BUILDING ELECTRICAL INSTALLATION

NTQF- LEVEL II

Learning Guide-35

Unit of Competence: Connect Wiring Systems and Equipment

Module Title: Connecting Wiring Systems and Equipment

LG Code: EIS BEI2 M10 LO1-LG-35

TTLM Code: EIS BEI2 M10 TTLM 0919v1

LO 1: Plan and Prepare

Instruction Sheet	Learning Guide-35

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

- Identifying hazards of connection of wiring systems, wiring enclosures and equipment
- Identifying means of electrical isolation
- Carrying out isolation procedures to ensure a safe connection

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

- Identify hazards of connection of wiring systems, wiring enclosures and equipment
- Identify means of electrical isolation
- Carry out isolation procedures to ensure a safe connection

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, and Sheet 3” **in** page 3, 9, and 12.
4. Accomplish the “Self-check 1, Self-check 2, and Self-check 3” **in page 8, 11, and 13.**
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 ” **in page -14, 16, and 18.**
6. Do the “LAP test” **in page – 18**.

Information Sheet-1	Identifying hazards of connection of wiring systems, wiring enclosures and equipment

1.1 Identifying hazards of connection of wiring systems, wiring enclosures and equipment

- **Electrical wiring** is the electrical power distribution through the **wires** in a perfect manner for economic use of **wiring** conductors inside a room or building with better load control.
- **An electrical enclosure** is a cabinet for electrical or electronic equipment to mount switches, knobs and displays and to prevent electrical shock to equipment users and protect the contents from the environment.

1.1.1 Electrical hazard

Hazards are most likely to take of the life or leave of the human Bing by different condition by electricity, water fooled, earth rock and the like.

An **electrical hazard** can be defined as

- dangerous condition where a worker could make electrical contact with energized equipment or a conductor, and from which the person may sustain an injury from shock; and/or,
- There is potential for the worker to receive an arc flash burn, thermal burn, or blast injury.

Note: An electrical hazard is considered to be removed when protective measures are put in place at the source (remove hazard or de-energize), or along the path (place electrical insulation/barrier between the worker and the electrical hazard). Where PPE is relied upon for worker protection, an electrical hazard is considered to remain and it is still necessary to address safety requirements for other workers in the area.

Electrocution is one of the most common hazards across construction sites according to OSHA. Identifying electrical hazards can help raise awareness of the risks, their severity, and how it can harm workers.

Here are 7 of the most common **electrical hazards** in the workplace and tips on what you can do to mitigate these risks.

1. **Overhead Power Lines**

Overhead powered and energized electrical lines have high voltages which can cause major burns and electrocution to workers. Remember to maintain a minimum distance of 10 feet from overhead power lines and nearby equipment. Conduct site surveys to ensure that nothing is stored under overhead power lines. Also, safety barriers and signs must be installed to warn nearby non-electrical workers of the hazards present in the area.

2. **Damaged Tools and Equipment**

Exposure to damaged electrical tools and equipment can be very dangerous. Do not fix anything unless you are qualified to do so. Thoroughly check for cracks, cuts or abrasions on cables, wires and cords. In case of any defects, have them repaired or replaced. Lock out Tag out (LOTO) procedures should be performed at all times before commencing electrical maintenance and repairs. LOTO procedures are there to protect all workers on a worksite.

3.Inadequate Wiring and Overloaded Circuits

Using wires with inappropriate size for the current can cause overheating and fires to occur. Use the correct wire suitable for the operation and the electrical load to work on. Use the correct extension cord designed for heavy duty use. Also, do not overload an outlet and use proper circuit breakers. Perform regular fire risk assessments to identify areas at risk of bad wiring and circuits.

4.Exposed Electrical Parts

Examples of exposed electrical parts include temporary lighting, open power distribution units, and detached insulation parts on electrical cords. These hazards can cause potential shocks and burns. Secure these items with proper guarding mechanisms and always check for any exposed parts to be repaired immediately.

5.Improper Grounding

The most common OSHA electrical violation is improper grounding of equipment. Proper grounding can eliminate unwanted voltage and reduce the risk of electrocution. Never remove the metallic ground pin as it is responsible for returning unwanted voltage to the ground.

6. Damaged Insulation

Defective or inadequate insulation is a hazard. Be aware of damaged insulation and report it immediately. Turn off all power sources before replacing damaged insulation and never attempt to cover them with electrical tape.

7. Wet Conditions

Never operate electrical equipment in wet locations. Water greatly increases the risk of electrocution especially if the equipment has damaged insulation. Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.

Knowing your limits and applying best electrical safety practices can help reduce the risk of electrical shock and death. It is safer to work within your scope of expertise instead of taking the risk of working beyond your capacity. If you are not confident to do the job, don't hesitate to call for help from an authorized person.

Instead of relying on your memory, use a checklist when applying electrical safety practices in your workplace. A digital checklist is a powerful tool which can serve as a guide for performing work near electrical equipment and hazards.

1.1.2 Electrical Injuries

There are basically two ways to be injured by electricity. One is by electric shock and the other is by arc flash.

Electric shock is the passing of electric current through the body. Electrical contact can cause involuntary physical movements. The electrical current may do the following.

- Prevent you from releasing your grip from a live conductor
- Throw you into contact with a higher voltage conductor
- Cause you to lose your balance and fall
- Cause severe internal and external burns

A major cause of accidents involving electricity comes from the failure to identify the hazards associated with live electrical equipment and wiring (Figure-1).


Figure1.1: Electrical Injuries

1.1.3 Electric shock

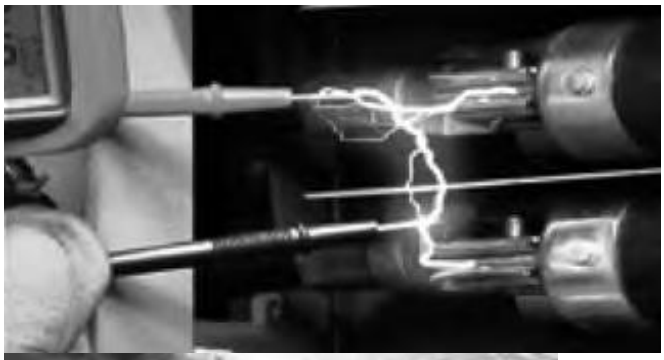
Electric shock is the physiological reaction, sensation, or injury caused by electric current passing through the (human) body. It occurs upon contact of a (human) body part with any source of electricity that causes a sufficient current through the skin, muscles, or hair.

- Fire
- Burns and
- Injury from mechanical movement of electrically actuated machinery.

1.1.4 Arc flash

An **arc flash** is a release of energy caused by an electric arc (Figure 26-2). The flash causes an explosive expansion of air and metal. The blast produces

- A dangerous pressure wave
- A dangerous sound wave
- Shrapnel
- Extreme heat
- Extreme light.



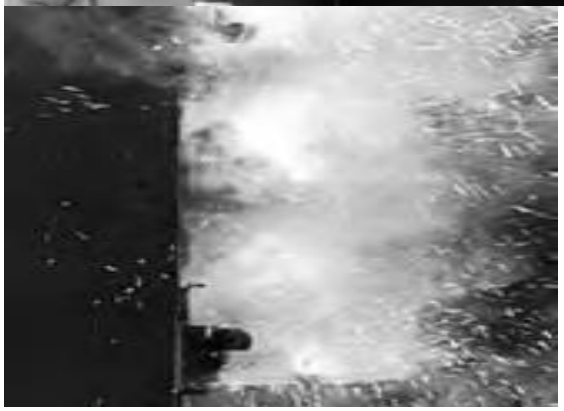


Figure1.2: Electric Arc

These conditions can lead to **arc flash**:

- Accidental contact between two conductors
- Wiring errors
- Insulation deterioration or failure
- Corrosion of equipment
- Contamination of the equipment (e.g., dust, moisture)
- Animals, tools, or fallen parts that short-circuit the equipment
- Poor maintenance
- Workers using improper or non-rated tools.

If a worker is close to energized electrical equipment, the worker may be exposed to a flash hazard, even if the source of the arc flash is not being worked on. Employers and supervisors need to ensure these workers are protected from flash hazards, and should educate workers on flash hazard recognition.

Figure1.3: Arc Flash

Protection from an arc flash is afforded by protective clothing and equipment such as

- Arc flash rated clothing
- Flame-resistant eye protection (arc-rated face shield is often required as well)
- Hand protection
- Hearing protection

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The condition of hazards are mostly likely to take of the life by:

A. Electricity

C. earth rock

B. water fool

D. all

2. Which of the following is the basic way to be injured by electricity?

A. Electric shock C. Water fool

B. Arc flush D. A and B

3. _____is the physiological reaction, sensation or injure caused by electrical current passes through the human body.

A. Electrical shock C. Earth rock

B. Arc flush D. all

4. Defective or inadequate insulation is a hazard?

A. True

B. False

5. Protection from an arc flash is afforded by :

A. Arc rated clothing protection C. Hand and hearing

B. Flame resistant eye protection D. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet- 2	Identifying means of electrical isolation

2.1 Introduction of electrical isolation

Electrical isolation is a method of corrosion control. Conductors are prone to corrosion from stray current that originates from dissimilar metals. Providing good isolation for these conductors manages the corrosion significantly**.**

2.2 Identifying means of electrical isolation

Emergency switching: Rapid cutting off of electrical energy to remove any hazard to persons, livestock or property which may occur unexpectedly.

Isolation Cutting off an electrical installation, a circuit or an item of equipment from every source of electrical energy.

Mechanical maintenance: The replacement, refurbishment or cleaning of lamps and non-electrical parts of equipment, plant and machinery.

Switch: A mechanical switching device capable of making, carrying and breaking current under normal circuit conditions, which may include specified overload conditions, and also of carrying, for a specified time, currents under specified abnormal conditions such as those of short circuit.

2.2.1 Types of isolators

Various electrical isolators can be used, depending on the requirements of the system. Some of types of isolators are:

1. **Single break isolators** - This type is divided into male and female contacts. The rotation of the post insulator moves the contact arms. Where both insulator stacks are rotated in opposite directions, the isolator is closed with the contact arm. Counter-rotation of both stacks causes the contact arm to open, and hence the isolator is turned off.
2. **Double break isolators** - Their constructional features are three post stacks where the central post is a tubular male contact that rotates horizontally. The rotation can be done manually using a lever at the base of the post, or by a motor that rotates the contact using a tie rod.

3. **Pantograph isolators** - This type of electrical isolation allows installation of modern switch gear with the least space required. It is comprised of an operating insulator and a post insulator.

Electrical isolators can be categorized differently, based on the position of the power system. The categorizations are:

Line side isolator - This type of isolator is fixed at the line of a feeder.

Bus side isolator - This kind of isolator is attached directly to the main bus.

Transfer bus side isolator - This type of isolator is attached directly to the transfer bus.

There is no arc-quenching technique used in an isolator, hence it must be operated when the circuit is free from any current. Opening or closing any live circuit by isolator is dangerous because there can be huge arcing between the contacts. A hand isolator can operate voltages that are up to 145kV, while higher voltages that are over 245kV require motorized isolators.

2.2.2 Isolation of Electrical Equipment

All electrical equipment and electrical circuits must be isolated from all sources of electrical supply before any work is started on the equipment and circuits. This will be achieved by operating the appropriate controlling device(s) and include:

- Opening switches;
- Opening circuit breakers; or
- Removal of circuit connections, after the power supply to the circuit connections has been isolated;
- Disconnection of battery

Self-Check -2	Written Test

Instructions: - choose the correct answer from the given alternative. Use the Answer sheet provided in the next page:

1. _____is cutting off an electrical installation, a circuit or an item of equipment from every source of electrical energy.

