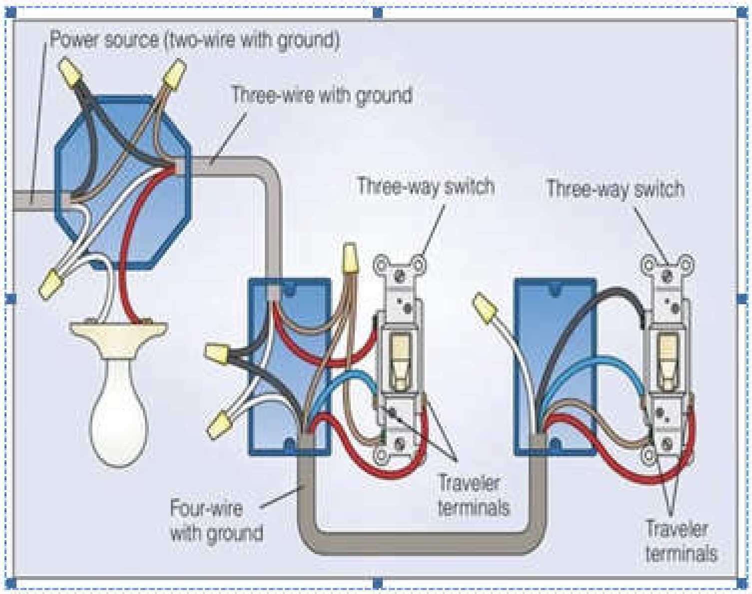
Industrial Electrical/Electronic Control Technology

Level-II

Based on March, 2022 Curriculum Version 1



Module Title: Installing and Terminating electrical wiring System

Module code: EIS IEC M07 0322

Nominal duration: 60 Hours

Prepared by: - Ministry of Labour and Skill

August , 2022

Addis Ababa, Ethiopia

Table of Content

Acknowledgment

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

Acronym

1. **OHS** occupational health and safety
2. **LED** light emitting diode
3. **SSL** solid stat lighting
4. **UV** ultra violet
5. **Co_2** carbon dioxide

Introduction to the Module

In Electrical filed, Install and terminate electrical wiring System wiring Systems are mostly standardized with several rules, regulations and laws. Electrical Wiring must be installed correctly and safely in accordance with electrical regulations and standards. If the electrical wiring is carried out incorrectly or without confirming to any standard, then it may lead to incidents like short circuits, electric shocks, damage the device / appliance or leads to the malfunctioning of device which further causes for the reduction of device .

This module is designed to meet the industry requirement under the Install and terminate electrical wiring occupational standard, particularly for the unit of competency: Install and terminate electrical wiring

This module covers the units:

- Electrical installation and connection of electronic circuits
- Installation and termination of wiring system/ electronic circuits
- Inspect and notify completion of work

Learning Objective of the Module

- Perform electrical and electronics installation
- Perform installation and termination
- Inspect and notify completion of work

Module Instruction

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

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Electrical installation and connection of electronic circuits

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

- OH&S policies and procedure for installation
- wiring systems' components and materials
- Obtain fitting accessories and electrical wiring
- Appropriate tools and equipment's
- Read and interpret lay out diagram, circuit diagram, wiring diagram
- Determine location of accessories, apparatus and circuits are to be installed

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

- Understand OH&S policies and procedure for installation
- Check wiring systems' components and materials
- Obtain fitting accessories
- Select an appropriate tools and equipment's
- Read and interpret lay out diagram, circuit diagram, wiring diagram
- Locate accessories, apparatus and circuits are to be installed

1.1 OH&S policies and procedure for installation

1.1.1 OHS policies /Occupational Health and Safety

Occupational health and safety can be important for moral, legal, and financial reasons. In common-law Authorities, employers have a common law duty (reflecting an underlying moral obligation) to take reasonable care for the safety of their employees. The goals of occupational safety and health programs include fostering a safe and healthy work environment. OHS may also protect co-workers, family members, employers, customers, and many others who might be affected by the workplace environment.

Health, safety and welfare legislation has increased the awareness of everyone to the risks involved in the work- place.

The employer has a duty to care for the health and safety of employees. To do this he must ensure that:

- The plant, tools and equipment are properly maintained.
- The necessary safety equipment – such as personal protective equipment, dust and fume extractors and machine guards – is available and properly used;
- The workers are trained to use equipment and plant safely.
- Take reasonable care to avoid injury to themselves or others as a result of their work activity.

A. **Safety rules for electrical works.**

Before we start any activity in electrical connection we have to think and remind about the five important safety rules in Electricity.

Before you start work:

- Switch off main supply.
- Isolate the circuits.
- Fix the appropriate tags.
- Test that the electricity supply is isolated and
- Always test your testing instruments.

B. Personal Protective Equipment

Your employer is required to provide personal protective equipment. Some of the items of PPE you may use in the electrical and electronics industry are given below.

Clothing:- provides protection from electric arcing/flash burns, flying objects and electric Shock. Ideally, clothing should cover the body completely.

Safety helmets:- should be non-conductive. They provide protection from overhead wires, Structures and falling objects.

Safety glasses:- provide protection from electrical arcing and flying objects.

Insulating gloves:-provide protection from electric shock. They should be worn when Accidental contact with live conductors is possible, but they must never be the sole means of insulation.

Safety footwear:- should be non-conductive. It provides protection from electric shock and falling objects.

1.2 Check wiring systems' components and materials

1.2.1 Terminate /connect electrical wiring/ electronic circuits

A. wiring techniques

This learning outcome will assist you in learning the basic skills of proper wiring techniques. It explains the different ways to terminate and splice electrical conductors. It also discusses various soldering techniques that will assist you in mastering the basic soldering skills. The learning outcome ends with a discussion of the procedure to be followed when you splice wire within electrical and electronic equipment.

B. conductor splices and terminal connections

Conductor splices and connections are an essential part of any electrical circuit. When conductors join each other or connect to a load, splices or terminals must be used. Therefore, it is important that they be properly made. Any electrical circuit is only as good as its weakest link.

The basic requirement of any splice or connection is that it be both mechanically and electrically as sound as the conductor or device with which it is used. Quality workmanship and materials must be used to ensure lasting electrical contact, physical strength, and insulation.

Preparing circuits for connection and termination:

- Selecting and checking appropriate materials, tools & equipment needed to perform termination/connection
- Preparing the circuits so that connection and termination can be taken easily and safely.

Tools and materials used for connecting/terminating wires

- Wire stripper/ Electrician Pocket knife
- Combination/Side cutting pliers
- Screw driver: Thin blade & Philips head
- Soldering Iron

- Solder Sucker
- Terminating lug
- Solder
- Flux
- Insulating tape

✓ insulation removal

The preferred method of removing insulation is with a wire-stripping tool, if available. A sharp knife may also be used. Other typical wire strippers in use in the Navy are illustrated in figure 1.2.1.

The hot blade, rotary, and bench wire strippers (views A, B, and C, respectively) are usually found in shops where large wire bundles are made. When using any of these automatic wire strippers, follow the manufacturer's instructions for adjusting the machine; this avoids nicking, cutting, or otherwise damaging the conductors.

The hand wire strippers are common hand tools found throughout the Navy. The hand wire strippers (view D of figure 2-1) are the ones you will most likely be using. Wire strippers vary in size according to wire size and can be ordered for any size needed.

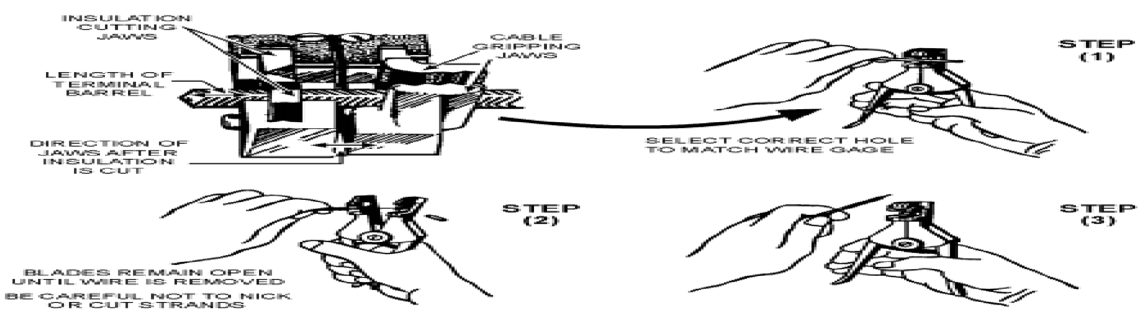


Figure 1.2.1. Typical wire-stripping tools.

1. Insert the wire into the center of the correct cutting slot for the wire size to be stripped. The wire sizes are listed on the cutting jaws of the hand wire strippers beneath each slot.
2. After inserting the wire into the proper slot, close the handles together as far as they will go.
3. Slowly release the pressure on the handles so as not to allow the cutting blades to make contact with the stripped conductor. On some of the newer style hand wire strippers, the cutting jaws have a safety lock that helps prevent this from happening. Continue to release pressure until the gripper jaws release the stripped wire, and then remove.

✓ Knife Stripping

A sharp knife may be used to strip the insulation from a conductor. The procedure is much the same as for sharpening a pencil. The knife should be held at approximately a 60º angle to the conductor. Use extreme care when cutting through the insulation to avoid nicking or cutting the conductor.

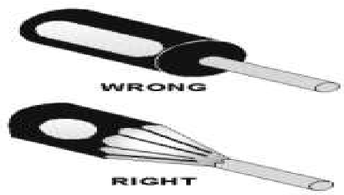


Figure1.2.2 Knife stripping.

General Wire-Stripping Instructions

When stripping wire with any of the tools mentioned, observe the following precautions:

1. Do not attempt to use a hot-blade stripper on wiring with glass braid or asbestos insulation.
These insulators are highly heat resistant.
2. When using the hot-blade stripper, make sure the blades are clean. Clean the blades with a brass wire brush as necessary.
3. Make sure all stripping blades are sharp and free from nicks, dents, and so forth.
4. When using any type of wire stripper, hold the wire perpendicular to the cutting blades.
5. Make sure the insulation is clean-cut with no frayed or ragged edges; trim if necessary.
6. Make sure all insulation is removed from the stripped area. Some types of wire are supplied with a transparent layer between the conductor and the primary insulation. If this is present, remove it.
7. When the hand strippers are used to remove lengths of insulation longer than 3/4 inch, the stripping procedure must be done in two or more operations. The strippers will only strip about3/4 inch at one time.
8. Re-twist strands by hand, if necessary, to restore the natural lay and tightness of the strands.
9. Strip aluminum wires with a knife as described earlier. Aluminum wire should be stripped very carefully. Care should be taken not to nick the aluminum wire as the strands break very easily when nicked.

1.2.2 Identifying Wire Splices

A splice may be considered as two or more conductors joined with a suitable connector, then reinsulated, re-shielded and re-jacketed with compatible materials and applied over a properly prepared surface. Whenever possible, splicing is normally avoided. However, splicing is often an economic necessity. There can be many reasons for building splices, such as:

• The supplied length of cable is not sufficient to perform the intended job, e.g., only so much cable can be wound on a reel (the reel ends), or only so much cable can be pulled through so much conduit, around so many bends, etc.

• Cable failures

• Cables damaged after installation

• A tap into an existing cable (tee or wye splices)

In all the above cases, the option is to either splice the cable or replace the entire length. The economy of modern splicing products, in many cases, makes splicing an optimal choice.

Whatever the reason to splice, good practice dictates that splices have the same rating as the cable. In this way, the splice does not derate the cable and become the weak link in the system.

Joining and splicing of electrical conductor plays a very important role in the field of electricity. Some expert say, "there is no better conductor than the un joined or un spliced conductor", unfortunately, any wiring installation, any wiring installation is impossible to accomplish without cutting the conductor for a certain length and then join or splice together afterwards to satisfy the desired connection for the operation of the circuitry. Therefore, an electrician must be equipped with proper technical skills in this activity.

- ✓ **Termination :-**The process of connecting lugs or connectors to the wires as well as the preparation of the wire ends so as to enable them to be connected to the terminals of electrical equipment is called Termination.
- ✓ **SPLICE** is the interlaying of the strands of two stranded conductors so that the union will be good both mechanically and electrically. **JOINT** is the tying together of two single wire conductors so that the union will be good both mechanically and electrically.

1.2.3. Types of splices

There are six commonly used types of splices. Each has advantages and disadvantages for use. Each splice will be discussed in the following section.

A. Western Union Splice

The Western Union splice joins small, solid conductors. Figure 2-5 shows the steps in making a Western Union splice.

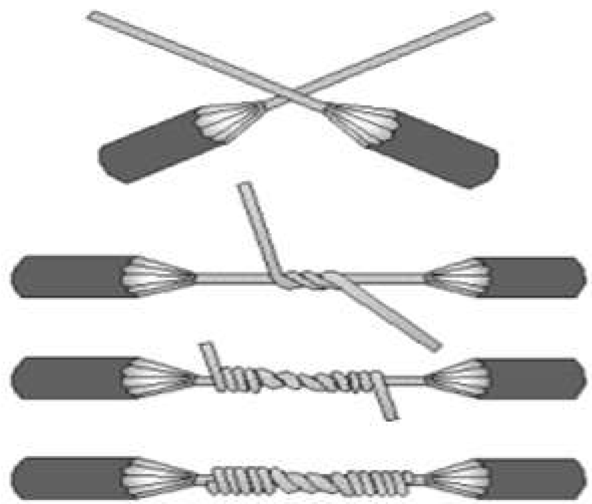


Fig 1.2.3 western union splice

1. Prepare the wires for splicing. Enough insulation is removed to make the splice. The conductor is cleaned.
2. Bring the wires to a crossed position and make a long twist or bend in each wire.
3. Wrap one end of the wire and then the other end four or five times around the straight portion of each wire.
4. Press the ends of the wires down as close as possible to the straight portion of the wire. This prevents the sharp ends from puncturing the tape covering that is wrapped over the splice. The various types of tape and their uses are discussed later in this chapter.

B. Staggering Splices

Joining small multi conductor cables often presents a problem. Each conductor must be spliced and taped. If the splices are directly opposite each other, the overall size of the joint becomes large and bulky. A smoother and less bulky joint can be made by staggering the splices.

Figure 2-6 shows how a two-conductor cable is joined to a similar size cable by using a Western Union splice and by staggering the splices. Care should be taken to ensure that a short wire from one side of the cable is spliced to a long wire, from the other side of the cable. The sharp ends are then clamped firmly down on the conductor. The figure shows a Western Union splice, but other types of splices work just as well.

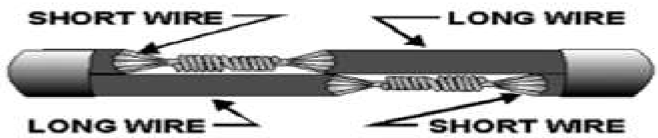


Figure 1.2.4 **Staggering Splices**

C. Rattail Joint

A splice that is used in a junction box and for connecting branch circuits is the rattail joint

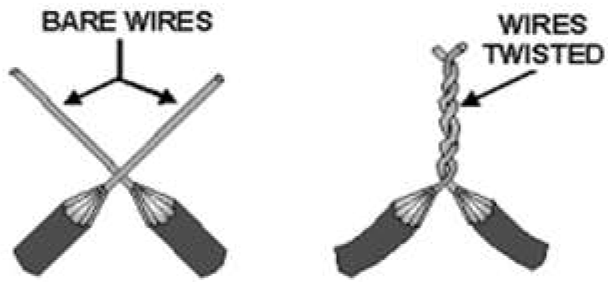


Figure 1.2.5 **Rattail Joint**

Wiring that is installed in buildings is usually placed inside long lengths of steel or aluminum pipe called a conduit. Whenever branch or multiple circuits are needed, junction boxes are used to join the conduit.

To create a rattail joint, first strip the insulation off the ends of the conductors to be joined. You then twist the wires to form the rattail effect. This type of splice will not stand much stress.

