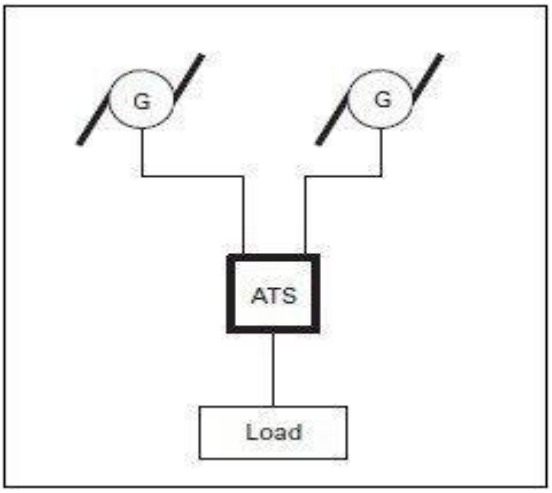


Figure 6.3 Generator-Generator

Utility—Generator—Generator

Critical facilities with an emergency standby generator system will often include provisions for a second generator connection to serve as a redundant emergency backup that can be used during periods of inclement weather, or when scheduled maintenance is being performed on the first generator.

As shown, in some cases, the first generator is permanently installed onsite whereas the second generator will be a portable roll-up type that is deployed when needed.

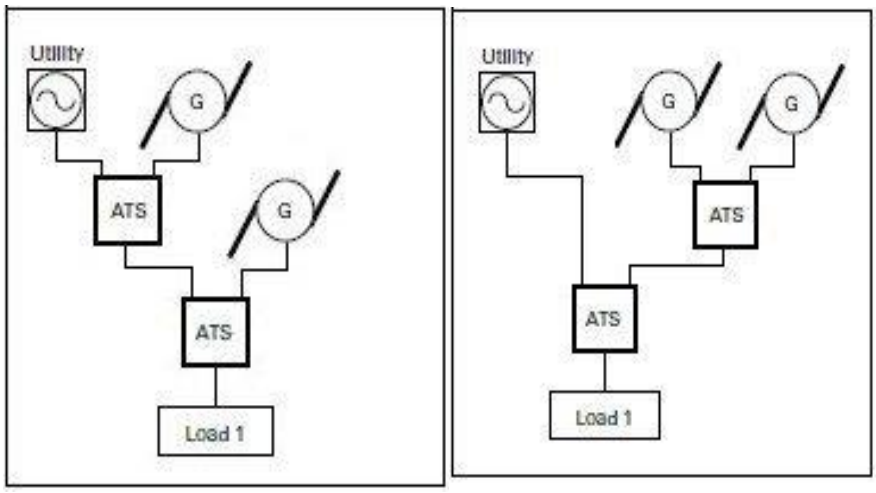


Figure 6.4 Utility—Generator—Generator

Utility—Utility—Generator

This configuration expands on the redundancy provided by a dual utility arrangement and includes an emergency standby generator source. As shown, the generator can be dedicated for use by a single transfer switch or shared among multiple transfer switches employing a priority control scheme.