A. Voltage

C. Resistance

B. Isolator

D. all

2. One of the following is type of isolator.

A. Single break C. Pantograph

B. Double break D. All

3. _____is a type of an isolator fixed at the line of a feeder.

A. Bus side isolator C. Transfer bus side isolator

B. Line side isolator D. A and B

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 2 points**

Information Sheet-3	Carrying out isolation procedures to ensure a safe connection

3.1 Introduction of isolation procedure

An isolation procedure is a set of predetermined steps that must be followed to ensure that plant and related hazards cannot jeopardize the safety of those working on the plant. There must be an isolation procedure for each item of plant, including the application of isolation devices, locks and tags, as practicable. While isolation procedures may vary in detail because of differences in plant, power sources, hazards and processes, they must include the following steps.

Safe isolation procedures are in place to ensure that workers on site are not exposed to danger when working on or near live electrical systems. There are many reports where these procedures have not been followed correctly and sadly this has resulted in needless loss of llife.

3.1.1 Basic isolation procedure for safe connection

Where these three conditions are met, live work may proceed, but minimum safe isolation procedures should be followed. These include:

- **Identify correct isolation point or device,**
  For all work on low voltage electrical equipment or circuits, it is important to ensure that the correct point of isolation is identified. When isolating the main source of energy, it is also essential to isolate any secondary source (such as standby generators, uninterruptable power supplies and micro generators).
- **Check condition of voltage indicating device** —such as a test lamp or two-pole voltage detector.
- **Switch off installation/circuit to be isolated.**
  It should never be assumed that equipment is dead because a particular isolation device has been placed in the OFF position.

- **Verify with voltage indicating device that no voltage is present.**

  It is important to ensure that the correct point of isolation is identified before proving dead. Adequate precautions should be taken to prevent electrical equipment which has been made dead, is carried out on or near that equipment, from becoming electrically charged during that work.
- **Re-confirm that voltage indicating device functions correctly on proving unit.**

  Use proving unit to confirm that the voltage on the indicating device is functioning correctly.
- **In IEE standards require additional steps, including:**
  A. Carry out earthing and short circuiting.
  B. Provide protection against adjacent live parts.
- **Lock-off device used to isolate installation circuit.**

  It is preferable for an appropriate locking-off device be used on the point of isolation.
- **Post warning notices.**

  Suitable labeling of the disconnected conductors using a caution notice is vital to prevent the supply being reinstated.

Self-check Test 3	**Carrying out isolation procedures to ensure a safe connection**

Instructions: - choose the correct answer from the given alternative. Use the Answer sheet provided in the next page:

1. _____is a set of pre-determined steps that must be followed to ensure that plant and relates hazards cannot jeopardize the safety of working on the plant.
   A. Isolation procedure C. working procedure
   B. Safety procedure D. All
2. Safe isolation procedures are in a place to ensure that workers on site are not exposed to danger when working on or near live electrical system.
   A. True
   B. False
3. Which of the following is the basic isolation procedure:

A. Identify all other hazards hazard
C. Control other potential
B. Shut the plant down
D. All

Note: **Satisfactory rating - 3 and 5 points** **Unsatisfactory - below 3 and 5 points**

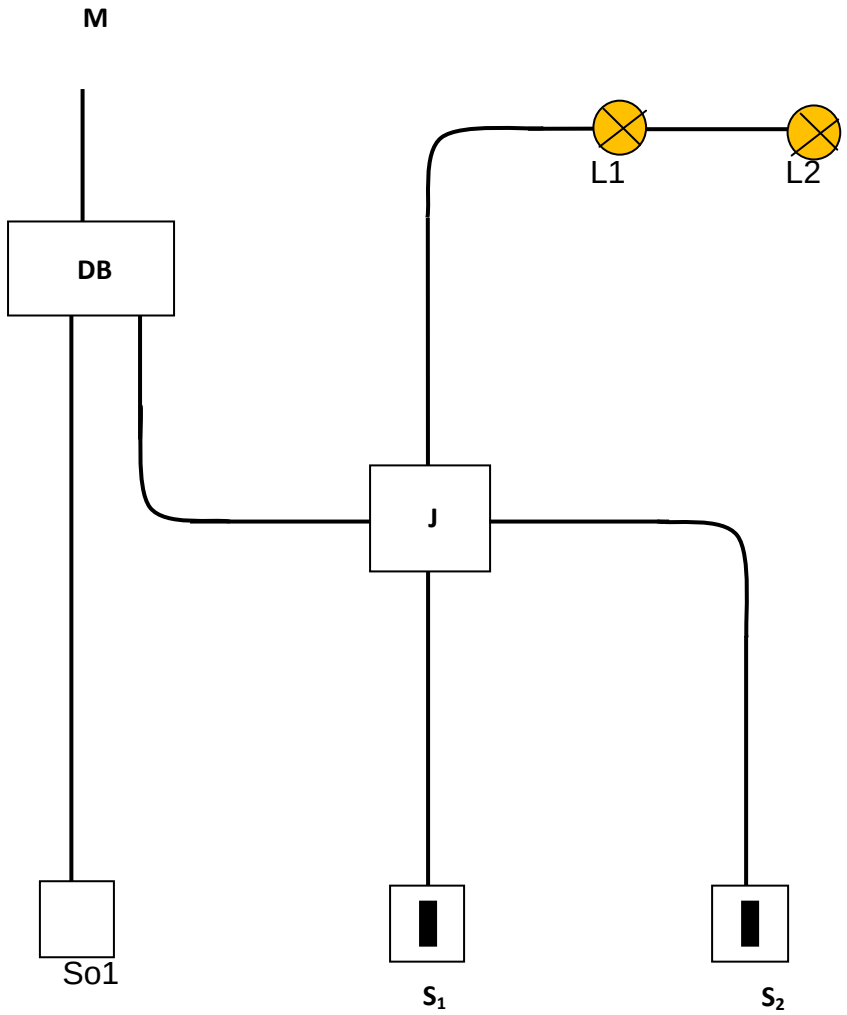
Operation Sheet 1	**Identify hazards related to the connection of wiring systems**

Title: Identify hazards relating to wiring system, wiring enclosure, and equipment **for** one lamp controlled by two positions on 220V/50Hz.supply

Procedure:

Step 1: wear PPE.

Step 2: Draw schematic diagram using the given lay out diagram.



Step 3: Draw wiring diagrams using the given lay out diagram.

Step 4: select required tools and materials

Step 5: Check the material and equipment

Step 6: install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7: Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11: Connect the components from the source to final circuit

Step 12: Check the whole installation circuit and connections

Step 14: To connect the supply with installation circuit

Step 15: Check the whole installation circuit after connect the power supply.

Step 16: Identify hazards related to the connection of wiring systems.

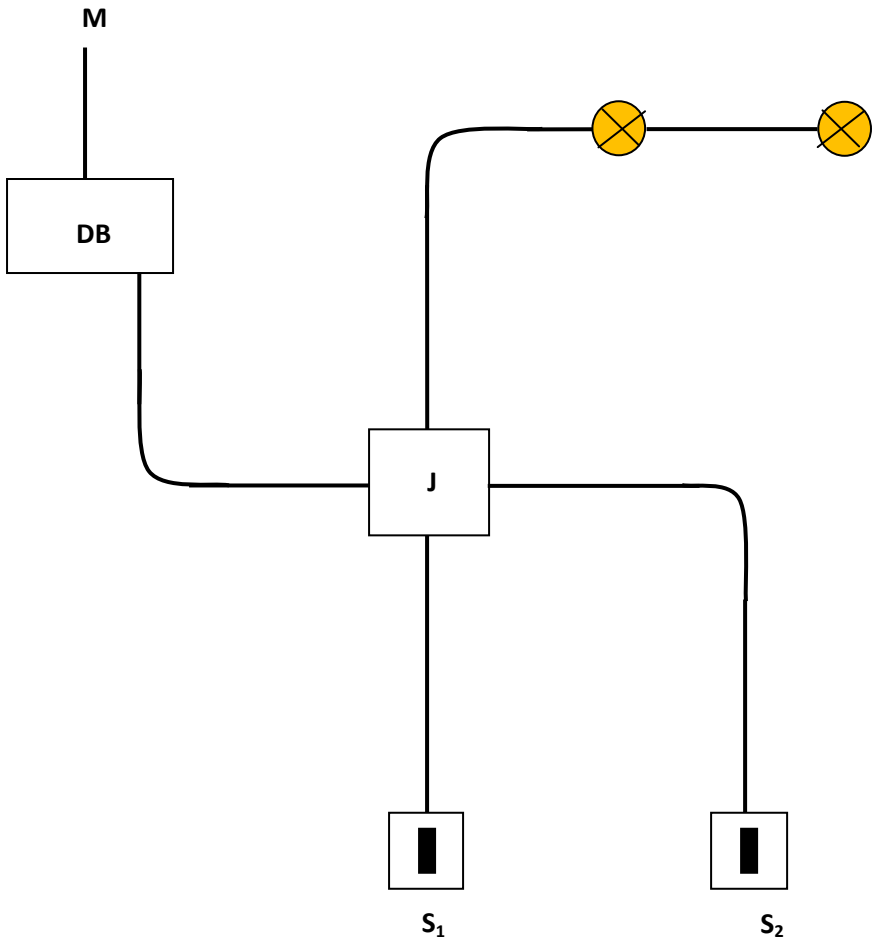
Operation Sheet 2	Identifying means of electrical isolation

Title: Identifying means of electrical isolation for two lamps controlled by two positions on 220V/50Hz.supply.

Procedure:

Step 1: wear PPE.

Step 2: Draw schematic diagram using the given lay out diagram.



Step 3: Draw wiring diagrams using the given lay out diagram.

Step 4: select required tools and materials

Step 5: Check the material and equipment

Step 6: install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7: Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11: Connect the components from the source to final circuit

Step 12: Check the whole installation circuit and connections

Step 14: To connect the supply with installation circuit

Step 15: Check the whole installation circuit after connect the power supply.

Step 16: Identifying means of electrical isolation.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hour.

Task 1: Identify hazards relating to wiring system, wiring enclosure, and equipment **.**

Task 2: Identify means of electrical isolation**.**

BUILDING ELECTRICAL INSTALLATION

NTQF- LEVEL II

Learning Guide-36

Unit of Competence: Connect Wiring Systems and Equipment

Module Title: Connecting Wiring Systems and Equipment

LG Code: EIS BEI2 M10 LO2-LG-36

TTLM Code: EIS BEI2 M10 TTLM 0919v1

LO 2: Connect Wiring System and Equipment

Instruction Sheet	Learning Guide-36

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

- Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations
- Checking connections
- Correcting identified defects after connection has taken place

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

- Make connections with specifications and IEE wiring regulations / Standard for Electrical Installations
- Check connections
- Correct identified defects after connection has taken place

Learning Instructions:

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below 3 to 6.
9. Read the information written in the information “Sheet 1, Sheet 2, and Sheet 3”.
10. Accomplish the “Self-check 1, Self-check t 2, and Self-check 3” **in page 40, 48, and 60**.
11. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2, Operation Sheet 3, Operation Sheet 4, and Operation Sheet 5 ” **in page -61, 63, 65, 67, and 69.**
12. Do the “LAP test” **in page – 71**.