D. Fixture Join

The fixture joint is used to connect a small-diameter wire, such as in a lighting fixture, to a larger diameter wire used in a branch circuit. Like the rattail joint, the fixture joint will not stand much strain

- The first step is to remove the insulation and clean the wires to be joined.
- After the wires are prepared, the fixture wire is wrapped a few times around the branch wire.
- The end of the branch wire is then bent over the completed turns. The remainder of the bare fixture wire is then wrapped over the bent branch wire. Soldering and taping completes the job.

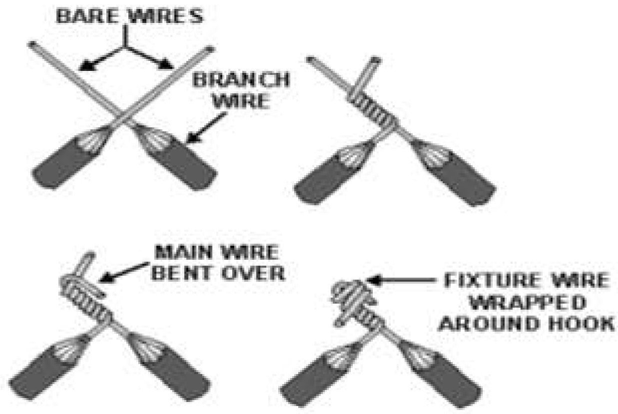


Figure 1.2.6 **Fixture Join**

E. Knotted Tap Joint

All the splices discussed up to this point are known as butted splices. Each was made by joining the free ends of the conductors together. Sometimes, however, it is necessary to join a branch conductor to a continuous wire called the main wire. Such a junction is called a tap joint.

The main wire, to which the branch wire is to be tapped, has about 1 inch of insulation removed. The branch wire is stripped of about 3 inches of insulation.

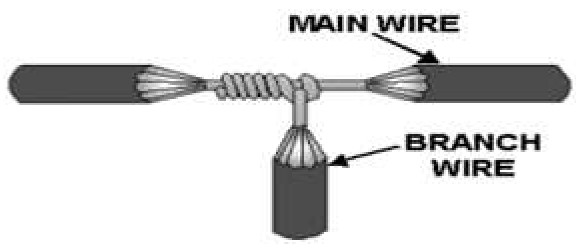


Figure 1.2.7 Knotted Tap Joint

The branch wire is laid behind the main wire. About three-fourths of the bare portion of the branch wire extends above the main wire.

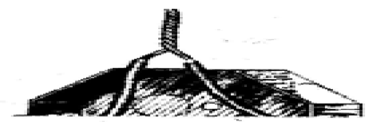
The branch wire is brought under the main wire, around itself, and then over the main wire to form a knot. The branch wire is then wrapped around the main conductor in short, tight turns; and the end is trimmed off.

The knotted tap is used where the splice is subject to strain or slippage. When there is no strain, the knot may be eliminated.

The code emphasizes that the joint or splice must be secured mechanically and electrically. Loose connection due to improper joining/splicing of conductor may lead to a big problem a few months after the commissioning, especially if the spliced conductor carries huge amount of electric current.

The connection generates heat that will cause the joined conductor to expand and thereby increasing the gap between the surfaces which then lead to arcing.

1. **Rat Tail or Pig Tail**– This kind of joint is commonly used to joint two or more conductor inside the junction box. It is suitable for service where there is no mechanical stress as where wires are to be connected in an outlet box, switch or conduit fitting.

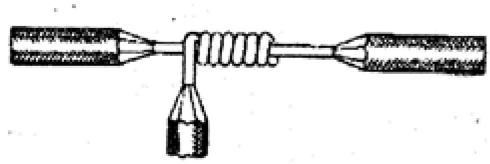


2. **Bell Hanger's Joint or Western Union Short Tie**– This joint is commonly used to join continuous run conductor where the tensile stress not too great, such as conductors inside conduit bodies.

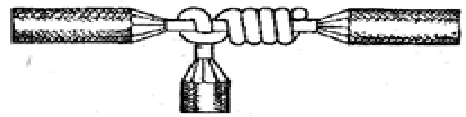
3. **Western Union Long Tie**– The modified form of bell hanger's joint, made in the same way as the latter with the exception that a number of twist is to make it more efficient mechanically as the tensile stress brought on this joint is Considerable.

4. **Duplex Joint** – Duplex wire joint is used where twin wire is employed, that is two-wire cables. It consists of two bell hanger's joints spaced so that they do not come opposite each other.

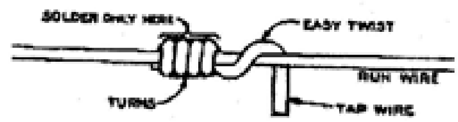
5. **Tap/ Plain Joint**– Tap is the connection of the end of one wire to some point along the run of another wire. There are various taps to meet different conditions. It is use where the tap wire is under considerable tensile stress.



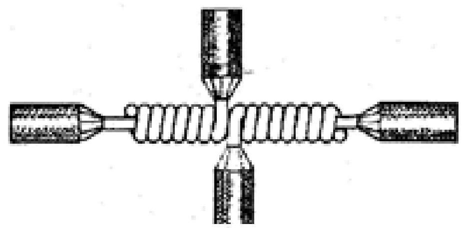
6. **Knotted Tap**– is used where the tap wire is under heavy tensile stress.



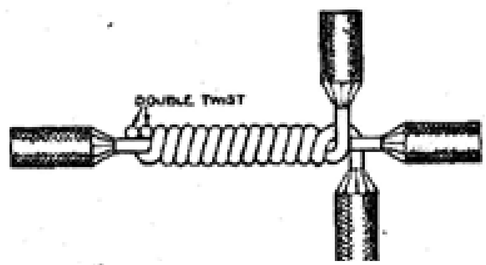
7. **Aerial Tap**– is used as temporary taps usually done in constructions sites. The easy twist will facilitate tap wire movement.



8. **Double Cross Joint**– the same application as plain tap do, the only difference is that this tap a combination of two plain taps place side by side with each other.

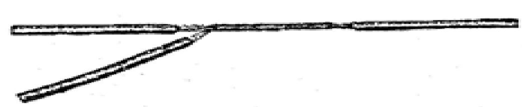


9. **Duplex Cross Joint**– a two tap wire turned simultaneously and is used where the two tap wire is under heavy tensile stress.



10. **Multi Wrapped Splice**– This method of wrapping is generally used on small cables because the strands are flexible and all can be wrapped in one operation. A three strand cable is selected so as to clearly show the method of wrapping.

11. **Y-splice**– This method of wrapping is generally used on small cables because the strands are flexible and all can be wrapped in one operation.



1.3 Obtain fitting accessories and electrical wiring

1.3.1. Electrical lights or lamps

A. Incandescent Lamps

Incandescent bulbs are standard bulbs and many people are quite familiar with these bulbs. These incandescent bulbs are available in a broad range of sizes and voltages. An incandescent bulb glows and produces heat when electricity passes through the tungsten filament present inside the bulb. The filament of this bulb is placed either in a mixture of nitrogen gas or in a vacuum. These bulbs are being gradually replaced by LEDs, fluorescent lamps, and other service based new technologies.

The reason for this is that when this bulb is switched on, the sudden flow of current, energy and heat penetrate the thin areas, which in turn heat up the filament; once the filament heats up, it tends to break and burns out the bulb. Incandescent bulbs can last for 700 – 1000 hours and can also be used with a dimmer. Incandescent bulbs generate steady heat, which is quite good for house hold applications. Luminous efficiency of incandescent lamp is about 15 lumens per watt.

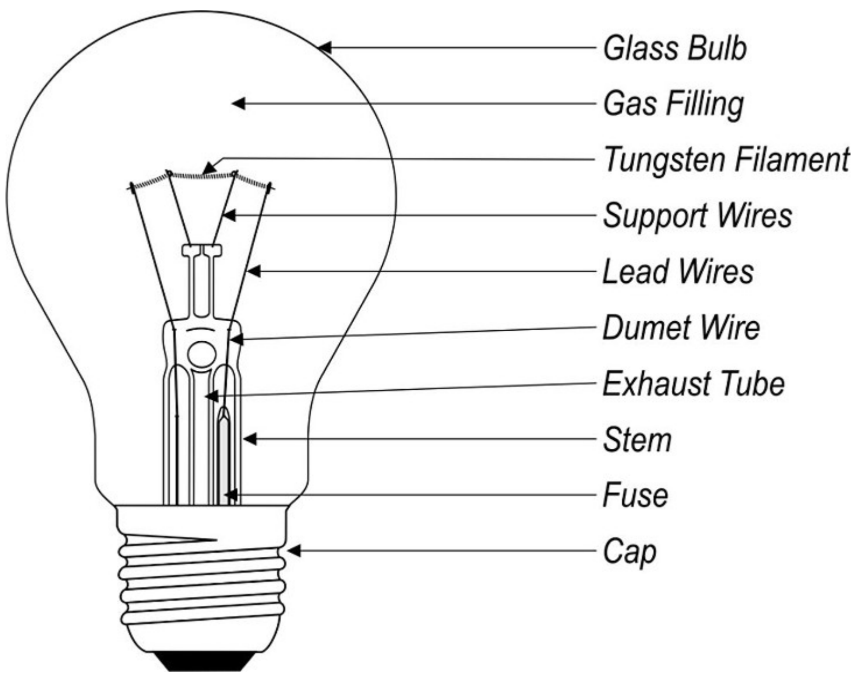


Fig. 3.1 incandescent lamp

B. LED light bulb

An LED light bulb is a solid-state lighting (SSL) device that fits in standard screw-in connections but uses LEDs (light-emitting diodes) to produce light.

LED light bulbs are a more environmentally-friendly alternative to incandescent bulbs. LED bulbs use a semiconductor device that emits visible light when an electric current passes through it. That property is known as electroluminescence, Compact fluorescents, the most common alternative to incandescent bulbs, use electricity to excite mercury gas until it emits ultraviolet (UV) light. That light is then passed through a phosphor, which causes it to emit more visible light.

LEDs themselves have been around for some time, but only recently have improvements in efficiency, cost and output made them viable for the larger-scale lighting used in households, businesses and other environments. Due to the rapid progress in LED technologies, products exist with wide ranges of efficiencies and life spans.

The bulbs can work for 50000 hours, if not run outside of the specified temperature range. They use about 8-11 watts of power to replace a 60-watt incandescent with at least 806 lumen and 9.5 watts for a 75-watt equivalent. This capacity provides an efficiency gain of up to 80% over incandescent bulbs.

Other benefits of LED light bulbs:

- Cooler than incandescent bulbs in operation.
- Instant on, unlike compact fluorescent bulbs.
- Broad range of color possibilities.
- Customizable lights can be controlled through a Bluetooth connection.
- Lowest cost over ownership of all lights.
- No mercury and minimal toxic materials required.
- A single lamp represents a reduction of hundreds of pounds of CO_2, compared to use of incandescent.

Fig.3.2 LED light bulbs

C. Spotlight

A **spotlight** is a powerful stage lighting instrument which projects a bright beam of light onto a performance space. Spotlights are controlled by a spotlight operator who tracks actors around the stage. Spotlights are most commonly used in concerts, musicals and large scale presentations where highlighting a specific mobile individual is critical. Spotlights are sometimes located overhead on catwalks. In some theatres, they may also be located in the control booth or purposely built "spot booths" in addition to the catwalk.

✓ Characteristics of a typical spotlight include:

- A strong light source, often a high-intensity discharge lamp with a high color temperature.
- A lens which can be manually focused.
- A manual device to change the intensity of the beam, especially when an HID source which cannot cannot be electronically dimmed, is used.
- An "iris" to adjust the size of the spot/angle of the beam.
- A color magazine or "boomerang" consisting of several gel frames which can be swung
- Some sort of physical sight to assist in aiming is sometimes added onto the lamp by the operator.

A. Fluorescent lamp

A **fluorescent lamp** is a low weight mercury vapour lamp that uses fluorescence to deliver visible light. An electric current in the gas energizes mercury vapor which delivers ultraviolet radiation through discharge process and the ultraviolet radiation causes the phosphor coating of the lamp inner wall to radiate visible light.

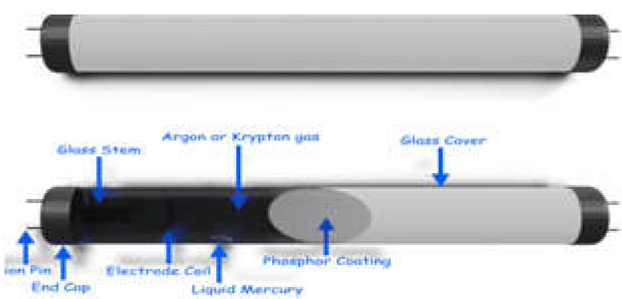


Fig.3.3 Fluorescent lamp

1.3.2 Domestic switch

The transportation of electrical energy from the source ti the load is done through the control devices call switching devices.

Any switch device is made for establishing and interrupting of electric circuit.

✓ Switching device are categorized in to two

1) Mechanical switching devices; are those which function mechanically.

2) Semi-conductor The transportation of electrical energy from the source ti the load is done through the control devices call switching devices.

Any switch device is made for establishing and interrupting of electric circuit.

- ✓ Switching device are categorized in to two

1) Mechanical switching devices; are those which function mechanically.

2) Semi-conductor switching devices; are those which function electrically.

Switch a switch is a mechanical device which closes or opens an electrical circuit during normal functioning. The quality of the switch contacts must be such that there should not be any formation of arc b/n the switch contacts during make and break.

Types of switches

A. Domestic switch

B. Industrial switch

Domestic switch; are those which are used for lighting and socket outlet control.

They are classified as;

1. Single pole one way switching
2. Series switching
3. Two way switching
4. Intermediate switching

1. **pole Single one way switching**; with single pole one way switching it should be possible to switch appliances(e.g. light);ON;OFF;
2. **Series switching;** with series switching, it should be possible from a switching point to switch two lamps or group of lamps selectively, ON, or ‘OFF, individually,
3. **Two way switch;** with two ways switching it should be possible to switch a lamp or group of lamps, <u>ON</u> ‘or, <u>OFF</u>, from two switching points,
4. **Intermediate switching;** The purpose of intermediate switching is to enable a current consuming device (lamp)or a group of devices (lamps) to be switched On & OFF From at least three switching points,

1.3.2 Lamp holder

Lamp holder adapters are devices used to convert gas lamps, socket, outlets or parts of lamps to those of an otherwise incompatible device or system of lamp parts. The porcelain function of lamp holder is specially designed for use with shielded metal halide lamps.

A device for securing a lamp to its support; specifically, a socket or holder fitted with electric terminals, into which the top of the glass globe of an incandescent lamp is fitted, or from which it hangs.

Fig.3.4 Lamp holder

What's the function of lamp holder?

What's the **function of lamp holder**? Lights are often inserted in lamp holders which offer electrical connections to the lamp and help it inside the lighting fixture. The usage of lamp bases allows lights to become safely and conveniently replaced (re-lamping) in the end of life, or to transform power, color, lighting technology or and so on. There are plenty of different standards for these lamp bases, created by de facto and by many standards bodies. A basic coding system is a letter or abbreviation followed by a number. Some miniature lights have wire leads suitable for direct connection to wires; some reflector equipment and lighting have screw terminals for wire connections.

The function of lamp holder defines and limits its intended use. Porcelain insulation can withstand considerably higher operating temperatures than bake lite or other plastics.

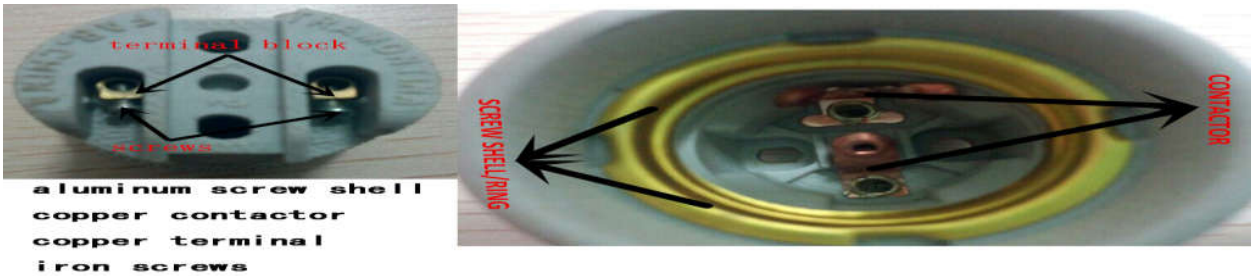


Fig.3.5 lamp holder

Tools and equipment

A. Soldering Irons (Gun)

Some common types of hand soldering irons are shown in figure-8. All high-quality soldering irons operate in the temperature range of 500 to 600º F. Even the 25-watt midget irons produce this temperature.