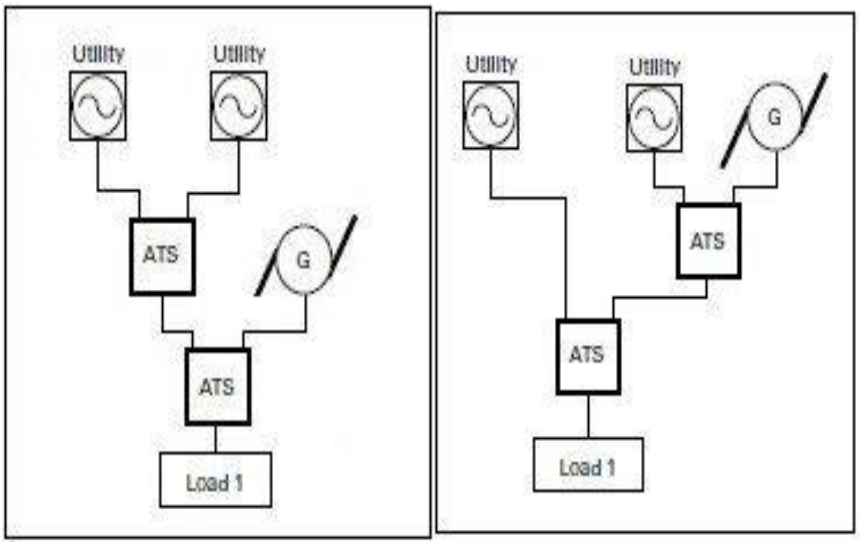


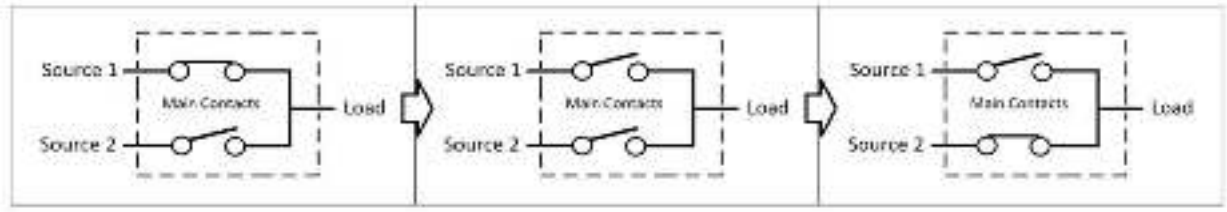
Figure 6.4 Utility—Utility—Generator

➢ **Different ATS transition types**

Transfer switches transition loads between normal and emergency power sources with open or closed options. The specific functions performed by a given load and the importance of those functions to safety or security play an important role in determining which kind of transition is required.

- **Open transition**

An open transition is a break-before-make transfer. The transfer switch breaks its connection to one power source before making a connection to the other. Open transitions include open-delayed and open in-phase.



- **Closed transition**

A closed transition is a make-before-break transfer. The transfer switch makes a connection to a second power source before breaking its connection with the first power source. As there's no gap between disconnection and connection, downstream loads receive continuous power throughout the transfer process.

➢ **ATS modes of operation**

Manual	Transfer initiation and operation are performed manually, typically by pushing a button or moving a handle; initiation occurs locally
Non-automatic	Manually initiate a transfer by pressing a button or rotating a switch to cause an internal electromechanical device to electrically operate the switching mechanism; initiation can occur locally or remotely
Automatic	Transfer switch controller is self-acting and completely manages both initiation and operation; initiation is triggered when the automatic controller senses an unavailability or loss of source power followed by operation of the switching mechanism

6.2 Selection of tools and equipment

The following tools and equipment are commonly used for automatic transfer switch (ATS) installations:

- ✓ **ATS:** The ATS is the main component of the system and is responsible for automatically transferring power between the primary and backup sources.
- ✓ **Enclosure:** The ATS is typically housed in an enclosure to protect it from the elements and other hazards.
- ✓ **Disconnect switches**: Disconnect switches are used to isolate the ATS and the connected loads from the power sources.
- ✓ **Circuit breakers:** Circuit breakers are used to protect the ATS and the connected loads from overcurrent.
- ✓ **Conductors:** Conductors are used to connect the ATS to the power sources and the connected loads.
- ✓ **Test equipment:** Test equipment is used to verify the proper operation of the ATS and the connected loads.

In addition to these basic tools and equipment, there may be other specialized tools and equipment required for specific ATS installations. For example, if the ATS is being installed in a hazardous location, such as a chemical plant, specialized enclosures and other components may be required.

Here are some additional tools and equipment that may be needed for ATS installations:

- **Hand tools:** Screwdrivers, wrenches, pliers, wire strippers, crimpers, etc.
- **Power tools:** Drill, saw, etc.
- **Measuring equipment:** Multimeter, me ohmmeter, etc.
- **Safety equipment**: Safety glasses, gloves, hard hat, etc.

It is important to note that the specific tools and equipment required for an ATS installation will vary depending on the size and type of ATS, the power sources being switched, and the specific application requirements. It is always best to consult with a qualified electrician to ensure that the proper tools and equipment are selected for the job.