Information Sheet-1	Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations

1.1 International electrical engineer (IEE) Wiring Regulations

The IEE Wiring Regulations Explained and Illustrated, Second Edition discusses the recommendations of the IEE Regulations for the Electrical Equipment of Buildings for the safe selection or erection of wiring installations. The book emphasizes earthing, bonding, protection, and circuit design of electrical wirings. The text reviews the fundamental requirements for safety, earthing systems, the earth fault loop impedance, and supplementary bonding. The book also describes the different types of protection, such as protection against mechanical damage, overcurrent, under voltage (which prevents automatic restarting of machinery and devices in the event of a voltage drop). The text explains in detail the stages of the designing process of electrical installation that include the design current, protection rating, correction factors, cable current-carrying capacity, cable size, voltage drop, shock risk constraints, and thermal constraints. The electrician should test the finished installation before energizing it by following a sequence of tests recommended in the Regulations. The book is suitable for electricians, technicians, building foreman, house contractors, as well as for students studying to be licensed electricians and technicians.

1.2 Appling IEE wiring regulation /standard for electrical installation

The IEE Wiring Regulations are divided into seven parts. These follow a logical pattern from the basic requirements to the final testing and inspection of an installation:

Part 1 indicates the range and type of installations covered by the Regulations, what they are intended for, and the basic requirements for safety.

Part 2 is devoted to the definitions of the terms used throughout the Regulations.

Part 3 details the general information needed before any design work can usefully proceed.

Part 4 informs the designer of the different methods available for protection against electric shock, overcurrent etc., and how to apply those methods.

Part 5 enables the correct type of equipment, cable, accessory etc. to be selected in accordance with the requirements of Parts 1 to 4.

Part 6 deals with particular requirements for special installations such as bathrooms, swimming pools, construction sites etc.

Part 7 provides details of the relevant tests to be performed on a completed installation before it is energized.

Electrical wiring is ultimately regulated to ensure safety of operation, by such as the Building Regulations, currently legislated as the Building Regulations 2010, which lists "controlled services" such as electric wiring that must follow specific directions and standards, and the Electricity at Work Regulations. The detailed rules for end-use wiring followed for practical purposes are those of BS 7671 Requirements for Electrical Installations. (IET Wiring Regulations), currently in its 17th edition Amendment 3, which provide the detailed descriptions referred to by legislation.

There are main IEE regulations but some of regulation listed below.

1. **Personnel Protective Equipment at Work Regulations (PPE)**

These regulations detail the requirements for safety regarding protective clothing, tools, etc., for example hard hats, protective footwear, rubber mats and insulated tools. Signs are usually posted on site to indicate the need for the use of such as equipment. This requires employers to provide suitable PPE for their employees.

2. **Health and Safety (First Aid) Regulations: -** This covers first aid requirements.
3. **The Health and Safety Information for Employees Regulations: -** This deals with the display of posters informing employees about health and safety.
4. **Electricity at Work Regulations 1989 (EAWR**) **:-** This places a responsibility on any person who has control of an electrical system to ensure safety
5. **Gas Safety (Installation and Use) Regulations:-**This covers the safe installation and maintenance of domestic and commercial Gas systems.
6. **The building regulations: -** Clearly these regulations encompass all aspects of building construction and are known as Approved documents (Ads) or Parts.

There are some Ads that are relevant to electrical installations. These are as follows:

Ad Part A. This, overall, deals with the building structure and, to some extent, on how the fabric of the building may be violated to accommodate electrical systems via chases, notching, drilling, etc. (see pp. 248–266 regarding joists).

Ad Part B. This concerns fire safety. All electrical systems should be constructed and installed to prevent the start of and the spread of fire. Such considerations would include: heat resistant sleeving on conductors, hoods over down lighters, fire barriers in trunking and sealing of holes made in the building fabric during the installation process. Added to this there is a requirement to provide smoke and fire alarm detection systems.

Ad Part Ventilation is important, especially in kitchens and bathrooms, and in consequence particular attention should be paid to the positioning and effectiveness of extract fans and the number of appliances installed.

Ad Part L. This is about the efficient use of fuel and energy. Generally in domestic dwellings, lighting is probably most abused and in consequence the types and control of luminaries have to be carefully considered.

Ad Part M. Disabled persons need access to buildings and facilities and hence the position of sockets and switches is important. The Part M document indicates reasonable heights of such accessories where there is access/use by the disabled.

Ad Part P. There is now a requirement to inform the Local Authority Building Control (LABC) of any electrical work carried out in a domestic dwelling. This is generally confined to kitchens, bathrooms and gardens, where the risk of shock is considerably higher. This does not extend to changing old for new fittings or accessories. Those who carry out electrical work in such areas must be competent and registered with an authoritative body before certification can legitimately be issued.

To connecting the wire we must Appling the above IEE regulation and wiring regulation.

7. **Wiring regulation:-**It refers to BS7671 requirements for electrical installation the IEE wiring regulations. The standard therefore a code of acceptable safety for electrical installation to protects
    - Persons
    - Property, and

- Livestock

Against electrical hazards which are described as

- Electrical shock
- Fire
- Burns and
- Injury from mechanical movement of electrically actuated machinery

Generally the modern electrical installation work is aimed at encourage safety consciousness, by providing the student with through knowledge of the application of I.E.E wiring regulation.

There are also a number of mandatory regulations for specialist installation requirements such as mines, cinemas and overhead lines.

Electrical supply regulation says that the insulation resistance must be such that leakage current in any installation does not exceed one ten –thousandth part of the maximum current. Example the total current of 60 A flows in a 240 V installation .what must be the minimum value of insulation resistance in order to conform to electricity supply regulation?

Maximum permitted linkage current = 1/1000 per of the total current

60/1000 = .006A = 6mA

1.2.1 GENERAL WIRING RULES FOR HOUSES

The following are the minimum cross-sectional areas of conductors based on their applications: -

Conductor Cross Sectional Area in mm^2	Material	Application
1.5 mm^2	Copper	Lighting/fan circuit
2.5 mm^2	Copper	13A socket outlet circuit
4.0 mm^2 – 6.0 mm^2	Copper	General Power Circuit (example: water heater, cooker unit, motor/pump)
16.0 mm^2 / 25.0 mm^2	Copper	Main Circuit

Table 1.1 cross-sectional areas of conductors

- **Wire and circuit breaker sizes:**

Wire size in mm	Description/Function	I/A (circuit breaker)
0.8mm	For bell	6A

1.5mm	For lighting	10A
2.5mm	For normal socket out let	16A
4 mm	For stove, Mittad, water heater	20/25A
6mm	For power supply	Above 25A

Table 1.2 Wire and circuit breaker sizes

1.2.2 EARTHING IN THE IEE REGULATIONS

In the preceding pages we have briefly discussed the reasons for, and the importance and methods of, earthing. Let us now examine the subject in relation to the IEE Regulations. standard for electrical Installations are distinguished by a number of criteria, such as voltage (low, very low, high, etc.), phase (single or 3 phase), nature of electrical signal (power, data), type and design of cable (conductors and insulators used, cable design, solid/fixed or stranded/flexible, intended use, protective materials), circuit design (ring, radial), and so on.

1.2.3 ISOLATION AND SWITCHING / IEE regulation /

All installations, whether they are the whole or part, must have a means of isolation and switching for various reasons. These are:

- To remove possible dangers associated with the installation/operation/testing of electrical installations.
- To provide a means of functional switching and control.

The **IEE Regulations** make reference to:

1. Switching off for mechanical maintenance: - The devices for this function should be manually operated and preferably located in the main supply circuit.

2. Emergency switching: - The devices for this function should preferably be hand operated and be capable of interrupting the full load of the circuit concerned.

3. Functional switching:-This is simply switching an item on or off to control its function, e.g. a light switch.

4. Firefighters' switches: - Clearly for the function of isolation in the event of a fire. They should be coloured red and be installed no more than 2.75 m above the ground with the OFF position at the top.

1.2.4 Wiring Installation of IEE regulation

The wiring installation shall be in conformity with IEE regulation and/or approved equivalent standard. Unless otherwise specified all wiring shall be in rigid PVC conduit embedded in wall, or ceiling or concealed in the false ceiling.

The size of conduits shall be selected in accordance with the IEE regulations and the minimum size of the conduit shall be 20 mm dia unless otherwise indicated or approved. Factory made conduit bends shall be used where required. Conduits shall be kept at minimum of 100 mm from the pipes of other non-electrical services.

Separate conduits and run ways shall be used for:

1. Lighting system.
2. Power outlets.
3. Emergency light.
4. Telephone system.
5. Fire alarm system.
6. Sound / public address system.
7. Television system.
8. Computer system.

1.3 Electrical Wiring Systems

Electrical Wiring is a process of connecting cables and wires to the related devices such as fuse, switches, sockets, lights, fans etc. to the main distribution board is a specific structure to the utility pole for continues power supply.

1.3.1 Methods of Electrical Wiring Systems

A process of connecting various accessories for distribution of electrical energy from supplier's meter board to home appliances such as lamps, fans and other domestic appliances are known as Electrical Wiring. Electrical Wiring Systems can be done using two methods which are:

A. **Joint box system or Tee system**
B. **Loop – in system**

A. Joint Box or Tee or Jointing System

In this method of wiring, connections to appliances are made through joints. These joints are made in joint boxes by means of suitable connectors or joints cutouts. This method of wiring doesn't consume too much cables size.

You might think because this method of wiring doesn't require too much cable it is therefore cheaper. It is of course but the money you saved from buying cables will be used in buying joint boxes, thus equation is balanced. This method is suitable for temporary installations and it is cheap.

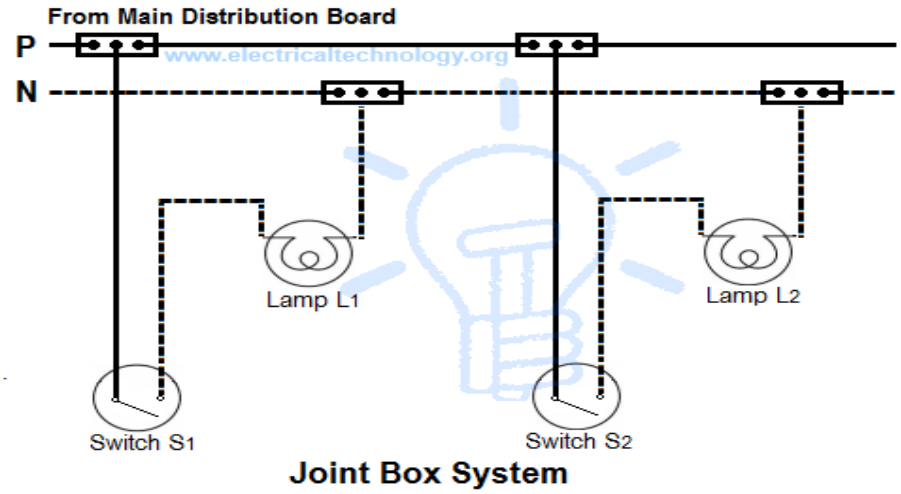


Figure1.1

B. **Loop-in or Looping System**

This method of wiring is universally used in wiring. Lamps and other appliances are connected in parallel so that each of the appliances can be controlled individually. When a connection is required at a light or switch, the feed conductor is looped in by bringing it directly to the terminal and then carrying it forward again to the next point to be fed.

The switch and light feeds are carried round the circuit in a series of loops from one point to another until the last on the circuit is reached. The phase or line conductors are looped either in switchboard or box and neutrals are looped either in switchboard or from light or fan. Line or phase should never be looped from light or fan.