The important difference in iron sizes is not temperature, but thermal inertia. Thermal inertia is the capacity of the iron to generate and maintain a satisfactory soldering temperature while giving up heat to the joint to be soldered. Although it is not practical to solder large conductors with the 25-watt iron, this iron is quite suitable for replacing a half-watt resistor in an electronic circuit or soldering a small connector.

One advantage of using a small iron for small work is that it is light and easy to handle and has a small tip that is easily used in close places. Even though its temperature is high enough, a midget iron does not have the thermal inertia to solder large conductors.

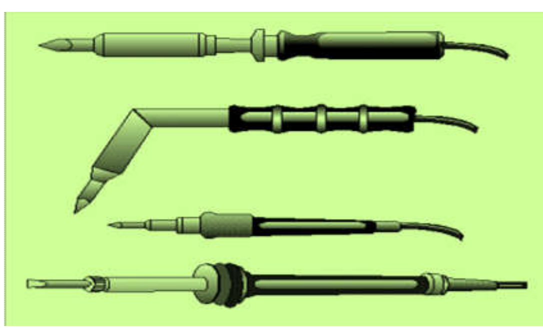


Figure-8.—Types of hand soldering Irons.

B. **Soldering lead**:- Soldering lead is an alloy (mixture) of tin and lead, typically 60% tin and 40% lead. It melts at a temperature of about 200°C. Coating a surface with solder is called 'tinning' because of the tin content of solder. Lead is poisonous and you should always wash your hands after using solder.

Figure 1.3.1- soldering lead

C. Soldering flux (paste)

flux is a cleaning agent to remove oxidation during soldering. Heating a metal causes rapid oxidation. Oxidation prevents solder from reacting chemically with a metal. Flux cleans the metal by removing the oxide layer.

Without flux most joints would fail because metals quickly oxidized and the solder itself will not flow properly onto a dirty, oxidized, metal surface.

Soldering flux performs three functions.

- It is an additional cleaning agent.
- It aids in tinning or coating the conductor when solder is applied.
- It ensures adhesion or connection of solder to the splice.

D. **De-soldering pump (solder sucker)**

A tool for removing solder when de-soldering a joint to correct a mistake or replace a component.

E. **Soldering iron stand**

You must have a safe place to put the iron when you are not holding it. The stand should include a sponge which can be dampened for cleaning the tip of the iron.

First a few safety precautions when soldering process:-

- Never touch the element or tip of the soldering iron. They are very hot (about 400°C) and will give you a nasty burn.
- Take great care to avoid touching the mains flex with the tip of the iron.
- An ordinary plastic flex will melt immediately if touched by a hot iron and there is a serious risk of burns and electric shock.
- Always return the soldering iron to its stand when not in use.
- Never put it down on your workbench, even for a moment!
- Work in a well-ventilated area. Avoid breathing it by keeping you head to the side of, not above, your work. Wash your hands after using solder.

F. splice insulation

The splices we have discussed so far are usually insulated with tape.

✓ **Plastic Electrical Tape**

Plastic electrical tape has come into wide use in recent years. It has certain advantages over rubber and friction tape. For example, it can withstand higher voltages for a given thickness. Single thin layers of certain plastic tape will withstand several thousand volts without breaking down. However, to provide an extra margin of safety, several layers are usually wound over the splice. The extra layers of thin tape add very little bulk. The additional layers of plastic tape provide the added protection normally furnished by friction tape.

Plastic electrical tape usually has a certain amount of stretch so that it easily conforms to the contour of the splice.

1.4 Select materials and prepare electrical wiring socket outlet

A socket is a software object that acts as an end point establishing a bidirectional network communication link between a server-side and a client-side program.

Socket Types

There are four types of sockets available to the users. The first two are most commonly used and the last two are rarely used.

Processes are presumed to communicate only between sockets of the same type but there is no restriction that prevents communication between sockets of different types.

- **Stream Sockets** − Delivery in a networked environment is guaranteed. If you send through the stream socket three items "A, B, C", they will arrive in the same order − "A, B, C". These sockets use TCP (Transmission Control Protocol) for data transmission. If delivery is impossible, the sender receives an error indicator. Data records do not have any boundaries.
- **Datagram Sockets** − Delivery in a networked environment is not guaranteed. They're connectionless because you don't need to have an open connection as in Stream Sockets − you build a packet with the destination information and send it out. They use UDP (User Datagram Protocol).
- **Raw Sockets** − these provide users access to the underlying communication protocols, which support socket abstractions. These sockets are normally datagram oriented, though their exact characteristics are dependent on the interface provided by the protocol. Raw sockets are not intended for the general user; they have been provided mainly for those interested in developing new communication protocols, or for gaining access to some of the more cryptic facilities of an existing protocol.
- **Sequenced Packet Sockets** − they are similar to a stream socket, with the exception that record boundaries are preserved. This interface is provided only as a part of the Network Systems (NS) socket abstraction, and is very important in most serious NS applications. Sequenced-packet sockets allow the user to manipulate the Sequence Packet Protocol (SPP) or Internet Datagram Protocol (IDP) headers on a packet or a group of packets, either by writing a prototype header along with whatever data is to be sent, or by specifying a default header to be used with all outgoing data, and allows the user to receive the headers on income

1.4.1 Distribution board

A **distribution board** (also known as **panel board**, **breaker panel**, or **electric panel**) is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. Normally, a main switch, and in recent boards, one or more residual-current devices (RCD) or residual current breakers with over current protection (RCBO), are also incorporated.

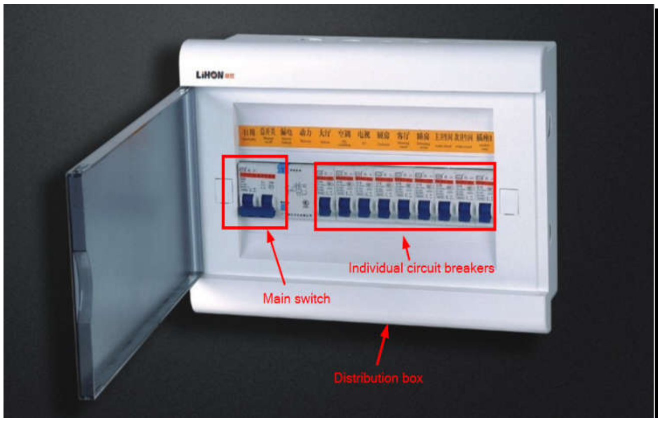


Fig.3.6 **Distribution board**

1.5. Reading and interpreting lay out, circuit, wiring diagram and determine the locations of material

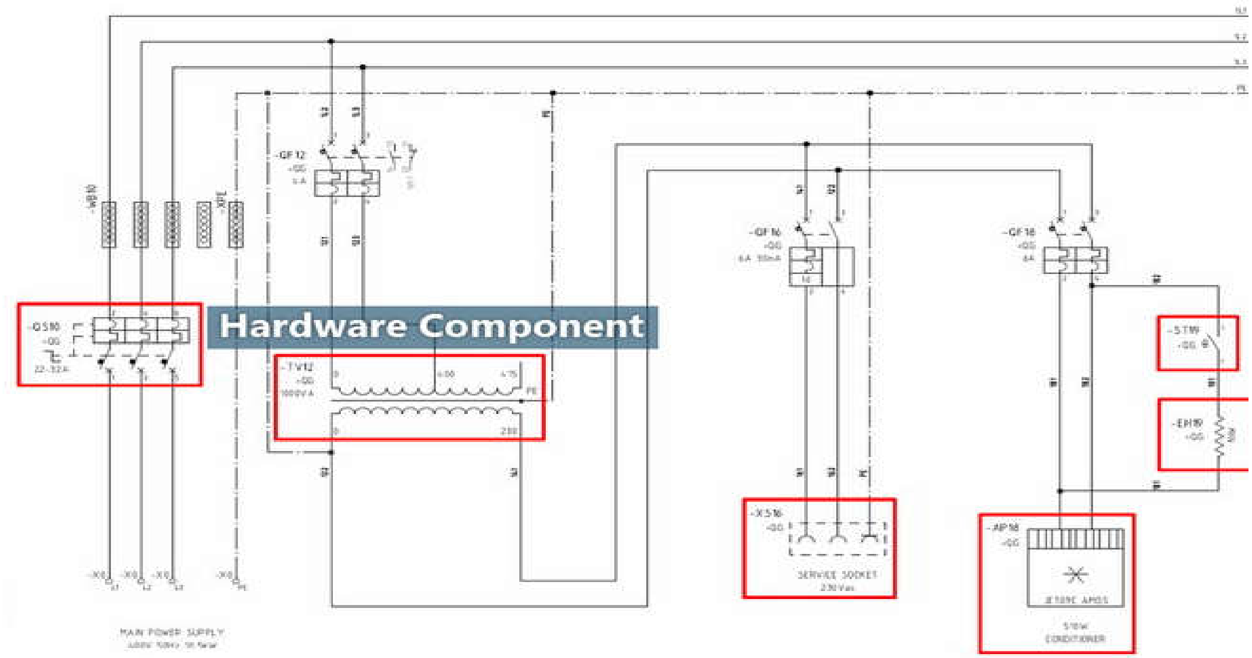
1.5.1 How to Read Electrical Diagrams?

An electrical wiring diagram could be a single page schematic of how a ceiling fan should be connected to the power source and its remote switches. A wiring diagram may include the wirings of a vehicle. For example, how the horns are powered and connected to the controller on your steering wheel.

First Things First! Wiring Diagram Symbols

Every wiring diagram includes:

- Hardware components
- Power sources
- Ground chassis
- Terminals
- Some wires of course
- Numbers, letters, and maybe some nomenclatures



Normally the very first step to learn reading a wiring diagram is becoming familiar with the symbols of the equipment and each wiring diagram is supposed to have a page or two for this purpose.

1.6. Determining location of apparatus from job requirements

1.6.1 Sockets

Sockets may be wired on ring circuits or radial circuits. Mostly rings are used, as they use less copper for most circuit layouts, they have safety advantages over radial circuits (sometimes debated), can provide more power, and cover more floor area per circuit.

Ring

Sockets are on 32A ring circuits in most house installations. These use a ring of cable (i.e. a loop), so that at the CU 2 cables are connected to the MCB instead of 1. An unlimited number of sockets may be connected on each ring.

One ring circuit per floor is a fairly common arrangement, but by no means the only option. Larger houses generally have more rings. It's also common to have a ring dedicated just for sockets in the kitchen since that is where you will find many of the highest power consuming appliances in a modern house.

2.5mm² cable is usually used for ring circuits. 4mm² is used when cable will be under insulation or bunched with other cables.

- **Spurs**

Spurs are permitted, but sockets should be included in the ring rather than spurred wherever practical. Spurring is best only used for later additions to circuits.

Rules apply to the loading and number of sockets allowed on the end of a spur.

Spurring sockets prevents the easy later addition of more sockets in some positions, as a spur may not be spurred off a spur. Spurs also prevent the addition of more sockets at existing spurred positions, whereas a practically unlimited number of sockets can be added where a socket is in the ring. Bear in mind the number of sockets wanted has risen greatly over the years

Radial

Radial socket circuits are used less often. These use a single cable from CU to socket, then a single cable to the next socket along the line etc. Radials use more copper on most circuits, though less cable on physically long narrow shaped circuits. Connection faults have greater consequences than with ring circuits. (Confusion over the relative safety of ring & radial circuits is widespread.) and can only be expected to rise further.

1.6.2 Lighting

Radial circuits are used for lighting. There is one lighting circuit on each lighting MCB. Lighting circuits are usually on a 10A MCB 10A can be used (with some extra restrictions (now removed in the 17th edition of the wiring regs)) for large circuits. However if the area served is large, more 5A or 6A circuits would in most cases be preferable.

Lighting circuits are typically wired in 1.5mm² T&E cable (1.5mm² allows a longer cable run, before suffering too much voltage drop).

Fuse or MCB

Filament lamp failures can trip MCBs, so fuses have an advantage over MCBs for lighting circuits, as they rarely nuisance trip on bulb failure. (Less sensitive type C and D MCBs can often be used to help reduce this problem.)

Loop-in Wiring

The power feed cable may go to either the switch or the bulb holder. If it goes to the bulb holder, this is called loop-in wiring, and the ceiling rose (a junction box with a downward facing cable outlet) then uses four sets of connections instead of 3, the extra one being a switched live.

With loop-in wiring, the cable from the ceiling rose to the switch has 3 conductors, namely earth, unstitched live and switched live. Regs conformance requires that brown sleeving be fitted over the neutral coloured conductor at each end of the switch cable since it is being used as a live.

A typical view inside a ceiling rose:

Self-check 1.

Part I True or False

1. Soldering is the process of joining two metals by the use of a solder alloy.
2. Duplex Cross Joint– a two tap wire turned simultaneously and is used where the two tap wire is under heavy tensile stress.
3. Knotted Tap– is used where the tap wire is under heavy tensile stress.
4. A splice that is used in a junction box and for connecting branch circuits is the rattail joint.
5. Re-twist strands by hand, if necessary, to restore the natural lay and tightness of the strands.

Test II: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points

1. List elements of receiving and checking incoming materials. (7 points)
2. Write the procedures for stripping wire with the hand wire stripper. (5 points)
3. What is the preferred method of removing insulation? (2 Points)
4. Why are the ends of the wire clamped down after a Western Union splice is made?
5. Why are splices staggered on multiconductor cables?
6. Where is the rattail joint normally used?
7. Which type of splice is used to splice a lighting fixture to a branch circuit?
8. What tool should be used to strip aluminum wire?

Part III. Give short answer

9. List the different types of electrical wiring splicing techniques

a) ___________________________________

b) ___________________________________

c) ___________________________________

d) ___________________________________

e) ___________________________________

10.What is the purpose of soldering the spliced wire

a) ___________________________________

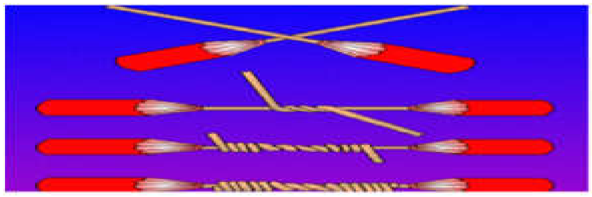
b) ___________________________________

Operation sheet .1.1: Make plain joint of splicing and soldering splices

- **Operation title:** splicing and soldering wires
- **Purpose:** Conductor Splices And Terminal Connections

1. **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



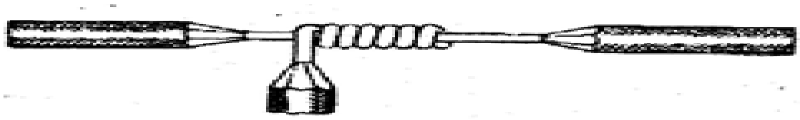
- Equipment, tools and materials:
  1. 5 pc. combinational plier
  2. 5 pc .Long noise plier
  3. 5 pcs. Side cutter
  4. 1 rolls 0.2mm. Rigged wire
  5. 5 pcs. Electrical knife
  6. 5 pcs. Wire striper
  7. 5 pcs. Soldering iron, soldering lead
- Procedures in doing the task
  1. Gather all the materials needed.
  2. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire. Enough insulation is removed to make the splice. The conductor is cleaned.
  3. Bring the wires to a crossed position and make a long twist or bend in each wire.
  4. Wrap one end of the wire and then the other end four or five times around the straight portion of each wire.
  5. Press the ends of the wires down as close as possible to the straight portion of the wire. This prevents the sharp ends from puncturing the tape covering that is wrapped over the splice.
- Quality criteria: The splicing wire joint is it should be strong and they be properly made and solder.
- Precaution : Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .1.2: Make different types of splicing and soldering wires

- **Operation title:** Make knotted tap splicing and soldering wires
- **Purpose:** Conductor Splices And Terminal Connections

2. **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
    1. 5 pc. combinational plier
    2. 5 pc .Long noise plier
    3. 1 rolls 0.2mm. Rigged wire
    4. 5 pcs. Electrical knife
    5. 5 pcs. Wire striper
    6. 5 pcs. Soldering iron, soldering lead,
- **Procedures in doing the task**

Step1. Gather all the materials needed.