Here are some safety tips for working with ATSs:

- Always disconnect the ATS from all power sources before performing any maintenance or troubleshooting work.
- Wear personal protective equipment (PPE) at all times when working with electrical equipment.

- Follow all applicable safety codes and regulations.
- Be aware of the potential hazards associated with ATS installations, such as electrical shock, arc flash, and fire.

6.3 Connection of ATS with stand by generator

An automatic transfer switch (ATS) is a device that automatically transfers power from a primary source to a backup source in the event of a power failure. In the image above, the ATS is connected to a standby generator. This means that if the primary power source fails, the ATS will automatically switch to the generator to provide backup power.

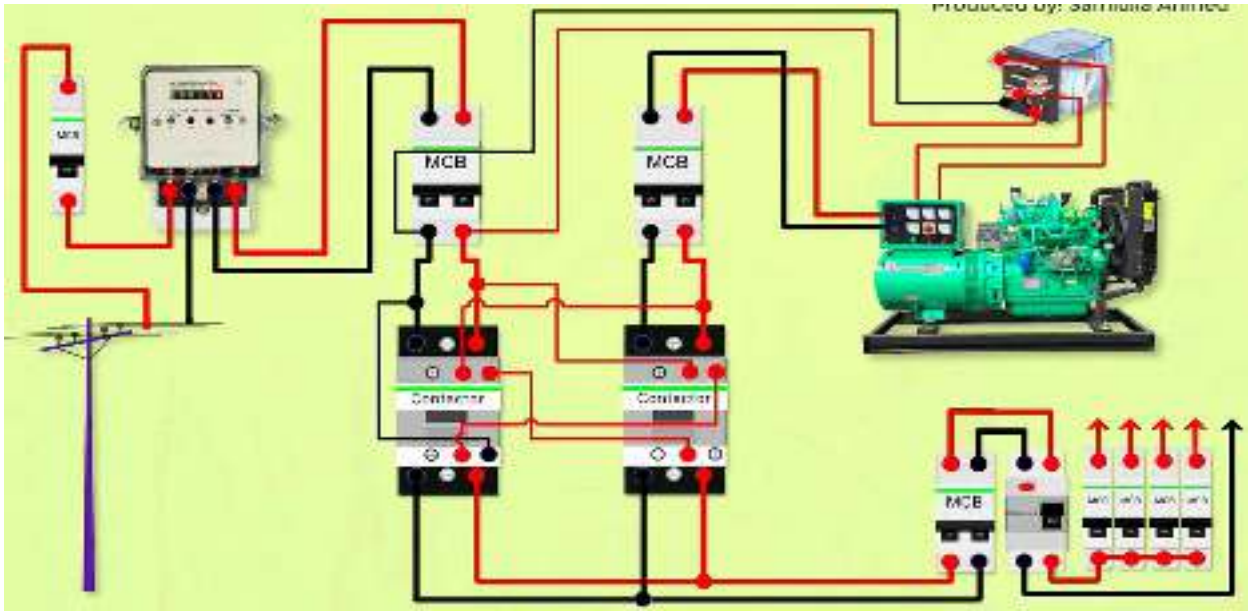


Figure 6.5 Contactor used Automatic transfer switch with out ATS

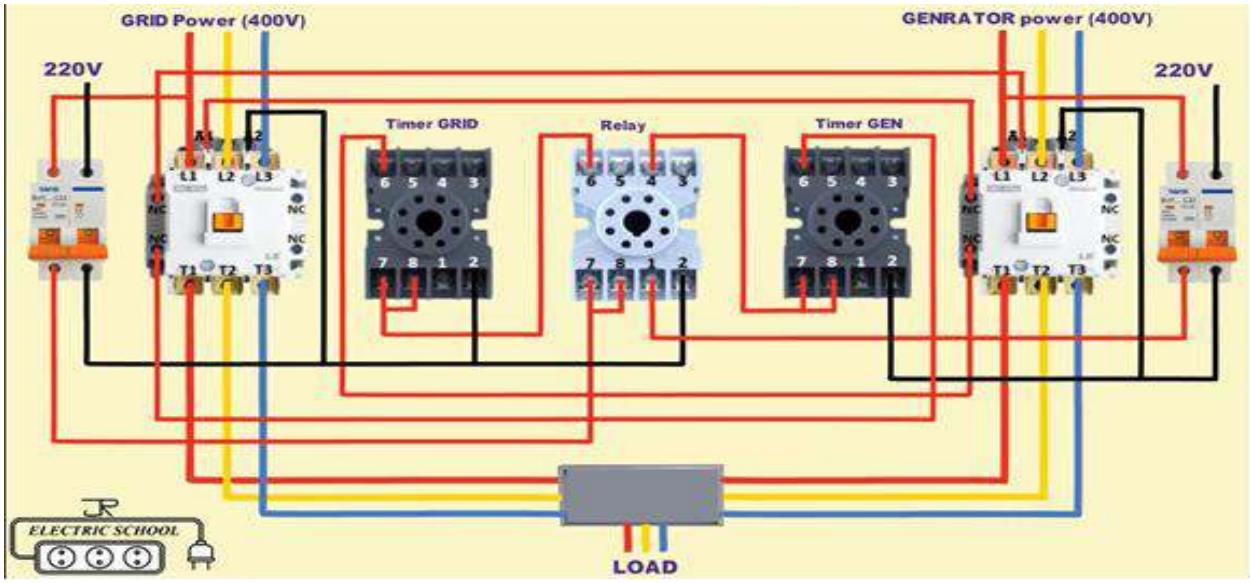


Figure 6.6 Timer used Automatic transfer switch without ATS

ATSs are commonly used in commercial and industrial settings, as well as in some residential applications. They are especially important in critical applications where uninterrupted power is essential, such as hospitals, data centers, and manufacturing facilities.

ATSs are available in a variety of sizes and configurations to meet the needs of different applications. They can be used to transfer power from one source to another, or from multiple sources to a single load.