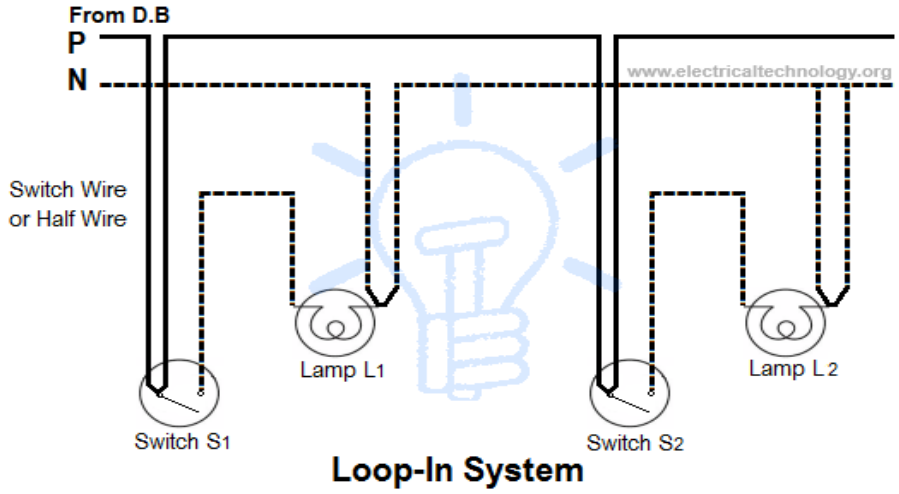


Figure1.2

Advantages of Loop-In Method of Wiring

- It doesn't require joint boxes and so money is saved
- In loop – in systems, no joint is concealed beneath floors or in roof spaces.
- Fault location is made easy as the points are made only at outlets so that they are accessible.

Disadvantages of Loop-In Method of Wiring

- Length of wire or cables required is more and voltage drop and copper losses are therefore more
- Looping – in switches and lamp holders is usually difficult.

1.3.2 Different Types of Electrical Wiring Systems

The types of internal wiring usually used are

- **Cleat wiring**
- **Wooden casing and capping wiring**
- *Batten Wiring (CTS or TRS)*
- **Lead sheathed or metal sheathed wiring**
- **Conduit wiring**

There are additional types of conduit wiring according to Pipes installation (Where steel and PVC pipes are used for wiring connection and installation).

- Surface or open Conduit type
- Recessed or concealed or underground type Conduit

A. Cleat Wiring

This system of wiring comprises of ordinary VIR or PVC insulated wires (occasionally, sheathed and weather proof cable) braided and compounded held on walls or ceilings by means of porcelain cleats, Plastic or wood.

Cleat wiring system is a temporary wiring system therefore it is not suitable for domestic premises. The use of cleat wiring system is over nowadays.

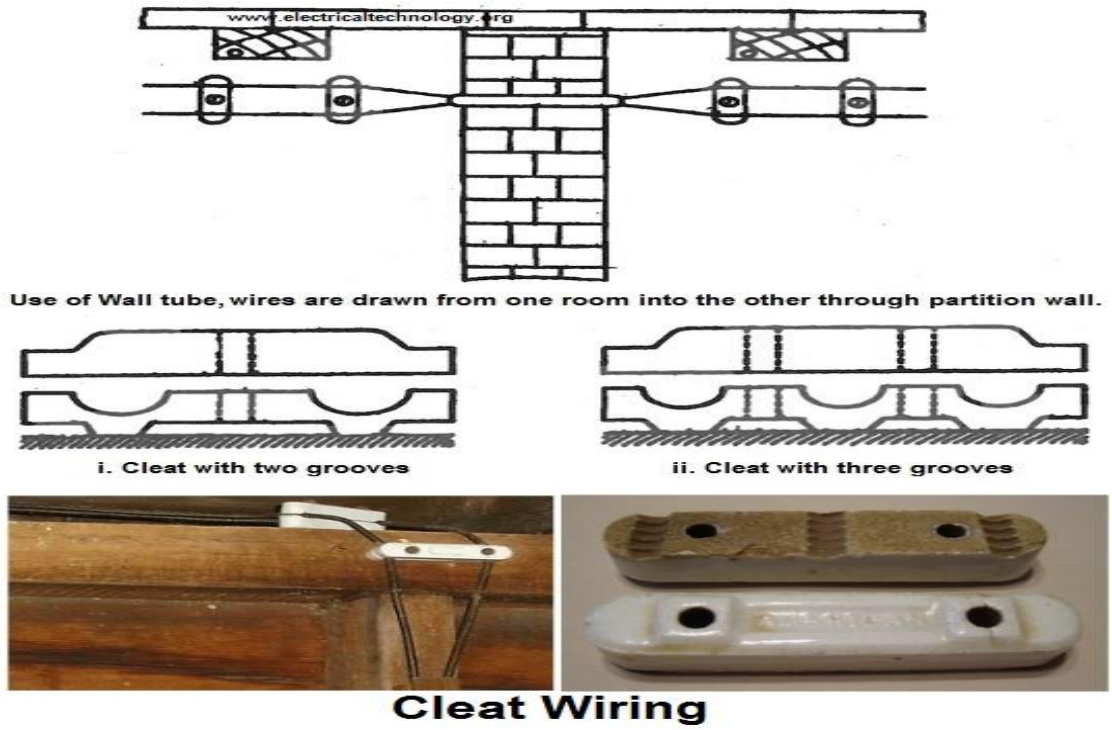


Figure 1-3 cleat wiring

Advantages of Cleat Wiring:

- It is simple and cheap wiring system
- Most suitable for temporary use i.e. under construction building or army camping
- As the cables and wires of cleat wiring system is in open air, Therefore fault in cables can be seen and repair easily.
- Cleat wiring system installation is easy and simple.
- Customization can be easily done in this wiring system e.g. alteration and addition.
- Inspection is easy and simple.

Disadvantages of Cleat Wiring:

- Appearance is not so good.
- Cleat wiring can't be used for permanent use because; Sag may be occurring after sometime of the usage.
- In this wiring system, the cables and wiring is in open air, therefore, oil, Steam, humidity, smoke, rain, chemical and acidic effect may damage the cables and wires.
- It is not lasting wire system because of the weather effect, risk of fire and wear & tear.
- It can be only used on 250/440 Volts on low temperature.
- There is always a risk of fire and electric shock.
- It can't be used in important and sensitive location and places.
- It is not lasting, reliable and sustainable wiring system.

B. Casing and capping wiring

Casing and Capping wiring system was famous wiring system in the past but, it is considered obsolete this day because of Conduit and sheathed wiring system. The cables used in this kind of wiring were either VIR or PVC or any other approved insulated cables.

The cables were carried through the wooden casing enclosures. The casing is made up of a strip of wood with parallel grooves cut length wise so as to accommodate VIR cables. The grooves were made to separate opposite polarity. The capping (also made of wood) used to cover the wires and cables installed and fitted in the casing.

Figure 1-4 casing capping wiring

Advantages of Casing Capping Wiring:

- It is cheap wiring system as compared to sheath and conduit wiring systems.
- It is strong and long-lasting wiring system.
- Customization can be easily done in this wiring system.
- If Phase and Neutral wire is installed in separate slots, then repairing is easy.
- Stay for long time in the field due to strong insulation of capping and casing...
- It stays safe from oil, Steam, smoke and rain.
- No risk of electric shock due to covered wires and cables in casing & capping.

Disadvantages Casing Capping Wiring:

- There is a high risk of fire in casing & capping wiring system.
- Not suitable in the acidic, alkalis and humidity conditions
- Costly repairing and need more material.
- Material can't be found easily in the contemporary
- White ants may damage the casing & capping of wood.

C. Batten Wiring (CTS or TRS)

Single core or double core or three core TRS cables with a circular oval shape cables are used in this kind of wiring. Mostly, single core cables are preferred. TRS cables are chemical proof, water proof, steam proof, but are slightly affected by lubricating oil. The TRS cables are run on well-seasoned and straight teak wood batten with at least a thickness of 10mm.

The cables are held on the wooden batten by means of tinned brass link clips (buckle clip) already fixed on the batten with brass pins and spaced at an interval of 10cm for horizontal runs and 15cm for vertical runs.

Figure 1-5 batten wiring

Advantages of Batten Wiring

- Wiring installation is simple and easy
- cheap as compared to other electrical wiring systems
- Paraphrase is good and beautiful
- Repairing is easy
- strong and long-lasting
- Customization can be easily done in this wiring system.
- less chance of leakage current in batten wiring system

Disadvantages of Batten Wiring

- Can't be installing in the humidity, Chemical effects, open and outdoor areas.
- High risk of firs
- Not safe from external wear & tear and weather effects (because, the wires are openly visible to heat, dust, steam and smoke.
- Heavy wires can't be used in batten wiring system.
- Only suitable below then 250V.
- Need more cables and wires.

D. Lead Sheathed Wiring

The type of wiring employs conductors that are insulated with VIR and covered with an outer sheath of lead aluminum alloy containing about 95% of lead.The metal sheath given protection to cables from mechanical damage, moisture and atmospheric corrosion.

The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against electrolytic action due to leaking current and to provide safety in case the sheath becomes alive. The cables are run on wooden batten and fixed by means of link clips just as in TRS wiring.

E. Conduit Wiring

There are two additional types of conduit wiring according to pipe installation

- **Surface Conduit Wiring**
- **Concealed Conduit Wiring**

Surface Conduit Wiring

If conduits installed on roof or wall, It is known as surface conduit wiring. in this wiring method, they make holes on the surface of wall on equal distances and conduit is installed then with the help of rawal plugs.

Concealed Conduit wiring

If the conduit is hidden inside the wall slots with the help of plastering, it is called concealed conduit wiring. In other words, the electrical wiring system inside wall, roof or floor with the help of plastic or metallic piping is called concealed conduit wiring. Obliviously, It is the **most popular, beautiful, stronger and common electrical wiring system** nowadays.

Surface Conduit Wiring

Concealed Conduit wiring

Figure 1-6 conduit wiring

In conduit wiring, steel tubes known as conduits are installed on the surface of walls by means of pipe hooks (surface conduit wiring) or buried in walls under plaster and VIR or PVC cables are afterwards drawn by means of a GI wire of size if about 18SWG.

In Conduit wiring system, the conduits should be electrically continuous and connected to earth at some suitable points in case of steel conduit. Conduit wiring is a professional way of wiring a building. Mostly PVC conduits are used in domestic wiring.

The conduit protects the cables from being damaged by rodents (when rodents bites the cables it will cause short circuit) that is why circuit breakers are in place though but hey! Prevention is better than cure. Lead conduits are used in factories or when the building is prone to fire accident. Trucking is more of like surface conduit wiring. It's gaining popularity too.

It is done by screwing a PVC trucking pipe to a wall then passing the cables through the pipe. The cables in conduit should not be too tight. Space factor have to be put into consideration.

Advantage of Conduit Wiring Systems

- It is the safest wiring system (Concealed conduit wring)
- Appearance is very beautiful (in case of concealed conduit wiring)
- No risk of mechanical wear & tear and fire in case of metallic pipes.
- Customization can be easily done according to the future needs.
- Repairing and maintenance is easy.
- There is no risk of damage the cables insulation.
- It is safe from corrosion (in case of PVC conduit) and risk of fire.
- It can be used even in humidity, chemical effect and smoky areas.
- No risk of electric shock (In case of proper **earthing and grounding** of metallic pipes).

- It is reliable and popular wiring system.
- Sustainable and long-lasting wiring system.