Step2. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire. Enough insulation is removed to make the splice. The conductor is cleaned.

Step3. Bring the wires to a crossed position and make a long twist or bend in each wire.

Step4. Wrap one end of the wire and then the other end four or five times around the t main branch portion of each wire.

Step5. Press the ends of the wires down as close as possible to the main branch portion of the wire. This prevents the sharp ends from puncturing the tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Lap Test-1.1

- Task-1: Perform measurement using ruler
- Task-2: check twisting
- Task-3: check soldered

Unit two: **Installation and termination of wiring system/ electronic circuits**

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

- wiring system
- Terminate and connect accessories
- Inform the specified time to customer/time management
- sequence of operation
- Respond unplanned events or conditions
- approval procedure for diagnosis and testing

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

- Install wiring system
- Terminate and connecting accessories
- specified time to customer
- follow correct sequence of operation
- Respond unplanned events or conditions
- Establish and approve procedure for diagnosis and testing

2.1. Wiring system

2.1.1 Installing the Fixture

Cut openings for the wiring. Cut openings into the ceiling, or wall surfaces for the boxes, for the switch(es), and for the fixture support by first tracing around the box on the wall or ceiling surface.

- Be sure to match the switch box height to those in the rest of your home.
- If a fixture is to be installed in the ceiling, the box should be a 4" octagon box. It is important to note that even if a small light fixture is planned to be installed here, consider installing a fan-rated box, as a paddle fan might be installed here in the future.
- If installing recessed light fixtures, no box is installed as a wiring compartment is provided on the fixture itself. The open to be cut in the ceiling is provided by the template included with the fixture by most manufacturers or by tracing around the rough-in housing opening.

1. **Install the wiring.** Install the Romex or other cable between the power source and boxes in the voids of the walls, ceilings, and floors with a snake or fish tape.[7] After determining there is enough ampacity in the circuit to support the additional load, extend wiring of the same size from the power source to the switch and fixture locations. If running a new circuit directly from the electrical panel, the new wire should be sized according to the fuse or circuit breaker size.
2. **Make sure your wiring is up to code.** National Electrical Code Requirements for wiring need to be followed closely when you're installing a new fixture. When you're selecting wire for the job, make sure it fits the following constraints:

A wire smaller than #14 copper is not permitted for power wiring. Smaller wires are permitted for low voltage applications such as thermostats and zone valves in gas & oil fired heating systems, door bells and buttons, alarm systems, telephones, networking, etc. These wires never enter electrical panels.

A 15 amp circuit breaker or fuse should have no less than a #14 gauge copper wire connected.

A 15 amp circuit is designed to safely carry up to 12 amps continuously on a #14 copper wire. Intermittent loads of up to 15 amps can be carrier for up to several hours.[8] If the load of any device or appliance is greater than 12 amps, a larger size wire and circuit breaker is required.

A 20 amp circuit breaker or fuse should have no less than a #12 gauge copper wire connected.

A 20 amp circuit is designed to safely carry up to 16 amps continuously on a 2.5mm copper wire.[9] Intermittent loads of up to 20 amps can be carrier for up to several hours. If the load of any device or appliance is greater than 16 amps, a larger wire and circuit breaker is required.

Connect the devices as shown in the diagram that matches your application. If you'd prefer to follow detailed instructions to wire the fixture to just two 3-way switches, please see the 3-way switch wiki.

2.2. Terminating and connecting accessories

1.2.1 Basic Electrical Device

A. Switch

In electrical engineering, a switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another. The mechanism of a switch may be operated directly by a human operator to control a circuit (for example, a light switch or a keyboard button), may be operated by a moving object such as a door-operated switch, or may be operated by some sensing element for pressure, temperature or flow. A relay is a switch that is operated by electricity. Switches are made to handle a wide range of voltages and currents; very large switches may be used to isolate high-voltage circuits in electrical substations.

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is nonconducting. The mechanism actuating the transition between these two states (open or closed) can be either a "toggle" (flip switch for continuous "on" or "off") or "momentary" (push-for "on" or push-for "off") type.

A switch may be directly manipulated by a human as a control signal to a system, such as a computer keyboard button, or to control power flow in a circuit, such as a light switch. Automatically operated switches can be used to control the motions of machines, for example, to indicate that a garage door has reached its full open position or that a machine tool is in a position to accept another work piece. Switches may be operated by process variables such as pressure, temperature, flow, current, voltage, and force, acting as sensors in a process and used to automatically control a system. For example, a thermostat is a temperature-operated switch used to control a heating process. A switch that is operated by another electrical circuit is called a relay. Large switches may be remotely operated by a motor drive mechanism. Some switches are used to isolate electric power from a system, providing a visible point of isolation that can be padlocked if necessary to prevent accidental operation of a machine during maintenance, or to prevent electric shock.

An ideal switch would have no voltage drop when closed, and would have no limits on voltage or current rating. It would have zero rise time and fall time during state changes, and would change state without "bouncing" between on and off positions.

Practical switches fall short of this ideal; they have resistance, limits on the current and voltage they can handle, finite switching time, etc. The ideal switch is often used in circuit analysis as it greatly simplifies the system of equations to be solved, but this can lead to a less accurate solution. Theoretical treatment of the effects of non-ideal properties is required in the design of large networks of switches, as for example used in telephone exchanges.

Types of Switches

Generally, Switches can be categories as.

1) Mechanical Switches
2) Electrical/Electronic Switches

Both of these types of switches are widely used in Electrical and Electronics systems. Type of switch selection depends upon the system in which they are going to be incorporated. Switches can also be categories on many different bases. We will discuss them one by one later in this article.

Switches can also be categories on the basis of holding the current state.

1) Late Switch

   The latch switch holds its state whether ON or OFF until the new commands initiated.

2) Momentary Switch

   Momentary switch holds the state only when the specific command is presented only.

Mechanical Switches:

Mechanical switch is a switch in which two metal plates touch each other to make a physical contact for the current to flow and separate from each other to interrupt the flow of current. There are many types of Mechanical switches and they are also be categories on the basis of power handling capacity. The contact material is chosen by keeping in mind that the metal oxides, which produced due to corrosion, are mostly insulator and layers of such oxides on the switch plates will hinder the normal operation of the switch.

Mechanical Switches can be categories on the basis of their operation:

- ✓ **SPST (Single Pole Single Through)**

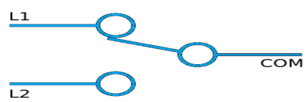
This is a simple ON/OFF switch. It is also called as On Way Switch. When a user press the button of the switch, then the plates of the switch connect with each other and the current starts to flow and vice versa.

SPST (Single Pole Single Through) Switch

- ✓ **SPDT (Single Pole Double Throw)**

This button has three pins in which, one pin is used as common and called a Two-Way Switch). We can send two different signals to same pin by using this switch. Because of this functionality, this switch is also called selector switch.

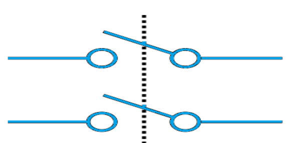
Other switches related to SPDT are SPCO (Single Pole Changeover) and SPTT (Single Pole Center Off or Single Pole Triple Throw)



SPDT (Single Pole Double Throw) Switch

- ✓ **DPST (Double Pole, Single Throw)**

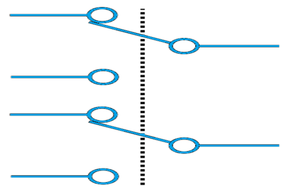
This switch is basically two SPST switches in one package and can be operated by a single lever. This switch is mostly used, where we have to break both ground and lines at the same time.



DPST (Double Pole, Single Throw) Switch

- ✓ **DPDT (Double Pole Double Throw)**

This switch is equivalent to two SPDT switches packaged in one pack. This switch has two common pins and four signal pins. Total four different combinations of singles can be applied to the input pins of this switch. Another switch, related to DPDT is **DPCO (**Double Pole Changeover or Double Pole, Centre Off).



DPDT (Double Pole Double Throw) switch

Types of Latch and Momentary operation switches:

- ✓ **Push Buttons:**

This button is used in many electronics circuits and can handle a small amount of current. When a user press the button, its metal plate connects with each other,

Hence the circuit is completed. When the user removes its finger from the button, contact of the pins detached.

- ✓ **Toggle switch:**

Toggle switches are actuated by a lever angled in one or more directions. This switch is stable in state and remains in that state unless or until lever is pushed in another direction. Most of all household applications have toggle switch and it can fall into any category as mentioned above e.g. SPST, DPDT etc.

Electrical and Electronic Switches:

The Above discussed switches are Mechanical switches and they are user manually operated. Now, we are going to discuss Electrical switches, which are faster in response than mechanical switches and can be switched automatically by an electronic circuit like microcontroller or microprocessor. They can also be categories on the basis of current and voltage rating like mechanical switches.

There are the most widely used electronic switches

1) Transistor

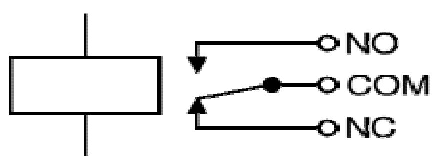
2) Mosfets

3) Relays

The question arises here, why we need electronics switch? The answer of the question is that sometimes, it is necessary that circuit, which makes decision also turn OFF or ON certain devices based on the decision. If only mechanical switch is used, then there should be one person present there all the time to make the device ON and OFF after getting indication message from the circuit. To eliminate this problem, electronics switches are used then. They are very much fast and accurate as compared to mechanical switches. Electronic switches are small in size and do not make noise while switching operation and they make sure the stability and reliability of the system.

- ✓ **Relay as a Switch:**

A Relay is an electromechanical device, which consists of an electromagnet. When a current is flowing through the coil, it becomes an electromagnet and this electromagnet can be used for switching purposes. Their contacts can fall into any category, e.g. SPDT, DPDT etc.



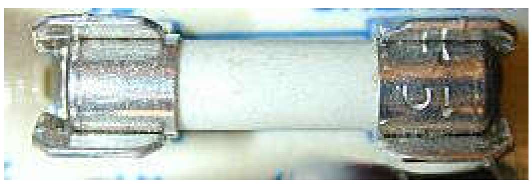
An electrically operated switch, for example a 9V battery circuit connected to the coil can switch a 230V AC mains circuit.

NO = Normally Open, COM = Common, NC = Normally Closed.

- ✓ **Circuit Breaker**

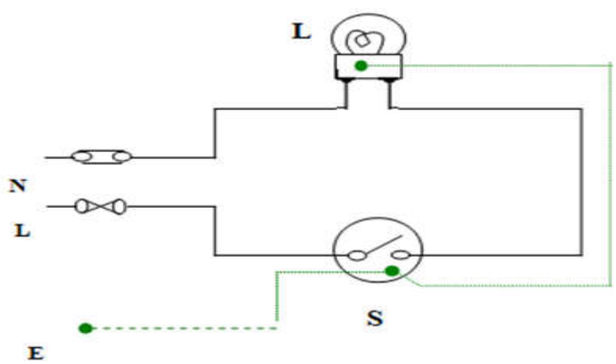
A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

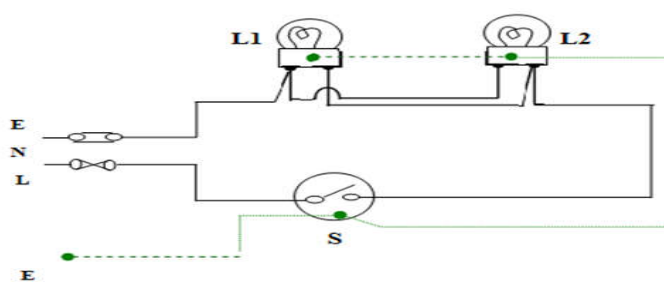
- ✓ **Fuse:** A fuse is a device designed to protect other components from accidental damage due to excessive current flowing through them. Each type of fuse is designed for a specific amount of current. As long as the current in the circuit is kept below this value, the fuse passes the current with little opposition. If the current rises above the rating of the fuse--due to a malfunction of some sort or an accidental short-circuit--the fuse will "blow" and disconnect the circuit. Fuses are the "heroes" of the electronics world, literally burning up or melting from the high current, causing a physical gap in the circuit and saving other devices from the high current. They can then be replaced when the problem condition has been corrected. All fuses are rated in amps for the amount of current they can tolerate before blowing; they are also rated for the maximum voltage they can tolerate. Always replace a blown fuse only with another of the same current and voltage rating.




A fuse, sitting in its fuse holder,
from the interior of a PC power supply.

1. Examples of lighting circuit's schematic wiring

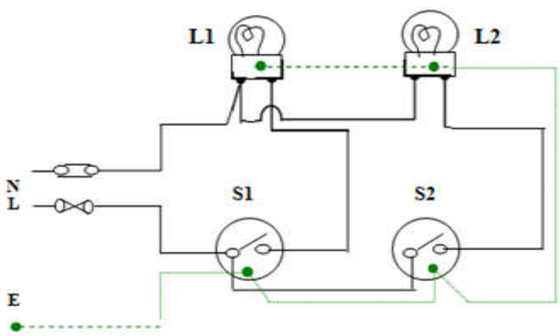




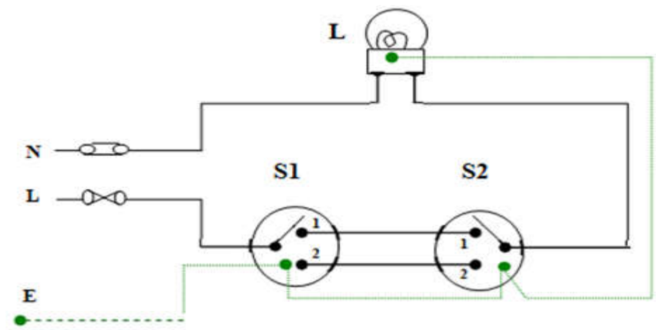
A. Single light point controlled by

B. Two light points controlled by a
a one way switch

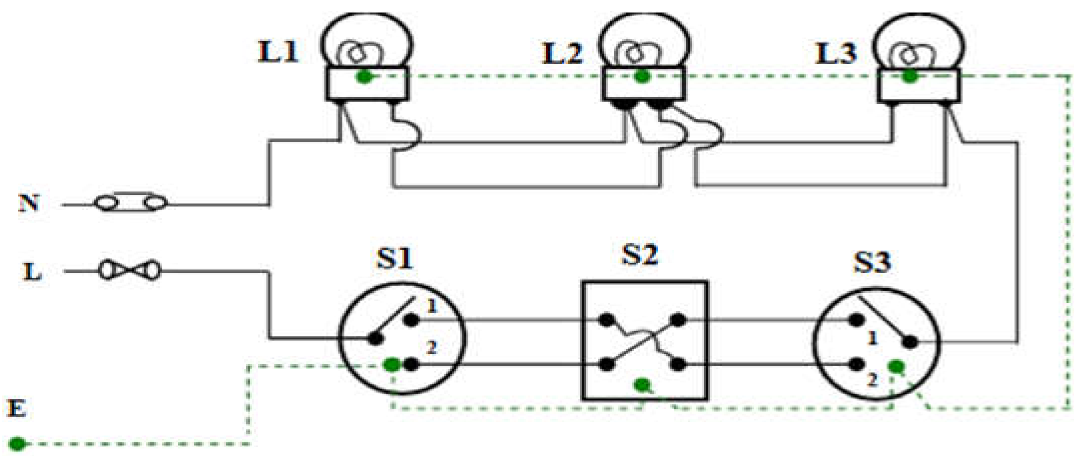
one way switch



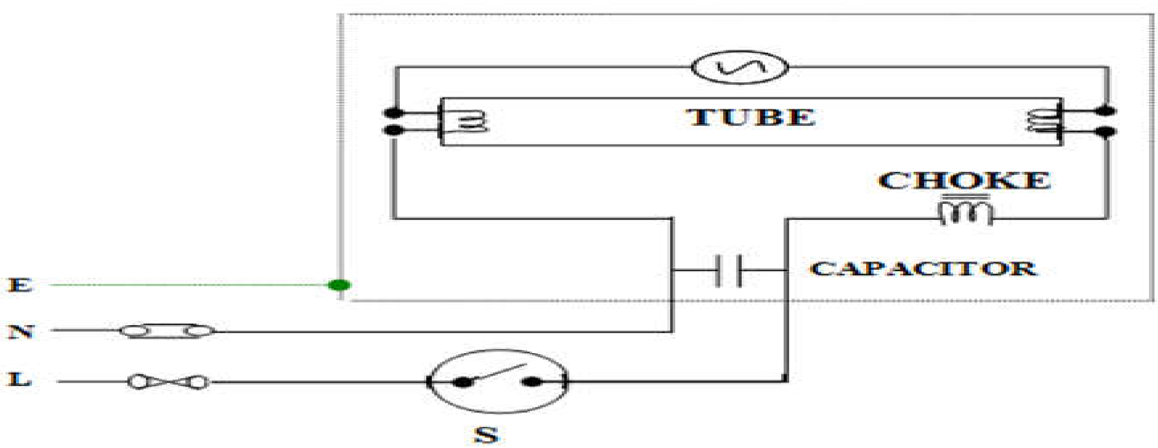
B. Two light point controlled separately by two one way switches