- **Where should I install my transfer switch?**

Where you install the transfer switch will depend on the type of switch and what type of generator you will be using. The following installations will work for both manual and automatic transfer switches.

- **Emergency Distribution:**

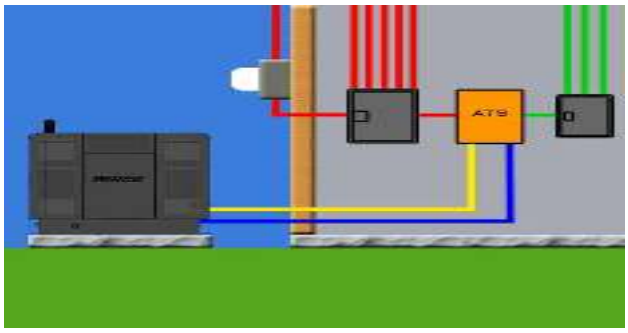


Figure 6.7 Emergency Distribution system

The transfer switch is installed between a main panel and a sub panel. The main panel connects to the non-essential loads. The sub panel connects to the essential loads. In the event of an outage, the transfer switch will only transfer power to the essential load panel.

This type of installation allows you to purchase a smaller generator and a smaller amperage transfer switch. As a result, it will keep costs down.

- **Transfer switch as a Load Control Device:**

Starting large motors at the same time will require a large generator to deal with the inrush. A cost effective solution is to install multiple transfer switches. By setting the transfer delay in staggered intervals each load will be added to the generator separately reducing total inrush. You can install the transfer switches in any variation of the three installations mentioned above on each load.

Be sure to size the generator so it will be able to run all connected loads and also have enough amperage to start the last motor.