Disadvantages of Conduit Wiring Systems

- It is expensive wiring system (Due to PVC and Metallic pipes, Additional earthing for metallic pipes Tee(s) and elbows etc.
- Very hard to find the defects in the wiring.
- Installation is not easy and simple.
- Risk of Electric shock (In case of metallic pipes without proper earthing system)
- Very complicated to manage additional connection in the future.

Comparison between Different Wiring Systems

Below is the table which shows the comparison between all the above mentioned wiring systems.

S.No	Particulars © www.electricaltechnology.org	Cleat Wiring	Casing Capping Wiring	Batten Wiring	Conduit Wiring
1	Life	Short	Fairly long	Long	Very long
2	Cost	Low	Medium	Medium	Highest
3	Mechanical Protection	None	Fair	None	Very good
4	Possibility of fire	Nil	Good	Good	Nil
5	Protection from dampness	None	Slight / a little	None	Good
6	Type of labor required	Semi-Skilled	Highly Skilled	Semi-skilled	Highly Skilled
7	Installation	Very Easy	Difficult	Easy	Difficult
8	Inspection	Easy	Easy	Easy	Difficult
9	Repair	Easy	Little bit difficult	Easy	Difficult
10	Popularity	Nil	Fair	Nil	Very High

Comparison of Different Wiring Systems

1.4 Distribution of Electrical Energy

There are two methods of distribution of electrical energy beyond energy meter in the domestic and power installation.

1. Distribution board system
2. The tree system

1. Distribution Board System: This method is a common system adopted by consumers of domestic installations. The fuses of various sub-circuits are grouped together at a place close to main switch known as distribution board. See figure below:

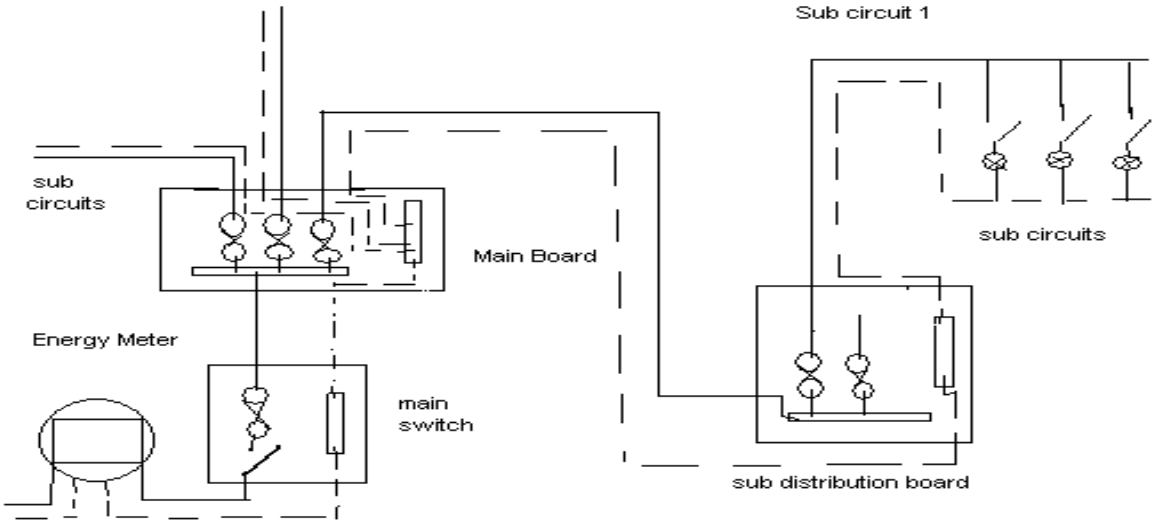


Fig 1.7 Electrical energy distribution (distribution board system)

One wire is taken from bus bar through a fuse and neutral is taken from a neutral link. The pair of wires (phase and neutral) taken from main distribution boards is fed to a final sub-circuit board.

The sub-distribution boards are employed near the load center if the building is large. The cable feeding the sub-distribution board should be large enough to carry a load of points to be fed from there. The sub-distribution board installed near the load center is mainly to save cable and to prevent too great voltage drop.

The number of circuits and sub-circuits are decided on the basis of number of points and load to be connected to the supply.

2. The Tree System: In this system, smaller branches are taken from the main branch. A fuse is inserted at the commencement of each branch. It has the following disadvantages:

i. Voltage across all the lamps doesn't remain the same. The lamp in the last branch will have less voltage across them due to voltage drop in the leads.

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

iii. The fuses are not at one place.

iv. Fault location is difficult. If a fault occurs, all the joints in the wiring will be inspected thoroughly to locate the fault. See figure below:

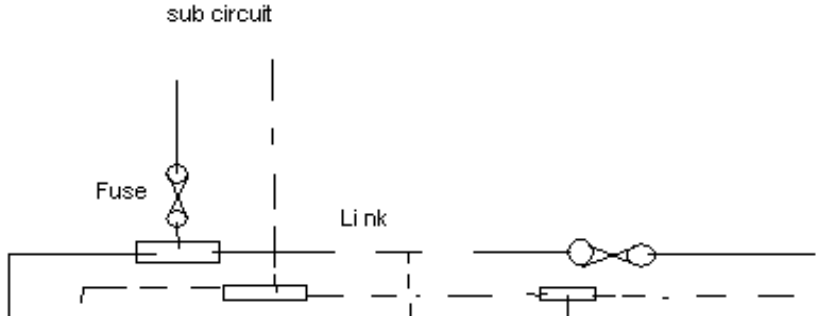


Fig. 1.8 Electrical energy distribution (Tree system)

1.5 Electrical connections

Electrical connections are all around your home. Electrical wiring connects to switches, outlets, appliances, disconnects, meters, and circuit breakers. There are a number of ways to make these connections, but what we are looking for is the safe and secure ways to make these connections that will last a lifetime!

Loose connections can cause electrical wiring and devices to heat up and are a potential electrical fire in the making. That's why safe and secure electrical connections are so important. In order to make these connections, you will need a little advice and a guide to making proper connections on devices, appliances, and the very important electrical panel connections.

Properly sized electrical wire and the properly sized circuit breakers connected to the wires are very important. A loose connection can lead to a fire-electrical safety is serious business. Please check these connections before turning on power to anything. Take a look now at the many different electrical connections around the home and how to do the projects yourself.

- **Appliance Connections**

Every appliance, whether it is a countertop appliance like a coffee pot or a major appliance like an electric range, has an electrical connection. Each has a specific outlet

and certain breaker size that they are needed to be connected to. These connections are easy enough if you can follow these simple instructions.

Figure 1-9 Appliance Connections

- **Electrical Connections You Should and Shouldn't Use**

There are good electrical connections and some that should never be made. Although manufacturers sometimes give you the choice of a couple of different connection points, like with switches and outlets, a closer look will reveal which connection should be your choice. Keep these connection tips in mind the next time you perform your next electrical wiring project.

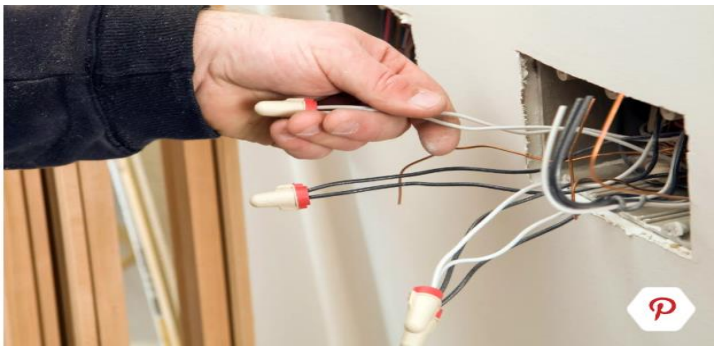


Figure 1-10 Electrical *Connections You Should and Shouldn't Use*

- **Proper Wire Color, Size, and Types of Wire to Use**

Before you can make electrical connections, you must first know what type wire to use for the installation, what color wire is needed for the application, and what is the proper

size wire to handle the load of the circuit. For electricians, wire colors mean everything. They identify whether the wire is a hot, neutral, or a ground wire.

Having the right sized wire to handle the ampacity flowing through it is just as important. The size of the wire also varies, depending on which type of wire you are installing. By following these steps, you'll be installing electrical circuits the right way and have a safer home because of it.

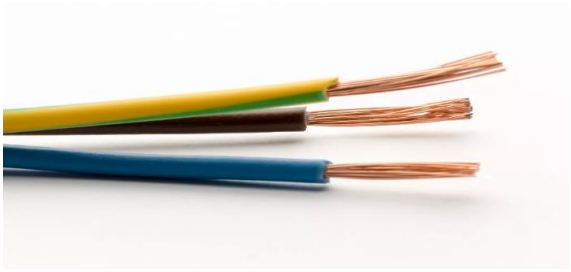


Figure 1-11 Proper Wire Color, Size, and Types of Wire to Use

- **Electrical Service Connections**

Making the proper connections to the electrical service components will help keep the electricity flowing trouble-free. Before trying to wire an electric meter, disconnect, electrical panel, or sub-panel, be sure you know where to place the wires on each. Here's a look at just a few that will help you keep your wiring projects safe and functional for years to come.

Figure 1-12 Electrical Service Connections

- **Electrical Device Connections**

Electrical devices must be wired right to make electrical connections safe and secure. Some appliances need only 120-volt outlets, but others need 240-volt outlets. Just connecting wires to the device terminals isn't enough. You need to know the proper way to strip, bend and tighten connections so they will provide you with a safe and functional connection for years to come.

Figure 1-13 Electrical Device Connection

Self-check Test 1	Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations

Instructions: - choose the correct answer from the given alternative.

1. One of the following is IEE regulations.
   A. PPE C. Electricity at Work Regulations
   B. The building regulation D. All
2. Safety for electrical installation to protects:
   A. Persons C. Live stock
   B. Property D. All
3. Which of the following are Methods of Electrical Wiring Systems?
   A. Joint box system C. Loop – in system
   B. Tee system D. All
4. _____is a process of connecting cables and wires to relates devices.
   A. Switch C. Electrical wiring

B. Earthing D. Fans

5. Which of the following are the types of internal wiring usually used?
   A. Cleat and conduit wiring C. Wooden casing and capping wiring
   B. Batten wiring D. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet- 2	**Checking connections**

2.1 Check the connections

Checking connection is testing and inspecting the installation diagram. With regard to inspection, one attempt to make visual checks on the equipment and wiring system. The area covered during inspection:

1. Connection of the conductor
2. Identification of conductor
3. Selection of conductor for current carrying capacity and voltage drop.
4. Correcting connection of socket outlet and lamp holders
5. Presence of fire barriers and protection against thermal effects
6. Method of protect against direct contact
7. Presence of appropriate device for isolation and switching
8. Choice and setting of protective and monitoring devices.
9. Labeling of circuits , fuses, switches and terminals

10. Selection of equipment and protective measures appropriate to external influence.
11. Presence of danger notices and other warning notices.
12. Presence of diagram, instruction and similar information's.

And final testing installation (**insulation or leakage test, continuity and circuit test, short circuit test, polarity test and earthling system test**)

2.1.1 Continuity Test

There are 3 main types of continuity tests for the final circuits:-

A. Protection Conductor Continuity Test.
B. Final Ring Circuit Conductor Continuity Test.
C. Live and Neutral Conductor Continuity Test.

A. Protection Conductor Continuity Test

- To ascertain that all protection conductors are connected in the correct and effective manner.
- Test equipment with Multi-meter (Ohm range) or Ohm-meter.