D. single light point controlled by a two way switch



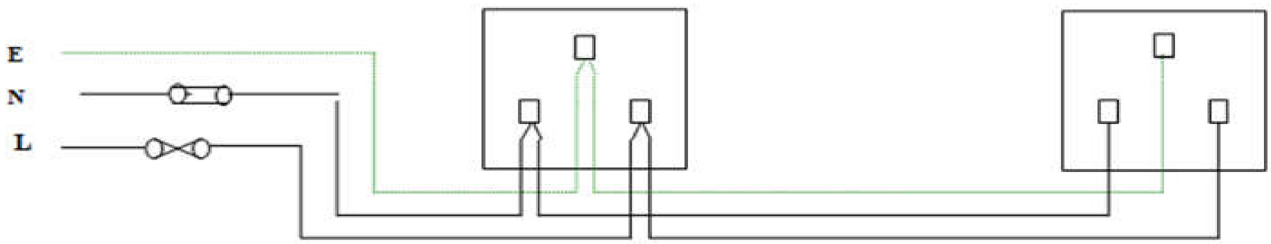
E. Three light points controlled by two way switches and intermediate switch



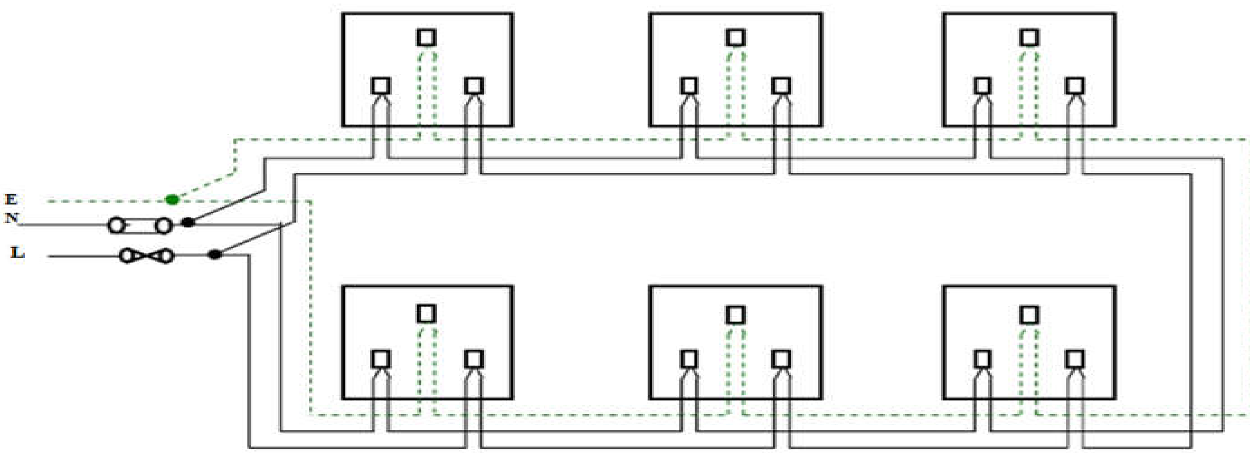
F. single fluorescent light point controlled by a one way switch

2. **Examples of lighting circuit's schematic wiring**

A. Socket outlet –single socket outlet



B. Socket outlet- radial connection



C. Socket outlet-Ring circuit connection

2.3. Sequence operation

2.3.1 Splicing steps

The previous definition accurately identifies the need for splicing, which leads into the five common steps for building a splice:

1. Prepare the surface
2. Join conductors with connector(s)
3. Reinsulated
4. Re-shield
5. Re-jacket

1. Prepare the surface

High-quality products usually include detailed installation instructions. These instructions should be followed. A suggested technique is to check off steps as they are completed. Good instructions alone do not qualify a person as a “cable splicer.” Certain manufacturers offer hand son training programs designed to teach proper installation of their products. It is highly recommended that inexperienced splice and termination installers take advantage of these programs where available

2. Join conductors with connector(s)

After the cables are completely prepared, the rebuilding process begins. If a cold shrink or pre-molded splice is being installed, the appropriate splice components must be slid onto the cable(s) before the connection is made. The first step is reconstructing the conductor with a suitable connector. A suitable connector for medium/high voltage cable splices is a compression or shear bolt connector. Do not use mechanical type connectors (such as split-bolt connectors.). Connector selection is based on conductor material: aluminum or copper.

3. Re-insulate

Perhaps the most commonly recognized method for re-insulating is the traditional tape method. Tape has a history of dependable service and is generally available. Since tape does not depend on cable types and dimensions, it is the most versatile approach. However, wrapping tape on a medium/ high voltage cable can be time consuming and error prone since the careful build-up of tape requires accurate half-lapping and constant tension in order to reduce built-in air voids.

4. Reshield

The cable's two shielding systems (strand shield and insulation shield) must be rebuilt when constructing a splice. The same two methods are used as outlined in the reinsulation process: tape and molded rubber. For a tape splice, the cable strand shielding is replaced by a semi-conductive tape. This tape is wrapped over the connector area to smooth the crimp indents and connector edges. The insulation shielding system is replaced by a combination of tapes. Semi-con is replaced with the same semi-conducting tape used to replace the strand shield.

5. Rejacket

Rejacketing is accomplished in a tape splice by using a combination of the rubber splicing tape Overwrapped with a vinyl tape. In molded rubber splice, rejacketing is accomplished by proper design of the outer semi-conductive rubber, effectively resulting in a semi conductive jacket.

When a molded rubber splice is used on internally shielded cable (such as tape shield, drain wire

2.4 Resend unplanned events or condition

2.4.1 Unsafe electrical equipment and electrical installations at the work place.

A person conducting a business or undertaking that has management or control of electrical equipment must ensure that any unsafe electrical equipment at the workplace is disconnected (or isolated) from its electricity supply and, once disconnected, is not reconnected until it is repaired or tested and found to be safe or is replaced or permanently removed from use.

Electrical equipment is unsafe if there are reasonable grounds for believing it to be unsafe. You should implement a safe system of work to deal with potentially unsafe electrical equipment at the workplace. This could include: requiring workers (if competent to do so) to undertake a check of the physical condition of the electrical equipment, including the lead and plug connections, prior to commencing use taking the electrical equipment out of service if in doubt as to safety, including at any time during us putting reporting arrangements in place to ensure, so far as is reasonably practicable,

that supervisors or line managers are advised if a worker takes electrical equipment out of service for safety reasons.

- ✓ Inspecting and testing electrical equipment

Inspecting and testing electrical equipment will assist in determining whether it is electrically safe. Regular visual inspection can identify obvious damage, wear or other conditions that might make electrical equipment unsafe. Many electrical defects are detectable by visual inspection. Regular testing can detect electrical faults and deterioration that cannot be detected by visual inspection. The nature and frequency of inspection and testing will vary depending on the nature of the workplace and the risks associated with the electrical equipment. Lower-risk workplaces include those workplaces that are dry, clean, well-organised and free of conditions that are likely to result in damage to electrical equipment, for example an office, retail shop, telecommunications centre, classroom, etc. Electrical equipment commonly used in these types of lower-risk workplaces includes computers, photocopiers, stationery or fixed electrical equipment. A key source of information on dealing with the inspection and testing of electrical equipment is the manufacturer's recommendations. In this section a reference to 'inspection' or 'testing' excludes repair of electrical equipment.

Inspection and testing of electrical equipment may involve, in part:

- ,, looking for obvious damage, defects or modifications to the electrical equipment, including accessories, connectors, plugs or cord extension sockets
- looking for discoloration that may indicate exposure to excessive heat, chemicals or moisture
- checking the integrity of protective earth and insulation resistance
- checking that flexible cords are effectively anchored to equipment, plugs, connectors and cord extension sockets
- looking for damage to flexible cords
- checking that operating controls are in good working order i.e. they are secure, aligned and appropriately identified
- checking that covers, guards, etc. are secured and working in the manner intended by the manufacturer or supplier
- checking that ventilation inlets and exhausts are un obstructed, checking that the current rating of the plug matches the current rating of the associated electrical equipment.

Self - check .2.

Part I . True or False

1. Inspecting and testing electrical equipment will assist in determining whether it is electrically safe
2. A fuse is a device designed to protect other components from accidental damage due to excessive current flowing through them
3. A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.
4. A Relay is an electromechanical device, which consists of an electromagnet.
5. Toggle switches are actuated by a lever angled in one or more directions

Part II. Fill the space provide

1.-------------- designed to protect other components from accidental damage due to excessive current
2. ---------------- electrical equipment will assist in determining whether it is electrically safe
3. ---------------- electromechanical device, which consists of an electromagnet.

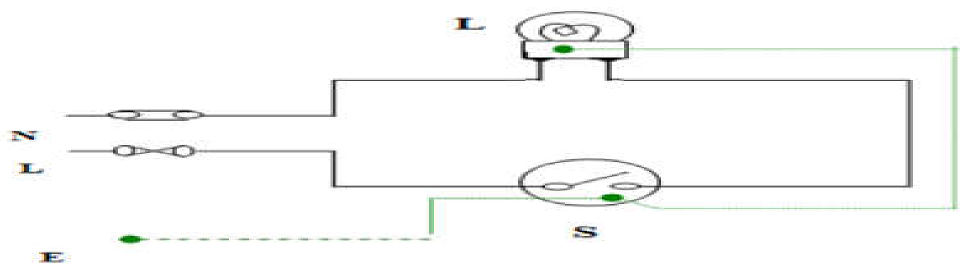
Part III. Answer all the questions listed below.

1. Why are the ends of the wire clamped down after a Western Union splice is made?
2. Why are splices staggered on multi conductor cables?
3. Where is the rattail joint normally used?
4. Which type of splice is used to splice a lighting fixture to a branch circuit?
5. What tool should be used to strip aluminum wire?

Operation sheet .2.1: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Single light point controlled by one way switch
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipmen

t, tools and materials:

1. 5 pc. combinational plier
2. 5 pc .Long noise plier
3. 5 pcs. Side cutter
4. 1 rolls 0.2mm. Rigged wire
5. 5 pcs. Electrical knife
6. 5 pcs. Wire striper
7. **7.** 1 incandescent lamp with holder
8. **8.** One way switch
9. Junction box

Procedures in doing the task

1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

2.Bring the wires to a crossed position and make a long twist or bend in each wire.

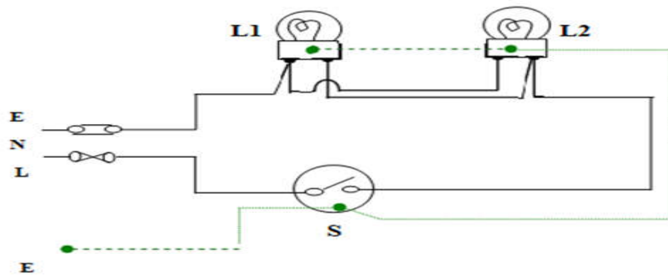
3.Press the ends of the wires down as close as possible to the main branch portion of the wire. 4.This prevents the sharp ends from puncturing the tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.2: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Two light point controlled by one way switch
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
  1. 5 pc. combinational pliers
  2. 5 pc .Long noise plier
  3. 5 pcs. Side cutter
  4. 1 rolls 0.2mm. Rigged wire
  5. 5 pcs. Electrical knife
  6. 5 pcs. Wire striper
  7. 2incandescent lamp with holder
  8. One way switch
  9. Junction box
- **Procedures in doing the task**

Step1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step2..Bring the wires to a crossed position and make a long twist or bend in each wire.

Step3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

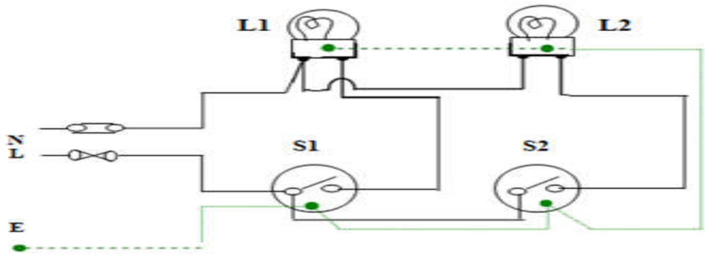
Step 4.This prevents the sharp ends from puncturing the covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.3: Installation and termination of wiring system/ electronic

- **Operation title:** wiring system
- **Purpose:** Two light point controlled by separately one way switch
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



Equipment, tools and materials:

1. 5 pc. combinational plier
2. 5 pc .Long noise plier
3. 5 pcs. Side cutter
4. 1 rolls 0.2mm. Rigged wire
5. 5 pcs. Electrical knife
6. 5 pcs. Wire striper
7. 2 incandescent lamp with holder
8. Two One way switch
9. Junction box

Procedures in doing the task

Step 1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

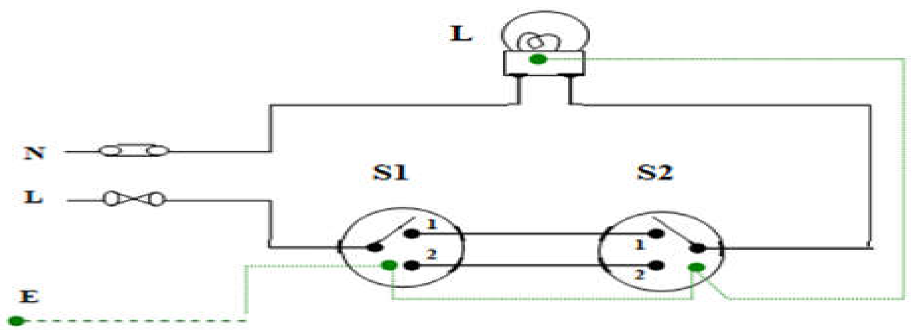
- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.4: Installation and termination of wiring system

Operation title: wiring system

- **Purpose:** Single light point controlled by two way switch
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
    1. 5 pc. combinational plier
    2. pc .Long noise plier
    3. 5 pcs. Side cutter
    4. 1 incandescent lamp with holder
    5. 2 two way switch
    6. Junction box

Procedures in doing the task

Step 1. Gather all the materials needed. Prepare the wires for splicing.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