➢ **Connection of ATS With Stand By Generator**

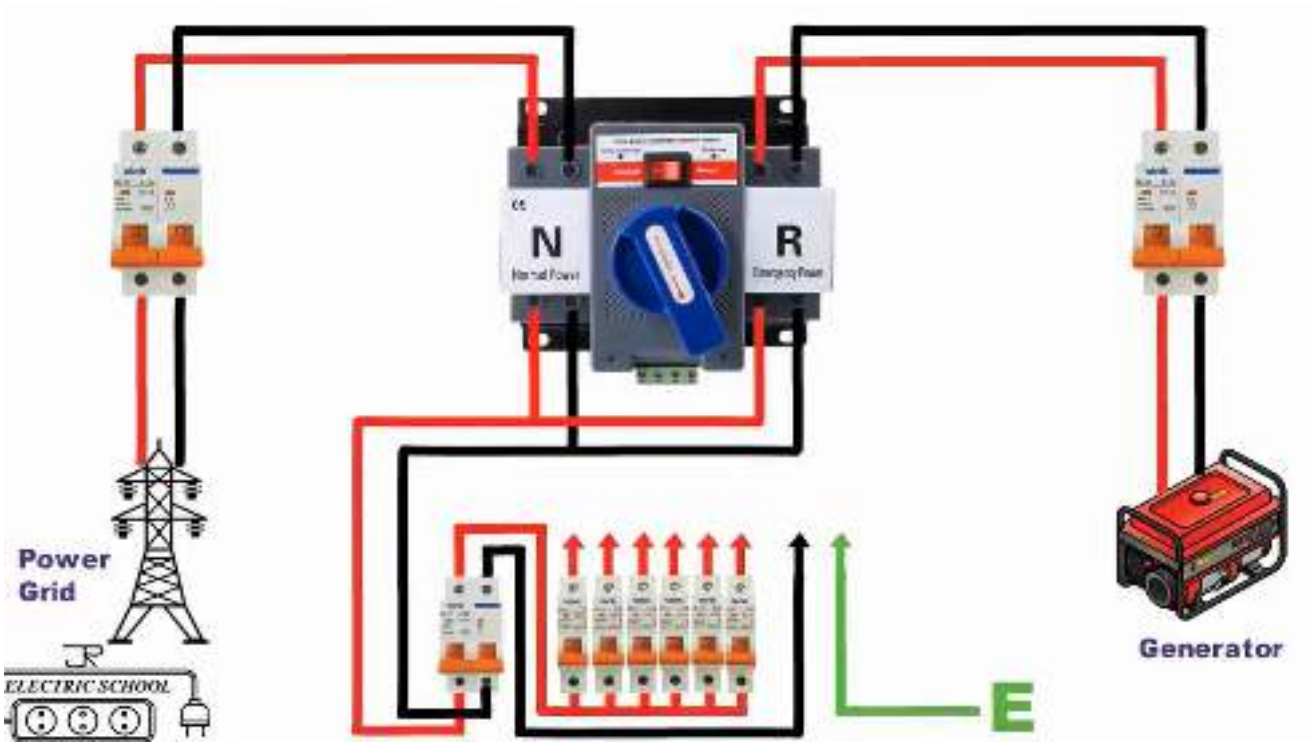


Figure 6.8 single phase Connection of ATS with stand by Generator

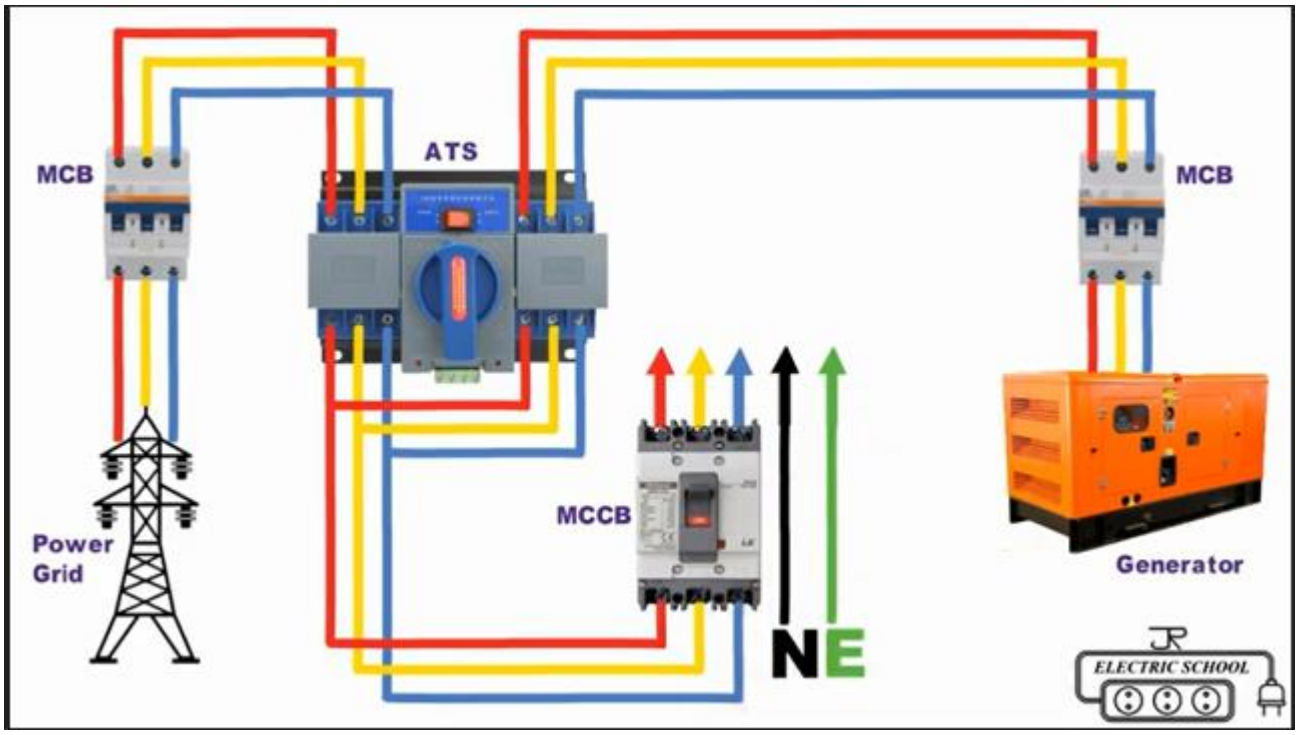


Figure 6.9 Three phase Connection of ATS with stand by Generator

6.4 Clean the work place

To clean and lubricate electrical tools/instruments and store the same as per standard procedures and clean the workplace. After electrical works cleaning is very important and essential for both tools and equipment used and also the workplace. To keep the tools and equipment clean, extra attention and experience required considering how to remove dirt, including dust, stains, bad smells and clutter on surfaces. For this, we can use some cleaning agents as follows:

- ✓
- ✓ Water (the best cleaning agent)
- ✓ Soap or detergent
- ✓ Calcium hypochlorite (powdered bleach)
- ✓ Sodium hypochlorite (liquid bleach)
- ✓ Acetic acid (vinegar)

- ➢ Methods of cleaning: cleaning can be done with the following methods:
- ➢ ▪ Dusting
  - ▪ Shaking and beating
  - ▪ Sweeping
  - ▪ Mopping
  - ▪ Washing
  - ▪ Polishing
- ➢ **Rough Cleaning:**
  - ▪ First remove all debris either by hand or use of brushes, brooms, scrapers, squeegees etc.
  - ▪ Collect and dispose of all debris appropriately.
  - ▪ A warm rinse is recommended to complete the rough cleaning.

6.1.1 Tools and equipment are selected & collected.

Tools and equipment used for cleaning:

Broom: A broom is a cleaning tool consisting of usually staff known as coconut broom	
Dusters/Dust protector: A duster/dust protector is a light, loose - fitting. long c	

Dust pan: A dustpan is used in combination with a broom. It is us dust/waste/small debris.	
Cleaning brushes: Cleaning brushes are tool with bristles, wire or other f for cleaning, painting, and surface finishing, and for many purposes	
Mop: A mop is a bundle of coarse strings or a piece of clot other absorbent material, attached to a stick. It is us liquid, for cleaning floors and other surfaces, to mop other cleaning purposes.	
Waste container: A waste container is a container for temporarily storing usually made out of metal or plastic. Some common term are dustbin, garbage can, trash can and dumpster.	
Cotton rags: A rag is a piece of old cloth which can be used to clean	

Lubricant: is used to reduce friction between surfaces. Adequate lubrication allows smooth operation of equipment, reduces the rate of wear and prevents excessive stresses.