Test Method:

- Ensure that the main switch, RCD and MCB are open circuited (switched off) and all loads are disconnected;
- connected the test leads as in the Figure 2.1;
- The meter reading shall be less than 1 ohm.

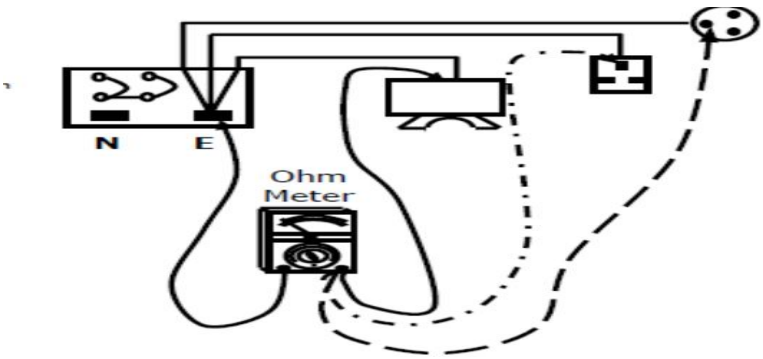


Figure 2.1 – Protection Conductor Continuity Test

B. Final Ring Circuit Conductor Continuity Test

- To ensure that all conductors around the ring circuit have continuity;

- Test Equipment with Multi-meter (Ohm range) or Ohm-Meter.

Test Method:

- Disconnect both the supply source live conductors from the MCB(main circuit breaker), the neutral conductor from the neutral terminals and the earth conductor from the earth terminal in the distribution fuse box;
- Connect the test leads as in the Figure 2.2 (EE); E-earthing
- Repeat the procedure for (L-L) and (N-N); N- neutral, L- line
- The meter reading value shall be less than 1 ohm.

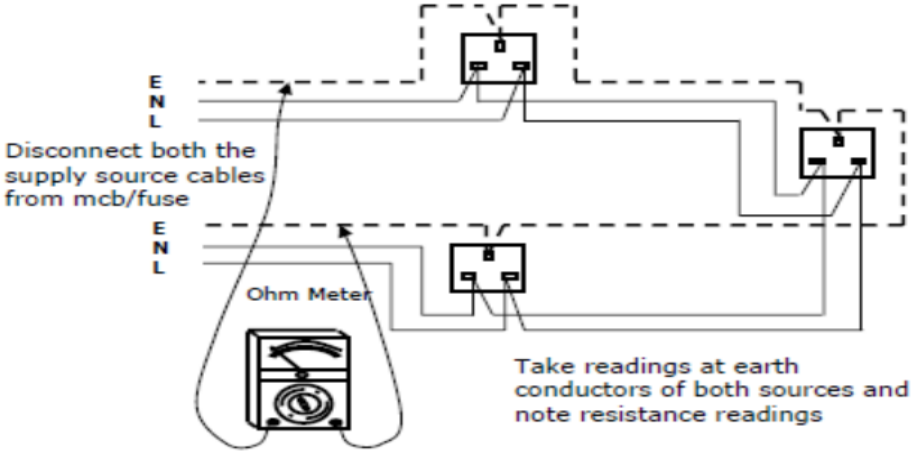


Figure 2.2 - Final Ring Circuit Conductor Continuity Test

C. Live and Neutral Conductor Continuity Test

- To ensure that each conductor in the circuit has continuity;
- Test Equipment with Multi-meter (Ohm range) or Ohm-Meter.

Test Method:

- Switch off the Main switch, RCD and MCB;
- Disconnect all loads;
- Switch on all switches in the circuit;
- Disconnect the fuses/final circuit breakers and close the circuit;
- Carry out the test as shown in Figure 2.3;
- The meter reading value shall be less than 1 ohm.

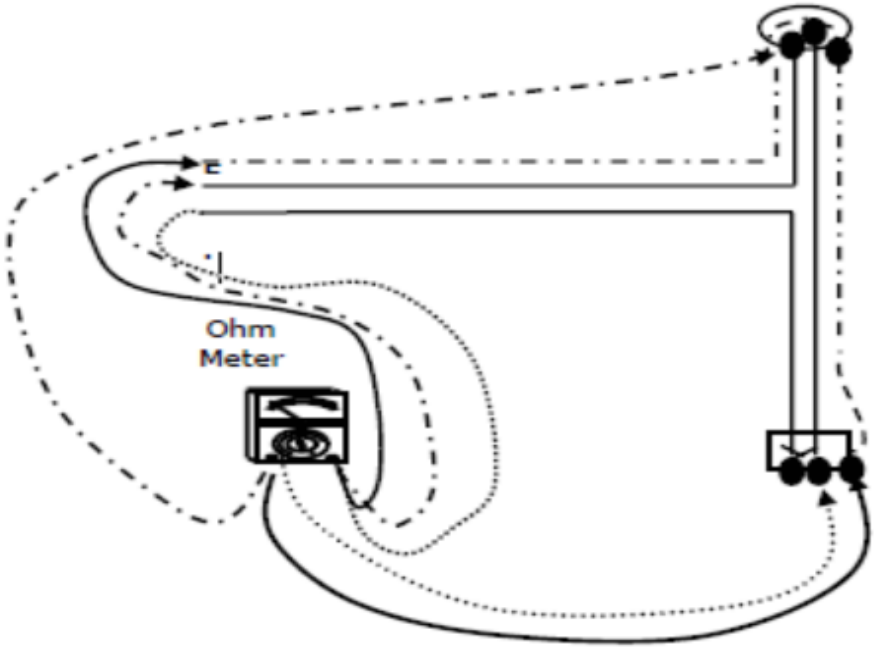


Figure 2.3 - Live and Neutral Conductor Continuity Test

2.1.2 Polarity Test

A. Ensure that each fuse or single pole control and protection device is connected only in the phase conductor.
B. Intermediate contact of Edison screw lamp holder is connected to the phase conductor.
C. Ensure that phase, neutral and earth conductors at socket outlets are connected at the correct terminals.
D. Test Equipment with Multi-meter (Ohm range) or Ohm meter.

Test Method:

- Switch off Main switch;
- Disconnect all loads
- Switch on all circuit control switches;
- Carry out test as in Figure 2.4;
- Test switches and single phase control devices at the phase conductors.
- Test socket outlet connection sources.
- Test Edison screw lamp holder connections.
- Meter reading value shall be less than 1 ohm.

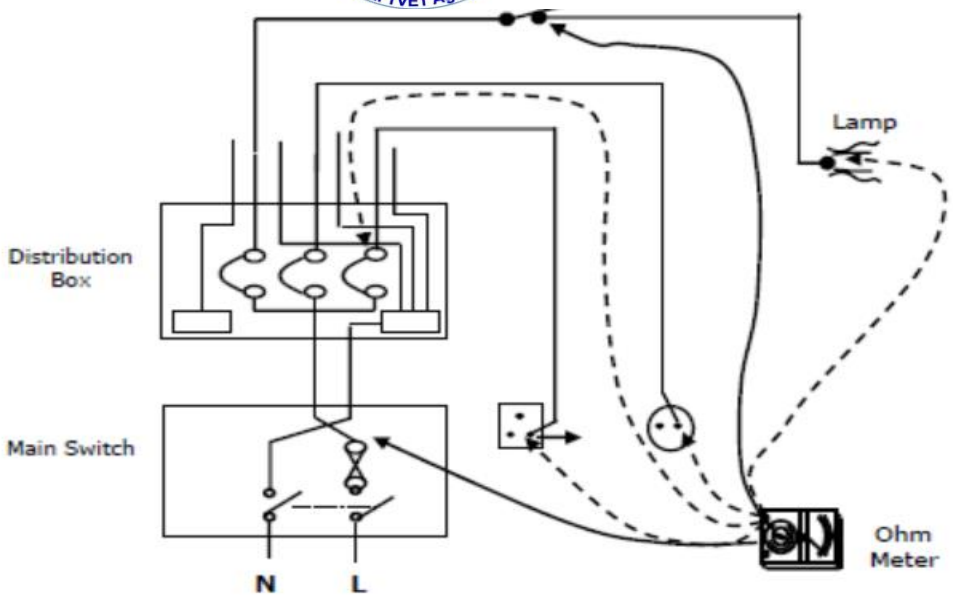


Figure 2.4 – Polarity Test

2.2 Common Wire Connection Problems and Their Solutions

A great many electrical problems around the house are traced to different versions of the same essential problem: wire connections that are made improperly or that have loosened over time. You may have inherited the problem from a previous owner or from an electrician who did an inadequate job, or perhaps it's the result of work you did yourself. Many wire connection problems are no one's fault but are simply the result of time. Wires are under a constant cycle of heating and cooling, expansion and contraction, every time a switch is used or appliances are plugged in, and the natural result of all this usage is that wire connections can loosen over time.

Your electrical system has a lot of safeguards against danger from bad wire connections, such as its grounding system, its circuit breakers, and GFCI and AFCI protection. Still, there is danger from sparking and arcing whenever there is a loose wire connection in your system. Many of these problems are quite easy for a homeowner to spot and repair, while others are best handled by a professional electrician. Understanding where these problems commonly occur will help you decide how to handle them.

There are six very common places that wire connection problems occur.

- Flashlight
- Wire strippers
- Screwdrivers
- Utility knife
- Wire connectors (wire nuts)
- Eye protection
- Electrical wire in various gauges

2.2.1 Loose Wire Connections at Switches and Outlets

By far the most common problem is when screw terminal connections at wall switches and outlets become loose. Because these fixtures get the most use within an electrical system, these are the places to look first if you suspect wire connection problems.

Loose wire connections at a switch, outlet, or light fixture are often signaled by a buzzing or crackling sound or by a light fixture that flickers.

To address this problem, it involves first turning off the power to the suspected wall switch, light fixture, or outlet. With the power shut off, you can remove the cover plate and use a flashlight to carefully examine the screw terminals inside where the wires are connected. If you find any that are loose, carefully tighten the screw terminals down onto the wires; in all likelihood, this will fix the problem.

Sometimes, you may find that the wire connections are made via push-in fittings on the back of the switch or outlet. This method of connection is notorious for being prone to failure—so much so that most professional electricians don't use the push-in fittings at all, but instead make all wire connections with the screw terminal connections on the sides of the switch or outlet. If you find that your device is made with the push-in fittings, you might want to remove them and reconnect the wires to the screw terminals on the device.

Finally, if there are pass-through wire connections inside the box that are made with wire nuts or another type of connector, check these to make sure the wires are tightly joined together. A loose connector is also a common source of problems.

2.2.2 Wire Connections Made With Electrical Tape

A classic wire connection error is when wires are joined together with electrical tape rather than a wire nut or other sanctioned connector.

To fix the problem, first, turn off the power to the circuit. Then, remove the electrical tape from the wires and clean them. Make sure there is the proper amount of exposed wire showing (for most connectors, this means about 3/4 inch), then join the wires together with a wire nut or other approved connector (there are now push-in connectors that some pros like to use).

If the wire ends are damaged, you can cut off the ends of the wires and strip off about 3/4 inch of insulation in order to make a proper wire nut connection.

2.2.3 Two or More Wires Under One Screw Terminal

Another common wire connection problem is when you find two or more wires held under a single screw terminal on a switch or outlet. This is a clear sign of amateur work and a distinct fire hazard. It is allowable to have a single wire under each of the two screw terminals on the side of an outlet or switch, but it is a code violation to have two wires wedged under a single screw. This is most often seen when two bare copper grounding wires are found under the grounding screw on the outlet or switch, but you also may occasionally find hot wires or neutral wires connected to a single screw terminal.