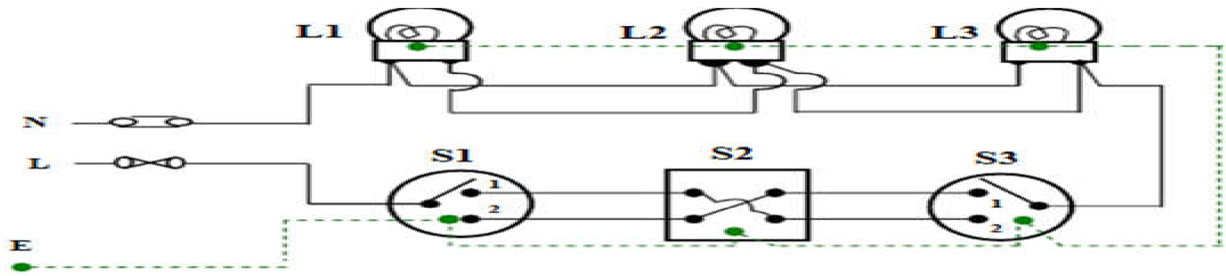
- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.5: Installation and termination of wiring system

Operation title: wiring system

- **Purpose:** Single light point controlled by one way switch
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
    1. 5 pc. combinational plier
    2. 5 pc .Long noise plier
    3. 5 pcs. Side cutter
    4. 1 rolls 0.2mm. Rigged wire
    5. 5 pcs. Electrical knife
    6. 5 pcs. Wire striper
    7. 1 incandescent lamp with holder
    8. 2 two way and 1 four way switch
    9. Junction box

Procedures in doing the task

Step 1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

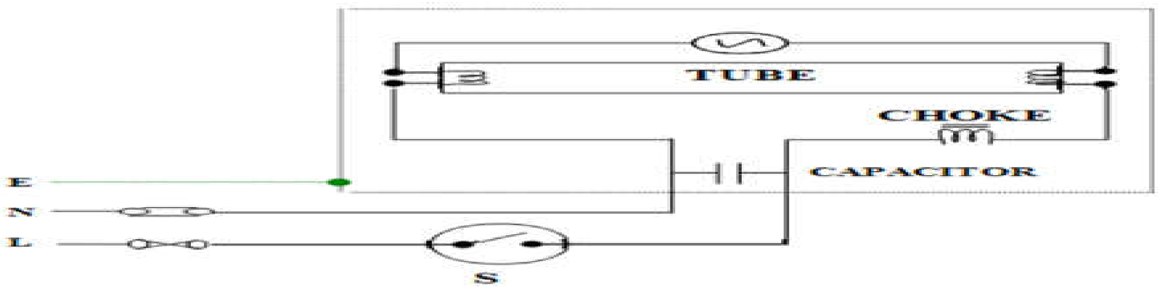
Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.6: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Single fluorescent light point controlled by two way and intermediate switch
  Instruction: covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
  1. 5 pc. combinational pliers
  2. 5 pc .Long noise pliers
  3. 5 pcs. Side cutter
  4. 1 rolls 0.2mm. Rigged wire
  5. 5 pcs. Electrical knife
  6. 5 pcs. Wire striper
  7. 1 fluorescent lamp with holder
  8. One way switch
  9. Junction box

Procedures in doing the task

Step 1. Gather all the materials needed. Prepare the wires for splicing.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step. 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

Step. 4.This prevents the sharp ends from puncturing the tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet.2 .7: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Socket out let –single socket outlet
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity

- Equipment, tools and materials:
    1. 5 pc. combinational pliers
    2. 5 pc .Long noise pliers
    3. 5 pcs. Side cutter
    4. 1 rolls 0.2mm. Rigged wire
    5. 5 pcs. Electrical knife
    6. 5 pcs. Wire striper
    7. 1 socket out let
    8. Junction box

Procedures in doing the task

Step 1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

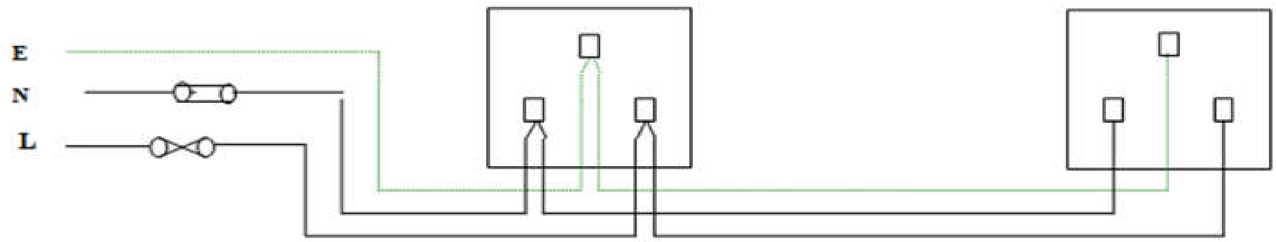
Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.8: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Socket out let –radial connection
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
  1. 5 pc. combinational pliers
  2. 5 pc .Long noise pliers
  3. 5 pcs. Side cutter
  4. 1 rolls 0.2mm. Rigged wire
  5. 5 pcs. Electrical knife
  6. 5 pcs. Wire striper
  7. 2 socket out let
  8. Junction box
- **Procedures in doing the task**

step 1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

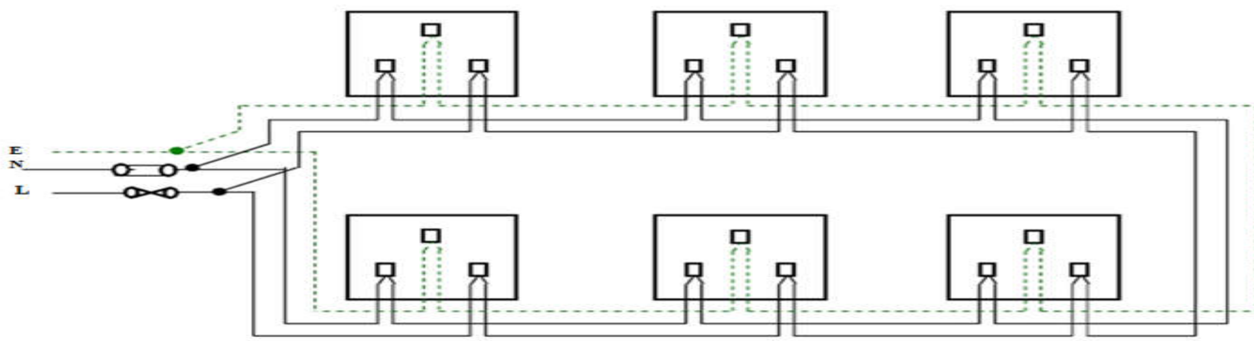
Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Operation sheet .2.9: Installation and termination of wiring system

- **Operation title:** wiring system
- **Purpose:** Socket outlet-Ring circuit connection
- **Instruction:** covering that is wrapped over the splice by soldering technique

Write your observation and conclusion in this activity



- Equipment, tools and materials:
    1. 5 pc. combinational pliers
    2. 5 pc .Long noise pliers
    3. 5 pcs. Side cutter
    4. 1 rolls 0.2mm. Rigged wire
    5. 5 pcs. Electrical knife
    6. 5 pcs. Wire striper
    7. 1 socket out let
    8. Junction box
- **Procedures in doing the task**

Step 1. Gather all the materials needed. Prepare the wires for splicing. Removed about 30 mm of insulation along the run wire and about 75 mm at the end of the tap wire.

Step 2.Bring the wires to a crossed position and make a long twist or bend in each wire.

Step 3.Press the ends of the wires down as close as possible to the main branch portion of the wire.

Step 4.This prevents the sharp ends from puncturing tape covering that is wrapped over the splice.

- **Quality criteria :** The splicing wire joint is it should be strong and they be properly made and solder
- **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Lap Test .2.

Task 1: identify the required material and equipment for terminate/connect electrical wire.

Task 2: perform the following circuits

- Socket outlet-Ring circuit connection
- Socket out let –radial connection
- Socket out let –single socket outlet
- Single fluorescent light point
- Single light point controlled by one way switch
- Single light point controlled by two way switch
- Two light point controlled by separately one way switch
- Two light point controlled by one way switch
- Single light point controlled by one way switch

Task3: solder each type of splice.

Task 4: apply insulate for splice.

Unit three : **Inspect and notify completion of work**

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

- Install apparatus
- work completion
- Test completed termination / connections of wiring
- Respond unplanned events or conditions

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

- Installed apparatus
- work completion
- Test completed termination / connections of wiring
- Respond unplanned events or conditions

3.1 Inspect installed apparatus

- ✓ visual inspection

The installation must be visually inspected before visual begins. The aim of the visual inspection is to confirm that all equipment and accessories are undamaged and comply with the relevant British and European Standards, and also that the installation has been securely and correctly The aim of the visual inspection is to confirm that all equipment and accessories are undamaged and comply with the relevant British and European Standards, and also that the installation has been securely and correctly erected.

checklist for the initial visual inspection of an installation, including:

connection of conductors;

- Identification of conductors;
- routing of cables in safe zones;
- Selection of conductors for current carrying capacity and volt drop;
- Connection of single-pole devices for protection or switching in phase conductors
- Correct connection of socket outlets, lamp holders, accessories and equipment;
- Presence of fire barriers, suitable seals and protection against thermal effects;
- Methods of 'Basic protection ' against electric shock, including the insulation of live parts and placement of live parts out of reach by fitting appropriate barriers and enclosures;
- Methods of 'Fault Protection ' against electric shock including the presence of earthling conductors for both protective bonding and supplementary bonding.
- prevention of detrimental influences (e.g. corrosion);
- presence of appropriate devices for isolation and switching;
- presence of under voltage protection devices;
- choice and setting of protective devices;
- labeling of circuits, fuses, switches and terminals;
- selection of equipment and protective measures appropriate to external influences;
- adequate access to switchgear and equipment;
- presence of danger notices and other warning notices;
- presence of diagrams, instructions and similar information;
- appropriate erection method

A regular visual inspection should be carried out in all electrical installations. A visual inspection of this type does not necessarily need to be carried out by an electrician, but it should reveal any areas which are obviously in need of attention.

A visual inspection should look for:

- ✓ Breakages
- ✓ Wear & deterioration
- ✓ Signs of over heating
- ✓ Missing parts (covers, screws) and Loose fixings and confirm
- ✓ Switchgear accessibility (no obstructions) andDoors of enclosures are secure It

Summary of the condition of the installation

The summary should adequately describe the general condition of the installation in terms of electrical safety, taking into account the specific observations made. It is essential to provide a clear summary of the condition of the installation having considered, for example:

The adequacy of the earthling and bonding arrangements

- The suitability of the consumer unit and other control equipment
- The type(s) of wiring system, and its condition
- The serviceability of equipment, including accessories
- The presence of adequate identification and notices
- The extent of any wear and tear, damage or other deterioration
- Changes in use of the premises that have led to, or might lead to, deficiencies in the installation

Minimal descriptions such as ‘poor’, and superficial statements such as ‘recommend a rewire’, are considered unacceptable as they do not indicate the true condition of an installation. It will often be necessary or appropriate to explain the implications of an electrical installation condition report in a covering letter, for the benefit of recipients who require additional advice and guidance about their installation.

3.2 Work of completion.

3.2.1 introduction

Written notice issued by the owner of a project (or his or her agent) to notify concerned parties that all work on the project has been completed. This notice also sets the period within which concerned parties may exercise their lien rights against one another.

A document recorded by a property owner to notify potential Mechanics Lien claimants that a specific construction project has been completed. The effect of a properly recorded Notice of Completion is to reduce the time in which a subcontractor, material supplier or general contractor can record a Mechanics Lien against a private works construction project.

3.2.2 **Works completion**

This concept is not defined nor is there any set date but it follows from practical completion. The process starts with the principal agent issuing a works completion list to the contractor which details defective and incomplete work present at practical completion but which are not required to achieve practical completion. The contractor must remedy the defects in this list in order to achieve works completion.

Once the contractor has addressed all incomplete and defective items on the 'works completion list' he must notify the principal agent to inspect these items, and if satisfied, issue a certificate of works completion. If the principal agent remains unsatisfied then he is required to identify which items have not been completed or rectified to his satisfaction and the contractor must carry out the rectification and completion procedure again in accordance with sub-clause. This procedure may be repeated several times until the principal agent is satisfied that all the items on the work completion list have been appropriately addressed.

Alternatively, should the principal agent not issue a works completion list within 5 working days of the date of practical completion the contractor is obliged to notify both the employer and principal agent in this regard and the principal agent is required to submit a works completion list within 5 working days of receipt of the contractor's notice.

Should the principal agent fail to submit the works completion list thereafter, works

3.3.3 Final completion

At the end of the defects liability period, or when the contractor believes the defects liability period has come to an end, he must submit a notice to the principal agent who is obliged to inspect the works within the period specified in order to determine whether any defects are present. Should any defects be identified, the principal agent is obliged to provide the contractor with a defects list, which have arisen during the defects liability period and which the contractor must rectify in order to achieve final completion of the works.

Similarly, as provided for under works completion, if the principal agent does not issue a defects list within the period prescribed of 5 working days from the end of the defects liability period, the contractor is obliged to notify both the employer and principal agent in this regard and the principal agent is required to submit the defects list within 5 working days of receipt of the contractor's notice. Should the principal agent fail to submit the works completion list thereafter, final completion shall be deemed to have been achieved on the expiry of the initial 5 working day period after the end of the defects liability period.

The achievement of final completion by the contractor has the following consequences:

all the contractor's liabilities and obligations in relation to a subcontractor's defects comes to an end and any remaining portion of the subcontractor's defects period is agreed and assumed by the employer ;

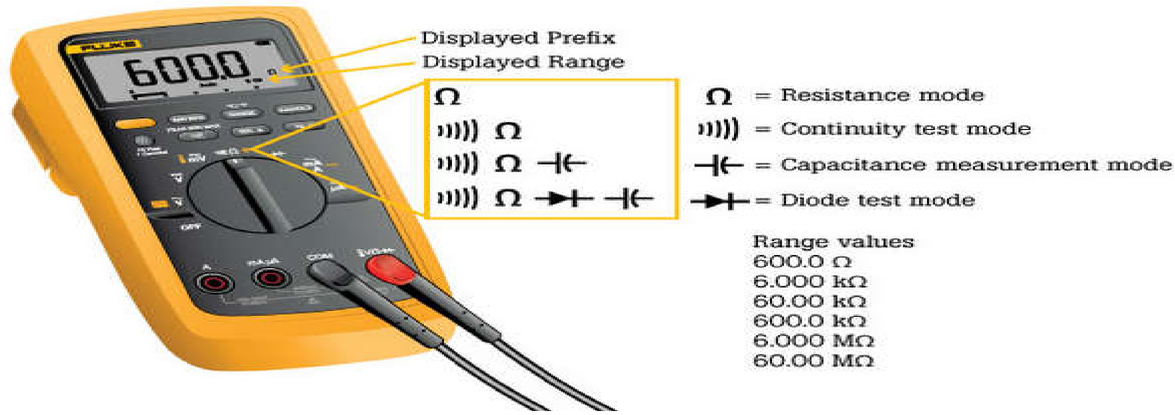
All guarantees, warranties and indemnities provided by the contractor, subcontractors and suppliers are ceded to the employer on the date which the certificate of final completion is issued ; and

The certificate of final completion constitutes conclusive evidence as to the sufficiency of the works and that the contractors obligations have been fulfilled other than latent defects.

Practical completion, works completion and final completion deal exclusively with the construction period. Once the contractor has achieved final completion he still retains certain obligations in relation to the latent defects liability period. The latent defects liability period commences when construction begins and ends 5 years after the date when final completion was achieved.