Advantages of proper storage of tools and equipment:

- ✓ Ensures that tools and equipment remain in good condition and last for a long time.
- ✓ Easy to find when needed and are less likely to be lost.
- ✓ Productivity is increased because time is not lost looking for tools and equipment.

After cleaning the tools and equipment, you should follow the good habits of inventry, display and/or store the same in accordance with the workplace requirements.

- **Waste materials are disposed.**
  - **Waste disposal methods**

In general, waste should undergo material recycling or thermal treatment. If this is not possible for technical reasons, or it is not economically viable, the waste is deposited in a landfill following suitable treatment. The standard waste disposal methods used in Switzerland are defined and described below:

Figure 6.10 Waste disposal methods

- **Recycling**

Recycling refers to both the direct reuse of used products (e.g. used clothing and functioning parts removed from used vehicles) and material recycling, that is the recovery of raw materials from waste (e.g. production of new glass from fragments, the melting of scrap iron and the production of recycled building materials from construction waste). Down cycling refers to the transformation of waste to materials of lower quality than the initially used material.

- **Recycling**

Incineration

Combustible waste from households and waste wood that is not suitable for recycling undergo thermal treatment in waste incineration plants or waste wood furnaces. The heat released in the process is used to generate electricity and heat buildings. Waste with a high calorific value and low level of pollutant contamination can be used in industrial plants, e.g. cement plants, as an alternative to fossil fuels. Waste that is contaminated with organic pollutants undergoes separate thermal treatment (e.g. in hazardous waste incineration plants).

Self-Check -6

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Write the correct answer for the following questions:

1. What are the methods of cleaning?
2. What is a broom?
3. Write the uses of mops.
4. What is the common type of storage for electrical tools and equipment?
5. What are the advantages of properly storing electrical tools and equipment?
6. What is an automatic transfer switch (ATS)?
7. What are the benefits of using an ATS?
8. What are the different types of ATS arrangements?
9. What are the two main types of ATS transition types?
10. What are the three main ATS modes of operation?
11. How does an ATS work?
12. What are the different factors to consider when choosing an ATS?

Fill in the blank questions:

1. The _____continuously monitors the primary power source for voltage and frequency.
2. If the primary power source fails, the _____will automatically switch to the backup power source.
3. _____will also switch back to the primary power source once it has been restored.

Operation sheet #6

Operation Title: Install the single phase Connection of ATS with stand by Generator

Instruction:

Purpose: select of Measurement and cables size

Required tools and equipment: tools from workshops like screw drivers, pliers, measuring tools,

Precautions:

- use safety personal protective equipments properly
- Follow the selection instruction of the task.
- Check tools weather it is functional or not
- Select tools properly

Procedures:

Step 1: Prepare yourself in order to perform the given task

Step 2: Visualize the type of tool

Step 3: If the tool has specification read it

Step 4: Collect the required tools from tools room

Step 5: Inspect tools for any damage prior to each use.

Step 6: Check the handle and body casing of the tool for cracks or other damage.

Step 7: If it is a power tool plug in to the appropriate power source & try check

Step 8: Select the appropriate measuring hand & power tools

Quality criteria:

LAP Test #6

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, connect cables with a pole and energy meter you are required to perform the following tasks within 1 hours.

Task 1: single phase Connection of ATS with stand by Generator

Task 2: Three phase Connection of ATS with stand by Generator

Task 3: single phase Connection of without ATS with stand by Generator

Developer's Profile

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Mengistu Abiyu	MSc	Industrial Automation & Control Management	Lideta Manufacturing College	0913948480	menabiy@gmail.com
2	Samuel Bekele	MSc	Industrial Automation & Control Management	Haramaya PTC	910082977	samuelbekele460@gmail.com
3	Yidnekachew Seboka	BSc	Electrical Automation & Control Technology	Akaki PTC	920137899	www.yidne23@gmail.com
4	Zegeye Girma	BSc	Electrical Automation & Control Technology	Addis Ketema In.College	**926805563**	zegeyegirma2@gmail.com
5	Bacha Wake	MSc	Industrial Automation & Control Management	Hawassa Tegibarid PTC	**987065251**	bachawake@gmail.com