To fix this problem, once again, this repair involves first shutting off the power. Then, the two offending wires are removed from their screw terminal. Cut a six-inch pigtail wire of the same color as the two wires (use a green pigtail if you are joining two bare copper grounding wires). Strip 3/4 inch of insulation from each end of the pigtail, and then join one end to the two wires you just disconnected, using a wire connector (wire nut). Now, attach the free end of the pigtail wire to the screw terminal that once held the two wires.

You have essentially created a bridge, or pathway, that connects both wires to the desired screw terminal on the outlet or switch.

Note: Make sure the pigtail wire is the same wire gauge as the circuit wires. A 15-amp circuit normally used 14-gauge wire; a 20-amp circuit uses 12-gauge wire.

2.2.4 Exposed Wires

It is quite common, especially with amateur electrical work, to see a screw terminal connection or wire nut connection where there is too much (or too little) exposed copper wire showing at the wires. With screw terminal connections, there should be enough bare copper wire stripped to wrap entirely around the screw terminal, but not so much that excess bare copper wire extends out from the screw. The excess exposed wire can short out if it touches a metal box or other wires. Wires should be wrapped clockwise around the screw terminals; if they are reversed, they can be prone to loosening.

With wire nut connections, all of the bare copper wire should be hidden under the plastic cap, with no exposed wire showing at the bottom of the wire nut.

To fix the problem, turn off the power to the device, then disconnect the wires and either clip off the excess wire or strip off additional insulation so the proper amount of wire is exposed. Then, reconnect the wires to their screw terminal or wire nut. Tug lightly on the wires to make sure they are securely connected.

2.2.5 Loose Connections on Circuit Breaker Terminals

A less common problem is when the hot wires on circuit breakers in the main service panel are not tightly connected to the breaker. When this happens, you may notice lights flickering or service problems on fixtures all along the circuit. When making connections to circuit breakers, be sure to strip the proper amount of wire insulation from the wire and make sure that only the bare wire is placed under the terminal slot before tightening. Insulation under the connection slot is a code violation.

To fix the problem, repairs at the main service panel should be handled by a professional electrician. Amateurs should attempt these repairs only if they are quite experienced and knowledgeable about electrical systems.

The electrician will address this problem by turning off the breaker, then unclipping it from the hot bus bar in the main service panel. He or she will check the hot wire connected to the breaker to make sure that the screw is tight and that there is no insulation under the terminal and no excess bare copper wire exposed. With repair complete, the electrician will snap the breaker back into place on the hot bus bar and turn the breaker back on.

2.2.6 Faulty Neutral Wire Connections at Circuit Breaker Panels

Another less common problem—and another that is usually handled by a pro—is when the white circuit wire is not correctly mounted to the neutral bus bar in the main service panel. Symptoms here will be similar to those with a faulty hot wire.

To fix this problem, the electrician will check to make sure the neutral wire is sufficiently stripped and correctly attached to the neutral bus bar.

Self-check Test 2	**Checking connections**

Instructions: - choose the correct answer from the given alternative.

1. _____is testing and inspecting the installation diagram.
   A. Checking connection C. Checking defects
   B. Checking conduit D. None
2. The area covered during inspection is _____.
   A. Connection of the conductor
   B. Correcting connection of socket outlet and lamp holders
   C. Identification of conductor
   D. All
3. Which of the following is the types of continuity tests for the final circuits:-
   A. Protection Conductor Continuity Test.
   B. Final Ring Circuit Conductor Continuity Test.
   C. Live and Neutral Conductor Continuity Test.
   D. All
4. Which of the following the Common Wire Connection Problems?

A. Over current

B. Loose Wire Connections

C. Voltage drop

D. All

Note: **Satisfactory rating - 2 points** **Unsatisfactory - 2 points**

Information Sheet-3	Correcting identified defects after connection has taken place

3.1 Correcting identified defects after connection has taken place

Electrical defects pose a safety hazard and damage expensive equipment. Defects in the planning, design, and installation of an electrical system can be more than an inconvenience. Electrical defects can create shock and fire hazards, leading to serious injuries or loss of property.

3.2.1 Electrical Service Conductors (SEC), or Entrance Wires & Cables Defects

The following are some of the defects:

- Conduit or cable damaged
- Conduit or cable covered by siding or roof penetrations for additions. JDG
- Conduit or cable not weather tight
- Drip loop too low (touching roof)
- Frayed, damaged SEC
- Mast rust, bent, rot, loose, not weather tight
- Masthead not weather tight

3.2.1.1 Electrical Grounding System Defects

The following are some of the defects:

- Aluminum ground wire, bare, corroded, loose, damaged
- Box not bonded to ground
- Connections not accessible
- Corroded grounding conductor
- Grounding electrode rod cut or disconnected.
- Missing
- Neutral bonded to grounding conductor wire downstream of service box
- Neutral not bonded to ground at box
- Spliced grounding conductor wire
- Undersized grounding conductor wire

3.2.1.2 Electrical Wire Defects & Damage

The following are some of the defects & Damage:

- Abandoned wire
- Aluminum branch circuit solid conductor wiring, evidence of improper or incomplete repair
- Buried cable
- Damaged
- Exposed on walls or ceilings
- Exposed in attics
- Improper color coding
- In steel studs without protection
- Indoor cable used outdoors
- Loose connections
- Open splices
- Permanent wiring used as extension cord
- Undersized wire

3.2.2 Electrical distribution system, Wiring, Lights & Fixtures, Typical defects

3.2.2.1 Electrical Lights, Lighting Defects

The following are **Electrical Lights, Lighting** Defects:

- Damaged
- Heat lamps over doors
- Improper closet lighting
- Loose
- Not grounded
- Obsolete
- Poor stairway lighting, improper location, dim, not switched properly

3.2.2.2 Electrical Switch Defects

The following are **Electrical Switch** Defects

- Damaged, loose, rust

- Faulty 3-way switch
- Inoperative, obsolete
- No shut off
- Overheated
- Poor location at furnace and garbage

3.2.2.3 Electrical Junction Box Defects

The following are **Electrical Junction Box** Defects

- Concealed boxes

- Cover loose or missing
- Damaged, rust
- Missing, loose
- Not grounded
- Overcrowded
- Overheating

3.2.3 Inspectors Finding of Common Electrical Defects at home

Electrical defects can result in shock, injury and fires. The good news is that most electrical defects can be corrected without spending a fortune.

Some of the defects can be corrected by the home owner, the buyer or a handyman; others should have an electrician correct.

A. Double Tapping of Circuit Breakers

Double tapping is basically two or more “hot” wires running to one circuit breaker. By “hot’ we are referring to energized wires, ones that can shock you.

The older the home is or the more remodeling that has been done, the more likelihood of this condition existing. This is an issue that an electrician should investigate. **Read more**

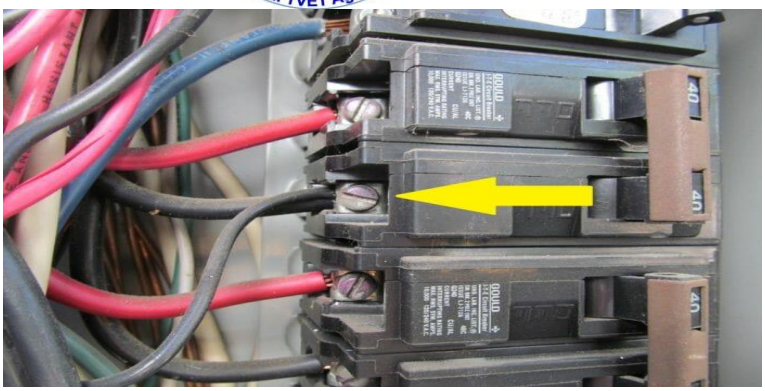


Figure 3-7 Double Tapping of Circuit Breakers

B. Reversed Polarity

Outlets with reverse polarity cannot be identified by just looking at them. Generally a small electrical tester is used to determine if an outlet has reverse polarity. Most small appliances work, even if an outlet has reverse polarity. However, there can be a safety issue with some lamps or a few appliances. Note that electricians refer to outlets as receptacles. **Read more**

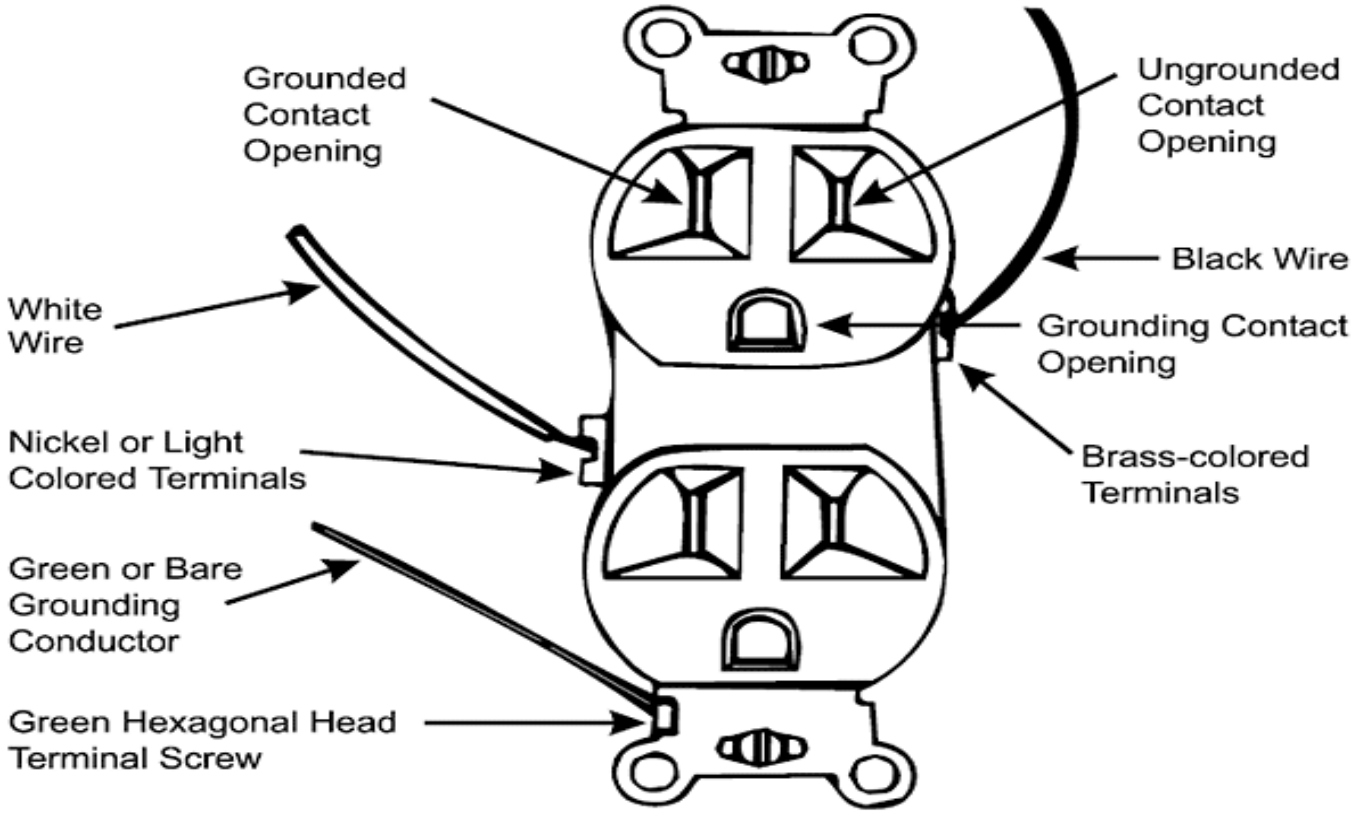


Figure 3-2 Reversed Polarity

C. Ungrounded 3 Prong Plugs (outlets)

Ungrounded outlets are a safety concern and under some circumstances a person can be shocked when using an ungrounded outlet.