3.3.1. Test completed termination / connections of wiring

A. Electrical tests



➢ **Testing Voltage**

Steps of testing voltage:

1. Power off the **circuit**/wiring under test if there is a danger of shorting out closely spaced adjacent wires, terminals or other points which have differing voltages
2. Plug the black ground probe lead into the COM socket on the meter
3. Plug the red positive probe lead into the socket marked V (usually also marked with the Greek letter "omega" Ω and possibly a diode symbol)
4. Next you need to decide whether the voltage being measured is AC or DC. If you are measuring the voltage from a mains socket outlet or the output voltage of a transformer, you need to select AC. Voltages of batteries, or the output of a power supply circuit or adapter is likely to be DC
5. Multimeters may have several ranges for each function. For example the DC measuring mode may have ranges of 200mv, 2v, 20v, 200v and 1000 V in order to facilitate the measurement of a large range of voltages. Turn the dial of the meter to a range which is just above the voltage being measured, and ensure that you pick the AC voltage or DC voltage range. So for instance if you are measuring the voltage of a car battery which is approximately 12 volts, you can set the range to 20v. This gives the most number of decimal places in the reading. Setting the range to 200 volts gives less decimal places. If the meter is

auto ranging, set it to the "V" setting. (See the photo near the bottom of the article for an explanation of symbols used).

6. A multimeter must be connected in parallel in a circuit (see diagram below) in order to measure voltage. So this means the two test probes should be connected in parallel with the voltage source, load or any other two points across which voltage needs to be measured. Touch the black probe against the first point of the circuitry/wiring
7. Power up the equipment
8. Touch the other red probe against the second point of test. Ensure you don't bridge the gap between the point being tested and adjacent wiring, terminals or tracks on a PCB
9. Take the reading on the LCD display

Note: A lead with a 4mm banana plug on one end and a crocodile clip on the other end is very handy. The croc clip can be connected to ground in the circuit, freeing up one of your hands

Steps of testing current

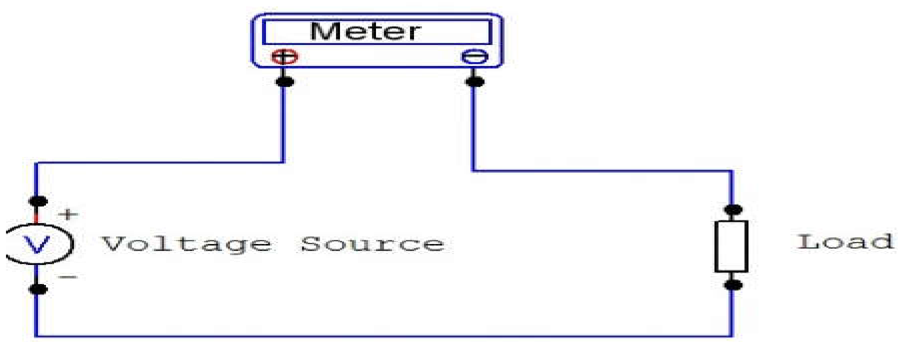
1. Turn off the power in the circuit being measured
2. A multimeter must be inserted in series with the load in a circuit in order to measure current. Plug the ground probe into the COM socket and plug the red positive probe lead either into the mA socket or the high current socket which is usually marked 10A (some meters have a 20 A socket instead of 10A). The mA socket is often marked with the maximum current and if you estimate that the current will be greater than this value, you must use the 10 A socket, otherwise you will end up blowing a fuse in the meter
3. Connect the meter in series as in the diagram below
4. Turn the dial on the meter to the highest current range (or the 10A range if the probe is in the 10A socket). If the meter is auto ranging, set it to the "A" or mA setting. (See the photo at the bottom of the article for an explanation of symbols used).
5. Turn on the power
6. If the range is too high, you can switch to a lower range to get a more accurate reading
7. Remember to return the positive probe to the V socket when finished measuring current. The meter is practically a short circuit when the lead is in the mA or 10 A socket. If you forget and connect the meter to a voltage source when the lead is in this position, you may end up

blowing a fuse at best or blowing up the meter at worst! (On some meters the 10A range is un-fused)

Test leads and sockets on a DMM, setup to measure current | Source

Fig. 3.1 current meter

Measuring Current - Meter in Series



DMM connected in series with load to measure current | Source

Fig. 3.2. current meter in series

✓ **Testing Resistance**

Steps of testing resistance:

1. Turn power to circuit OFF. If a circuit includes a capacitor, discharge the capacitor before taking any resistance reading.
2. Turn dial to Ω (resistance, or ohms), which often shares a spot on the dial with one or more other test/measurement modes (continuity, capacitance or diode; see illustration below).**Notes:** The display should show OL Ω. Why? In Resistance mode, even before test leads are connected to a component, a digital multimeter (DMM) automatically begins taking a resistance measurement. The MΩ symbol may appear in the display because resistance of open (unattached) test leads is very high. When the leads are

connected to a component, a DMM automatically uses the Auto range mode to adjust to the best range. Pressing the Range button allows a technician to manually set the range. Best results will be achieved if the component to be tested is removed from the circuit. If the component is left in the circuit, the readings could be affected by other components in parallel with the component to be tested.

3. First insert the black test lead into the COM jack.
4. Then insert the red lead into the V Ω jack. When finished, remove the leads in reverse order: red first, then black.
5. Connect test leads across the component being tested. Make sure that contact between the test leads and circuit is good.**Tip:** For very low-resistance measurements, use the relative mode. It may also be referred to as zero or Delta (Δ) mode. It automatically subtracts test lead resistance—typically 0.2 Ω to 0.5 ΩIdeally, if test leads touch (are shorted together), the display should show 0 Ω.Other factors that can affect resistance readings: Foreign substances (dirt, solder flux, oil), body contact with the metal ends of the test leads, or parallel circuit paths. The human body becomes a parallel resistance path, lowering total circuit resistance. Thus avoid touching metal parts of test leads to avoid errors.
6. Read the measurement on the display.
7. When finished, turn the multimeter OFF to prevent battery drain.

Testing Continuity

A continuity test tells us whether two things are electrically connected: if something is **continuous**, an electric current can flow freely from one end to the other. If there's no continuity, it means there is a break somewhere in the circuit. This could indicate anything from a blown fuse or bad solder joint to an incorrectly wired circuit.

Steps of testing continuity:

Step 1: to begin, make sure no current is running through the circuit or component you want to test. Switch it off, unplug it from the wall, and remove any batteries.

- Plug the black probe into the **COM** port on your multimeter.
- Plug the red probe into the **VΩmA** port.

- Switch on your multimeter, and set the dial to continuity mode (indicated by an icon that looks like a sound wave).Not all multimeters have a dedicated continuity mode. If yours doesn't, that's okay! Skip to Step 6 for an alternate way to perform a continuity test.

Step 2: The multimeter tests continuity by sending a little current through one probe, and checking whether the other probe receives it.

- If the probes are connected—either by a continuous circuit, or by touching each other directly—the test current flows through. The screen displays a value of zero (or near zero), and the multimeter **beeps**. Continuity!
- If the test current isn't detected, it means there's no continuity. The screen will display 1 or OL (open loop).

Step 3: To complete your continuity test, place one probe at each end of the circuit or component you want to test.

- It doesn't matter which probe goes where; continuity is non-directional.
- As before, if your circuit is continuous, the screen displays a value of zero (or near zero), and the multimeter **beeps**.
- If the screen displays 1 or OL (open loop), there's no continuity—that is, there's no path for electric current to flow from one probe to the other.

Step 4: If your multimeter doesn't have a dedicated continuity test mode, you can still perform a continuity test.

- Turn the dial to the lowest setting in the resistance mode.
- Resistance is measured in ohms, indicated by the symbol **Ω**.

Step 5: In this mode, the multimeter sends a little current through one probe, and measures what (if anything) is received by the other probe.

- If the probes are connected—either by a continuous circuit, or by touching each other directly—the test current flows through. The screen displays a value of zero (or near zero—in this case, 0.8). Very low resistance is another way of saying that we have continuity.
- If no current is detected, it means there's no continuity. The screen will display 1 or OL (open loop).

Step 6: To complete your continuity test, place one probe at each end of the circuit or component you want to test.

- Doesn't matter which probe goes where; continuity is non-directional.
- As before, if your circuit is continuous, the screen displays a value of zero (or near zero).

If the screen displays 1 or OL (open loop), there's no continuity—that is, there's no path for electric current to flow from one probe to the other.

3.3.2. Electrical circuit

A. Types of electrical installation testing

Following tests shall be carried out: Wiring continuity test, Insulation resistance test, Earth continuity test, Earth resistivity test, Performance test, and any other tests as instructed by the Supervising Engineer.

1. Electrical wiring continuity testing

All wiring system shall be tested for continuity of circuits, short circuits and earthing after wiring is completed and before energizing.

2. Electrical insulation resistance testing

The insulation resistance shall be measured across earth and the whole system of conductors, or any section thereof, with all fuses in place and all switches closed and except in concentric wiring all lamps in position of both poles of the installation otherwise electrically connected together.

A direct current pressure of not less than twice the working pressure provided that it does not exceed 660 V for medium voltage circuits. Where the supply is divided from AC three phase system, the neutral pole of which is connected to earth, either direct or through added resistance, pressure shall be deemed to be that which is maintained between the phase conductor and the neutral.

The insulation resistance measured as above shall not be less than 50 mega ohms divided by the number of points on the circuit provided that the whole installation, shall not be required to have an insulation resistance greater than one mega ohm.

Insulation Megger Testing of Machine to Panel Board

The insulation resistance shall also be measured between all conductors connected to one phase conductor of the supply and all the conductors connected to the middle wire to the neutral or to the other phase conductors to the supply. Such a test shall be carried out after removing all metallic connections between the two poles of the installation and in these circumstances the insulation shall not be less than that specified above.

The insulation resistance between the case or frame work of housing and power appliances, and all live parts of each appliance shall not be less than that specified in the relevant British standard specification or where there is no such specification shall not be less than a mega ohm.

4. Electrical earth continuity path testing

The earth continuity conductor metallic envelops of cables, shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance or earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

5. Electrical testing of non-linked single pole switches

In a two wire installation a test shall be made to verify that all non linked single pole switches have been fitted in the same conductor throughout, and such conductor shall be labeled or marked for connection, throughout, and such conductor shall be labeled or marked for connection to an outer or phase conductor or non earthed conductor a test shall be made three or four wire installation a test shall be made to verify that every non linked single pole switch is fitted in a conductor to one of the outer or phase conductor of the supply. The entire electrical installation shall be subject to the final acceptance of the Supervising engineer as well as the local authorities.

6. Electrical earth resistivity testing

Earth resistivity test shall be carried out in accordance with British Standard Code of Practice of Earthing. All tests shall be carried out in the presence of the Supervising Engineer.

7. Electrical performance testing

The complete electrical installation and equipment shall be subject to the final performance test as intended for each and every equipment shall be tested as per the manufacturer's instructions.

- ✓ Electrical Installation Testing Procedures

All new completed electrical installation should be tested before connection to the supply, to ensure that the installation is technically sound and free from any possible short circuits, etc. the main reasons, to test a new electrical installation or house wiring before it is switched on to the mains are as follows:

- To know the cause of failure of a particular circuit or circuits or equipment and to locate the exact position of break down.
- To ensure that it is free from faults and is as per electricity rules.
- These tests will receive the attention of the owner before any possible undue damage occurs

The tests should be made on a new electrical installation before it is switched

1. Insulation resistance test between installation and earth.
2. Insulation resistance test between conductors.
3. Testing of polarity.
4. Testing of earth continuity paths.
5. Earth resistance test.

1. Insulation Resistance Test between Installation and Earth

This test is performed to know the standard of insulation of wires and cables used in the installation.

Before performing insulation resistance test between installation and earth the conditions to be fulfilled for the position of the main switch, fuses, switches, and other points should be as under:-

- main switch in OFF position,
- fuses beyond the main switch should be in position,
- all switches in ON position.

all lamps and other equipment should be in their position.

For testing the whole installation, the test is conducted on the main switch. A testing set known as megger is used for the test. It is a special form of the ohmmeter.

To perform this test, the **phase and the neutral is short-circuited** temporarily at any suitable point as shown in Figure

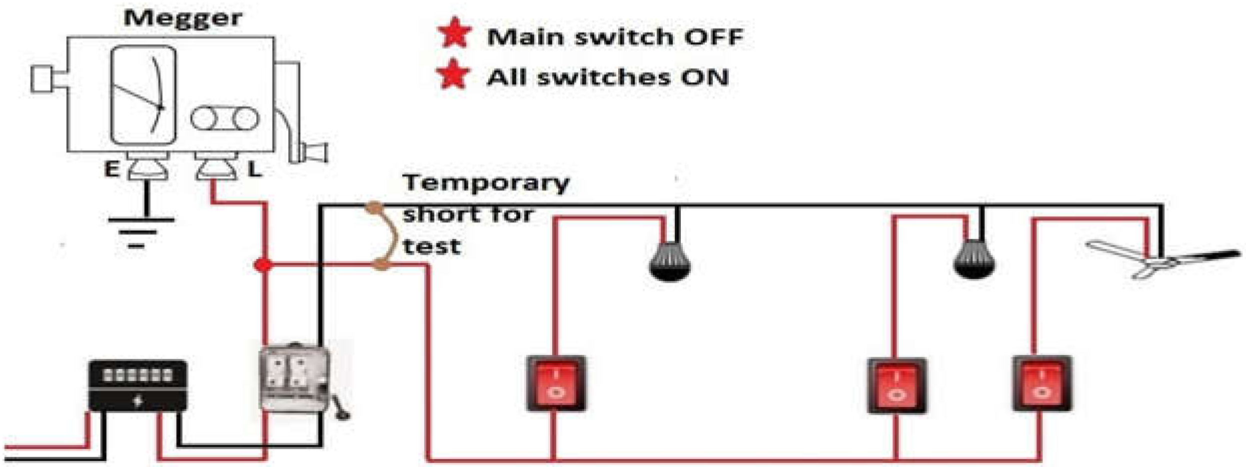


Fig.3.3. insulation resistance test between installation and earth

The ‘L’ (line terminal) of the megger is connected to the short circuit point in the main switch and the earth terminal marked (E) is connected to earth continuity conductor or some good earth point near-by.

The handle of the tester is turned at a high speed so that sufficient testing voltage is produced. The reading on the dial of the megger is noted.

The **insulation resistance thus measured should not be less than 0.5 MΩ** on a firm, sound and fixed wiring.

If the insulation resistance is below this value, the wiring section giving that value should be rewired or checked thoroughly until the required value is obtained.

2. Insulation Resistance Test between Wiring Conductors

To ensure that the insulation of the cables or wires is not damaged and there is no leakage between them, this test is performed.

Before performing this test, the position of the main switch, fuses, switches, etc. should be as under:

- main switch in OFF position,
- all switches in ON position,

- all lamps and other appliances should be removed,

fuses beyond the main switch should be in position

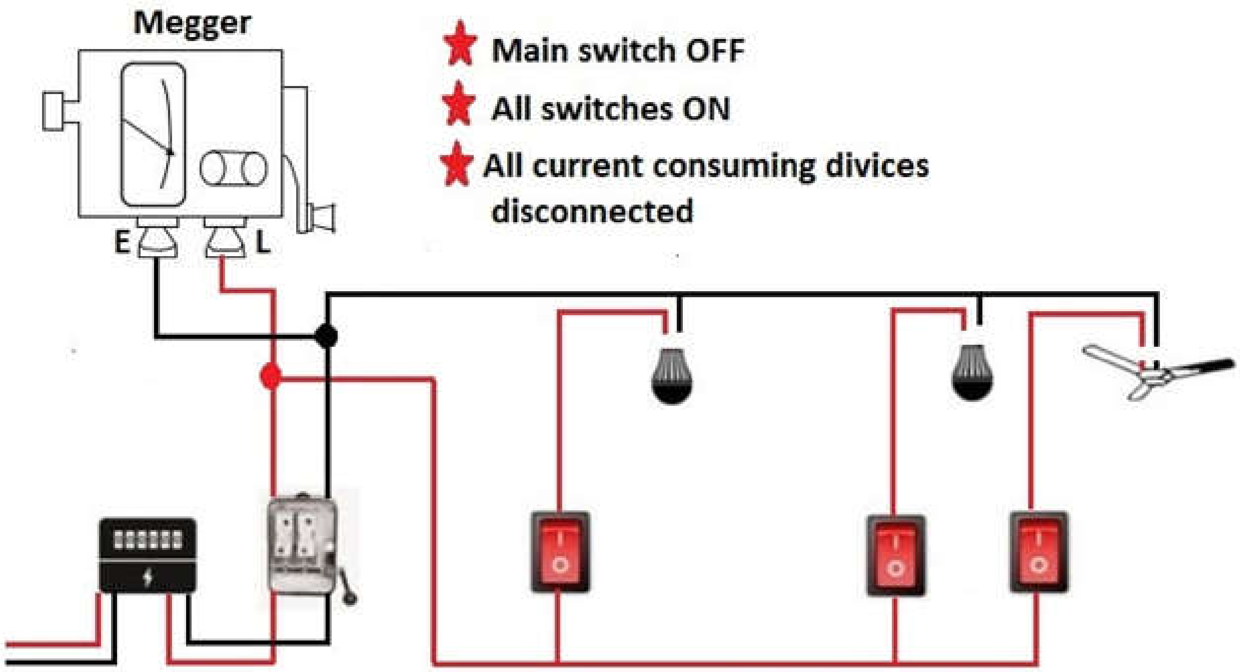


Fig.3.4. insulation resistance test btween

The line terminal of the megger is connected to phase terminal of the installation and the earth terminal of megger is connected to neutral wire. The insulation resistance so measured **should not be less than 0.5 MΩ and not more than**

8. Polarity Test in House Wiring

In a low voltage installation, this test is performed to verify that all single pole switches have been connected to phase wire throughout the installation.

It is very necessary to place all switches on phase so that when a switch is made OFF, the connected appliance is quite dead.

If the switch is connected to the neutral wire then the connected appliance will get phase even if the switch is in OFF position and remain alive.

There is absolutely no difference in the functioning of the switch in either case, but from the safety point of view to avoid shock, etc. the phase should always be given through the switch and neutral direct to the point.

The simple method of conducting the polarity test is by using a test lamp.

Before performing this test the position of the main switch, fuses, switches, etc. should be as under:

- main switch in ON position,
- all switches in OFF position,
- all lamps and other appliances should be removed.

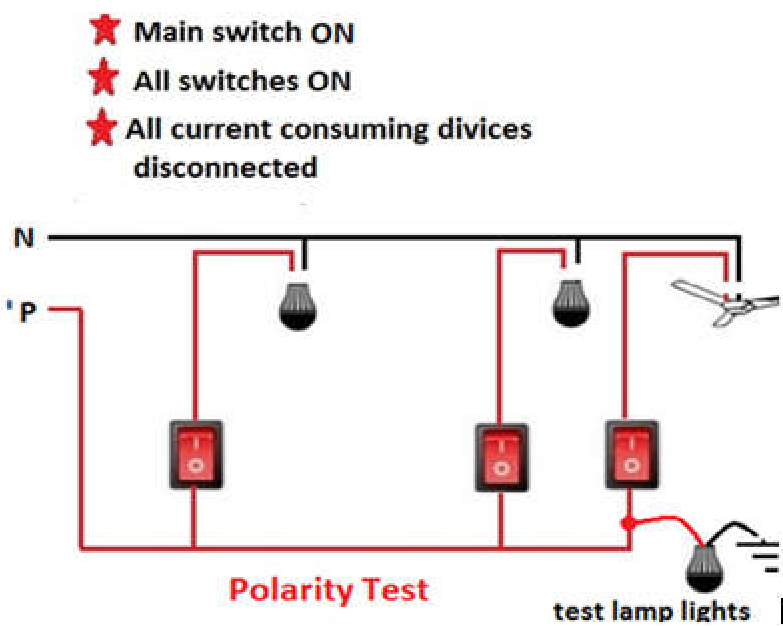


Fig.3.5 polarity test

One end of the test lamp is connected to earth wire and the other end to the incoming terminal of the switch.

If the lamp lights, it indicates that the switch is connected to phase wire, otherwise to neutral wire.

4. Earth Continuity Test of Electrical Installation

To perform this test with the help of megger, the main switch is opened, the main fuses are withdrawn, all the switches are made ON and all the lamps are put in position.

The ‘L’ (line terminal) of the megger is connected to the phase conductor in the main switch and ‘E’ (earth terminal) of the megger is connected to an earth point.

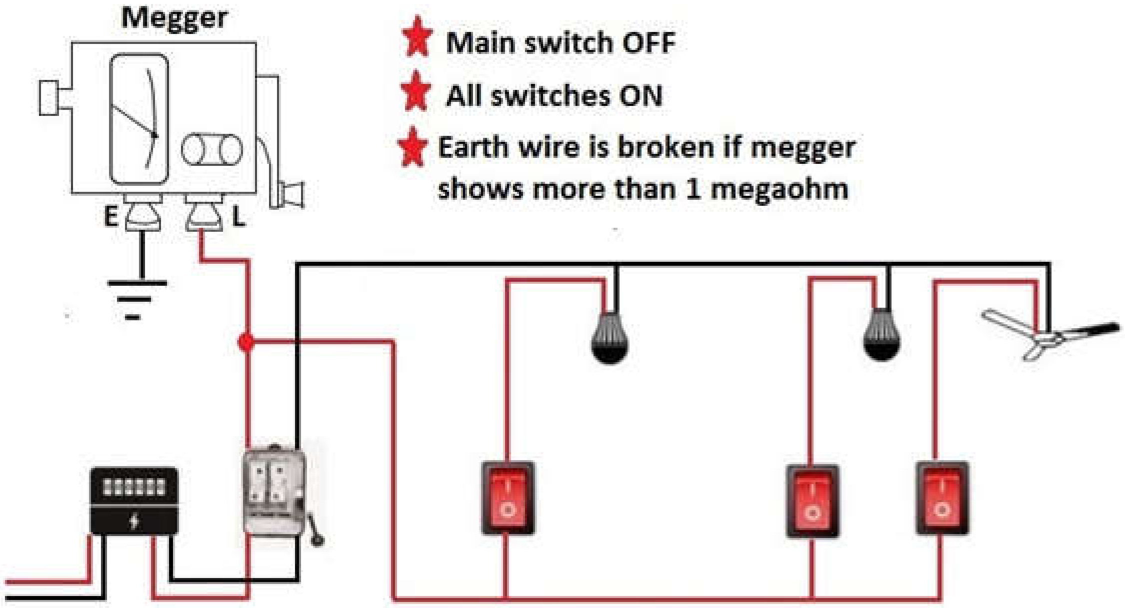


Fig.3.6. Earth continuity test

In this test, megger should indicate a resistance value between 0.5 and 1 mega ohm.

In this case, if earthing of all the metallic parts and the earth wire will be in good condition, a sufficient amount of current will flow through test circuit and megger will show a reading up to 1 MΩ.

If it will be in bad condition then it will offer high resistance to the current. As a result, a very low quantity of current will flow and megger will show a reading more than 1 MΩ .

Therefore, if the megger shows a high reading (more than 1 MΩ), it means that the main switch or conduit is not properly earthed or the earth wire is broken somewhere requiring correction.

✓ **Test Circuit breaker**

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by over current or overload or short circuit. Its basic function is to interrupt current flow after protective relays detect a fault. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city. The generic function of a circuit breaker, RCD or a fuse, as an automatic means of removing power from a faulty system is often abbreviated to ADS (Automatic Disconnection of Supply).

Operation

All circuit breaker systems have common features in their operation, but details vary substantially depending on the voltage class, current rating and type of the circuit breaker.

The circuit breaker must detect a fault condition; in common mains and low voltage circuit breakers, this is usually done within the breaker itself. Circuit breakers for large currents or high voltages are usually arranged with a protective relay pilot devices to sense a fault condition and to operate the trip opening mechanism. The trip solenoid that releases the latch is usually energized by a separate power source, such as a battery, although some high-voltage circuit breakers are self-contained with current transformers, protective relays, and an internal control power source.

Once a fault is detected, the circuit breaker contacts must open to interrupt the circuit; this is commonly done using mechanically stored energy contained within the breaker, such as a spring or compressed air to separate the contacts. Circuit breakers may also use the higher current caused by the fault to separate the contacts, such as thermal expansion or a magnetic field. Small circuit breakers typically have a manual control lever to switch off the load or reset a tripped breaker, while larger units use solenoids to trip the mechanism, and electric motors to restore energy to the springs.

The circuit breaker contacts must carry the load current without excessive heating, and must also withstand the heat of the arc produced when interrupting (opening) the circuit. Contacts are made of copper or copper alloys, silver alloys and other highly conductive materials. Service life of the contacts is limited by the erosion of contact material due to arcing while interrupting the current. Miniature and molded-case circuit breakers are usually discarded when the contacts have worn, but power circuit breakers and high-voltage circuit breakers have replaceable contacts.

When a high current or voltage is interrupted, an arc is generated. The length of the arc is generally proportional to the voltage while the intensity (or heat) is proportional to the current. This arc must be contained, cooled and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit. Different circuit breakers use vacuum, air, insulating gas, or oil as the medium the arc forms in. Different techniques are used to extinguish the arc including:

- Lengthening or deflecting the arc
- Intensive cooling (in jet chambers)
- Division into partial arcs

Finally, once the fault condition has been cleared, the contacts must again be closed to restore power to the interrupted circuit.

3.4. Respond unplanned events or condition

3.4.1 Unsafe electrical equipment and electrical installations at the work place.

A person conducting a business or undertaking that has management or control of electrical equipment must ensure that any unsafe electrical equipment at the workplace is disconnected (or isolated) from its electricity supply and, once disconnected, is not reconnected until it is repaired or tested and found to be safe or is replaced or permanently removed from use.

Electrical equipment is unsafe if there are reasonable grounds for believing it to be unsafe. You should implement a safe system of work to deal with potentially unsafe electrical equipment at the workplace. This could include: requiring workers (if competent to do so) to undertake a check of the physical condition of the electrical equipment, including the lead and plug connections, prior to commencing use taking the electrical equipment out of service if in doubt as to safety, including at any time during us putting reporting arrangements in place to ensure, so far as is reasonably practicable,

that supervisors or line managers are advised if a worker takes electrical equipment out of service for safety reasons.

- ✓ Inspecting and testing electrical equipment

Inspecting and testing electrical equipment will assist in determining whether it is electrically safe. Regular visual inspection can identify obvious damage, wear or other conditions that

might make electrical equipment unsafe. Many electrical defects are detectable by visual inspection. Regular testing can detect electrical faults and deterioration that cannot be detected by visual inspection. The nature and frequency of inspection and testing will vary depending on the nature of the workplace and the risks associated with the electrical equipment. Lower-risk workplaces include those workplaces that are dry, clean, well-organised and free of conditions that are likely to result in damage to electrical equipment, for example an office, retail shop, telecommunications centre, classroom, etc. Electrical equipment commonly used in these types of lower-risk workplaces includes computers, photocopiers, stationery or fixed electrical equipment. A key source of information on dealing with the inspection and testing of electrical equipment is the manufacturer's recommendations. In this section a reference to 'inspection' or 'testing' excludes repair of electrical equipment.

Inspection and testing of electrical equipment may involve, in part:

- „ looking for obvious damage, defects or modifications to the electrical equipment, including accessories, connectors, plugs or cord extension sockets
- looking for discoloration that may indicate exposure to excessive heat, chemicals or moisture
- checking the integrity of protective earth and insulation resistance
- checking that flexible cords are effectively anchored to equipment, plugs, connectors and cord extension sockets
- looking for damage to flexible cords
- checking that operating controls are in good working order i.e. they are secure, aligned and appropriately identified
- checking that covers, guards, etc. are secured and working in the manner intended by the manufacturer or supplier
- checking that ventilation inlets and exhausts are un obstructed, checking that the current rating of the plug matches the current rating of the associated electrical equipment.

Self check-3-

Part I True or false

1. Fuse is a type of low resistance resistor that acts as a sacrificial device to provide over current protection.
2. An inductive load causes the current wave to lag the voltage wave
3. power factor for a resistive load is unity
4. Power factor of a capacitive load is leading.
5. Voltage drops are the same across all the components connected in parallel.
6. Current through individual components connected in parallel, is inversely proportional to their resistances.
7. Total circuit current is the arithmetic sum of the currents passing through individual components connected in parallel.
8. The reciprocal of equivalent resistance is equal to the sum of the reciprocals of the resistances of individual components connected in parallel.

Part II. Fill in the space provide

1. --------------Voltage drops are the same across all the components connected in parallel

2. ----------------so measured should not be less than 0.5 MΩ and not more than

3. ----------------- insulation resistance shall be measured across earth and the whole system of conductors.

4.----------------------tested for continuity of circuits, short circuits and earthing after wiring is completed and before energizing.

Test III: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. What is the purpose of measurement?
2. Write down at least three measuring equipments?
3. What is the difference between ruler and tape?

Operation sheet .3: Inspect and notify completion of work

- **Operation title:** it is used to test the connection of electrical wire and to ensure the termination of wire properly
- **Purpose:** it is used to checking the connection of electrical wire and to ensure the termination of wire properly.
- **Instruction:** covering that is wrapped over the splice by soldering technique

  Write your observation and conclusion in this activity
- Equipment, tools and materials:
  1. **Multi-tester** 5 pc .Long noise plier
  2. Digital multi meter
  3. Soldering gun
  4. Soldering lead
- **Procedures in test the task**

Step 1. Select the ac or dc function with the selection switch on the side of the unit.
Step 2. Place the black probe of the unit under test into the (-) terminal and press down firmly.
Step 3. Place the red test probe of the unit under test in the (+) and press down firmly.
Step 4. Verify the meter reading of the tester is valid for the function tested.
Step 5. For low impedance testers the output voltage sourced should be >50 VAC or dc.
Step 6. It is recommended to test both ac and dc functions of your test tool.

3. **Quality criteria :** All these tasks should be performed using correctly according to the given procedure; we should have a good experience for testing electrical circuit.
4. **Precaution :** Be careful of using the knife to remove the insulation from the conductor (Use extreme care when cutting the insulation may be cut your finger)

Lap Test. 3.

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks within 8 hours.

Task 1: identify the required material and equipment for electrical tests.

Task2: construct parallel and series circuit and measure resistance.

Task3: measure voltage and current in circuit.

Task 4: tests voltage, current, resistance, continuity in DC and AC circuit.

Reference

1. CED ENGINEERING.COM continuing Education and Development, Wiring Techniques.
2. "Fuse Element Fatigue" (PDF). Cooper Bussmann. Retrieved 2015-05-26.
3. A. Wright, P.G. Newber (Jan 1, 2004). Electric Fuses, 3rd Edition. IET. pp. 124–125.
4. Robert Friedel and Paul Israel, Edison's Electric Light: Biography of an Invention, Rutgers University Press, New Brunswick New Jersey USA,1986 ISBN 0-8135-1118-6 pp.65-66
5. "1920-1929 Stotz miniature circuit breaker and domestic appliances", ABB, 2006-01-09, accessed 4 July 2011
6. Flurscheim, Charles H., ed. (1982). "Chapter 1". Power Circuit Breaker Theory and Design (Second ed.). IET. ISBN 0-906048-70-2.

Participants of this Module (training material) preparation

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Roman Ayalew	A	Industrial Automation & Control	Wonji PTC	911837475	nimonaroman@gmail.com
2	Sirgut Wandimagegn	A	Electrical Automation & Control Tech	Entoto PTC	911966234	sirgut10@gmail.com
3	Esubalew Amsalu	A	Electrical Automation & Control Tech	Harar PTC	910644790	balewesu@gmail.com
4	Adamu Asfaw	B	Electrical/Electronic Technology	M/G/Mulugeta Buli PTC	922839529	adamuasfaw95@gmail.com
5	Tenagnwork W/Hana	A	Electrical Automation & Control Tech	Kombolcha PTC	913659902	tenagneworkwoldehana@gmail.com
6	Biruk Aniley	A	Electrical Automation & Control Tech	Ethio-Italy PTC	920131850	birukanu@gmail.com

የሥራ እና ክህሎት ሚኒስቴር
MINISTRY OF LABOR
AND SKILLS