Older homes often have ungrounded outlets because only a hot and neutral wire were run to the outlets. The code stared requiring outlets to be grounded around 1965. Some homes built before then have grounded outlets, but many do not. Also, if the outlet was installed by a home owner, then it may not be grounded, even if it was a code requirement at the time. **Read more**

D. Outlets with Paint on Them

Inspectors generally recommend that any outlet with paint on it be replaced. One reason for this is that if paint (or even drywall mud) has gotten into the slots, then this may cause overheating and a fire.

Also, if the outlet is a tamper resistant type and the paint affects the operation of the tamper-resistant mechanism, then it becomes a safety concern. Replacing painted outlets is wise and inexpensive. **Read more**

Figure 3-3 Outlets with Paint on Them

E. Exposed Wiring and Splices

Exposed wiring or splices are called out by home inspectors for a number of reasons. One is that exposed wiring is a safety concern in some locations and may be subject to mechanical damage.

Expose splices are likewise a safety concern. Splices that have tape or wire nuts may be installed improperly. If the wire ends become bare and exposed, aching may occur which can cause fires. Having all splices done in an electrical junction box with a cover is much safer. **Read more**

Figure 3-4 Exposed Wiring and Splices

F. No GFCI protection

GFCI outlets are great safety devices and save many lives from electrical shock. The outlets will trip immediately if a slight imbalance of current is noted. GFCI"s can react as quickly as one-thirtieth of a second, much faster than a standard circuit breaker.

Many homes do not have any or do not have them in the proper locations. GFCI outlets should be in bathrooms, kitchens, exterior areas and garages to name just a few. **Read more**

Figure 3-5 No GFCI protection

G. Extension Cords Used For Permanent Power Source

One of the more overlooked issues is the use of extension cords around the home. The fire department can tell you that many house fires and injuries result from extension cords. You would be surprised at the number.

Any device (light, appliance, etc.) that is not temporary should not have an extension cord running to it. This includes the use of an extension cord running to a garage door opener. Another concern is that extension cords often get overloaded, like at Christmas time.

Figure 3-6 Extension Cords Used For Permanent Power Source

H. Panel missing knockouts – there are 2 types

Electrical panels have basically two types of knockouts. One is rectangular in shape and the other is round. When you open the door of an electrical panel there may be a slender rectangular piece missing. One where you could stick your finger in; about a ½ inch wide and 2 ½ inches long.

The other type of knock out is a round one. At times these get removed and the electrician forgets to put a round plug in the empty hole. These holes vary from a nickel to a silver dollar in size. **Read more**

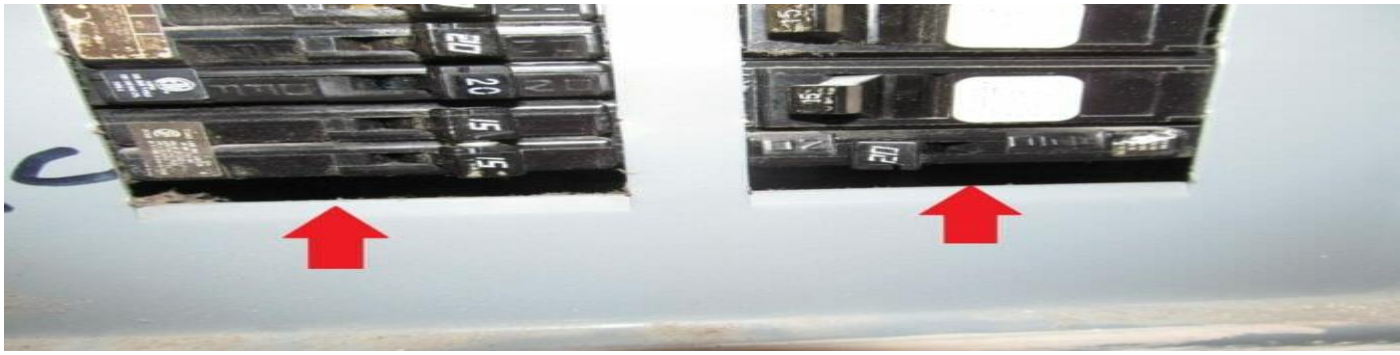


Figure 3-6 Panel missing knockouts

I. Two Neutrals in One Slot

Inspectors often find two or more neutral wires placed into one slot or hole in the neutral bar of an electrical panel. Generally this does not create a problem, however, if the set screw does not firmly hold the wires tight then over time “connection creep” may occur. Once in a blue moon, one wire may slip out resulting in an open neutral.

It is best to have just one neutral wire per slot, for the chance of coming loose is greatly reduced. **Read more**

Figure 3-6 Two Neutrals in One Slot

J. Wiring against Sharp Metal Edges

Wires that are exposed to sharp metal edges in panels and junction boxes may have damage to the insulation cover of the wire.

There should be a proper bushing or wire clamp holding or protecting the wires from the sharp metal edges.

Should proper protection be missing, then a low arch fault may occur where the current jumps from one conductor to another. In example, from the electrical wire to the metal edge of the J-box or electrical panel. Heat results when arching occurs and may result in a house fire. **Read more**

Figure 3-6 Wiring against Sharp Metal Edges

3.3 How to Wire Split Outlets

1. Turn off the Circuit Breaker

Before you attempt this installation, turn the power off by turning off the circuit breaker to the circuit that you'll be working on. Check to be sure that the circuit has been turned off by using a tester.

2. Remove the Switch

If you have an existing switch located in the room, remove the cover plate and then remove the switch. If you don't have a switch in your room, you'll have to add an electrical box to the wall to add a switch.

3. Run a New Wire

Locate the hot wire feeding the switch and disconnect it from the switch. Run an electrical wire down the wall to the new box. Install a 12-3 NM wire that has a ground wire. Leave about six to eight inches of wire hanging out of the boxes.

4. Strip the Wire Sheath

When wiring split outlets, you'll need to strip the wire sheath to access the wires. Using an NM (Romex) stripper or a razor knife, strip back about six inches of insulation from the wire. Cut off the excess insulation and separate the wires.

5. Strip the Wires

To attach the wires to the switch, first you must strip the insulation from the wires. Knowing exactly how much insulation to strip off of a conductor is crucial to properly fitting the wire on devices and making a good connection.

Using wire strippers, strip off about 3/4" of insulation off of the black, red and white wires. This will allow enough wire to make the proper connection without having excess hanging out and shorting out against the box.

6. Remove the Outlet's Hot Tab

There is a tab on the hot wire connection side of the outlet called the hot tab. Locate the side of the outlet where the brass screws are located. Between the two screws and the face of the outlet, you'll notice a small brass piece of metal (called a tab) connecting the hot feeds. Simply break it off by inserting a screwdriver under it and bend it back and forth. You can also use long-nosed pliers to break it loose. Once removed, the common bond is broken.

7. Wire the Outlet

Connecting the appropriate colored wire to the right screw terminal on an outlet is a must. Learn where each wire is connected.

8. Replace the Outlet

Now, you'll need to replace the outlet in the box. When you've finished wiring the outlet, use the two screws provided on the switch and tighten them to the box via the two screw holes provided.

9. Wire the Switch

The next step is to wire the switch. Starting with the feeder wire, locate the black wire and pigtail it to the black wire going to the outlet and also the bottom brass-colored screw on the switch.

Connect the red wire to the top brass-colored screw on the switch. This connection is what will turn on and off one part of the outlet.

Twist the white wires together and twist a wire nut over them.

Twist the ground wires together and pigtail them to the box and the green screw on the switch.

10. Replace the Switch and Cover Plate

When you've finished wiring the switch, you'll need to replace the switch. To do this, screw the two screws mounted on the switch into the two holes mounted on the box. Tighten these screws snugly, but don't over tighten. Now install the cover plate by installing the two screws into the switch screw holes. Be careful not to over tighten these. If you do, the cover may crack.

Self-check Test 3	**Correcting identified defects after connection has taken place**

Instructions: - choose the correct answer from the given alternative.

1. Electrical defects can result in _____?

D. Shock C. Fires

E. Injury D. All

2. _____ is basically two or more “hot” wires running to one circuit breaker.

A. Double tapping

B. Wire the Switch

C. Wire the Outlet

D. All

3. Electrical switch defects are _____?

A. Damaged, loose, rust C. Over heated

B. No shut off D. All

Note: **Satisfactory rating - 3 and 5 points Unsatisfactory - below 3 and 5 points**

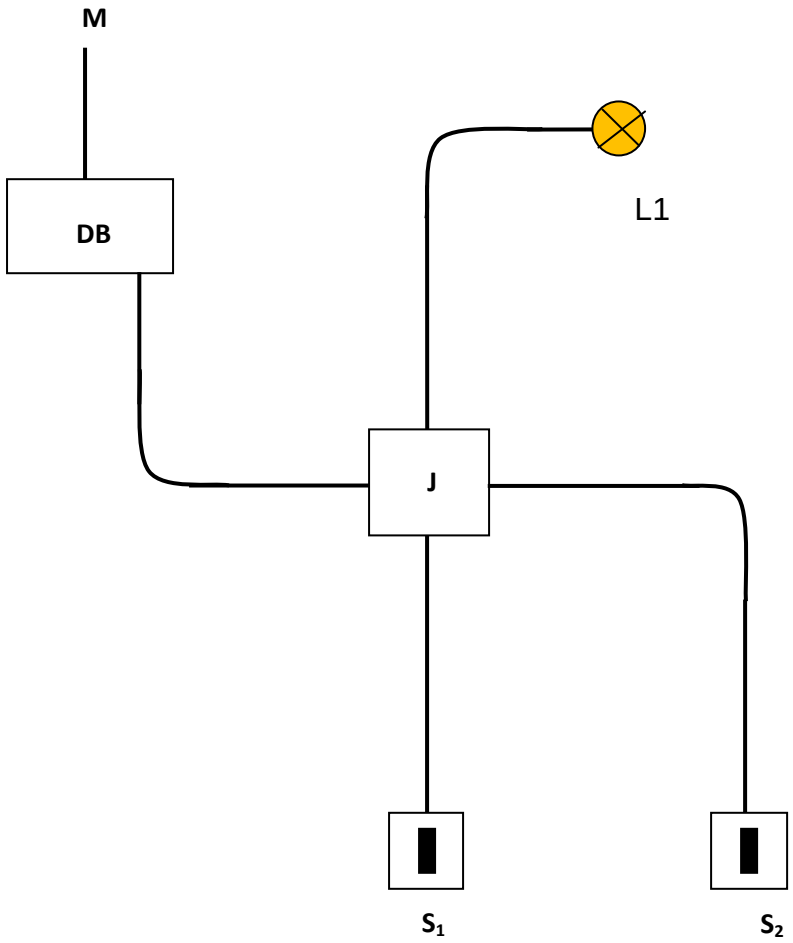
Operation Sheet 1	Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations

Title: - Making connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Joint box system or Tee system.**

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 14:- To connect the supply with installation circuit

Step 15:- Check the whole installation circuit after connect the power supply.

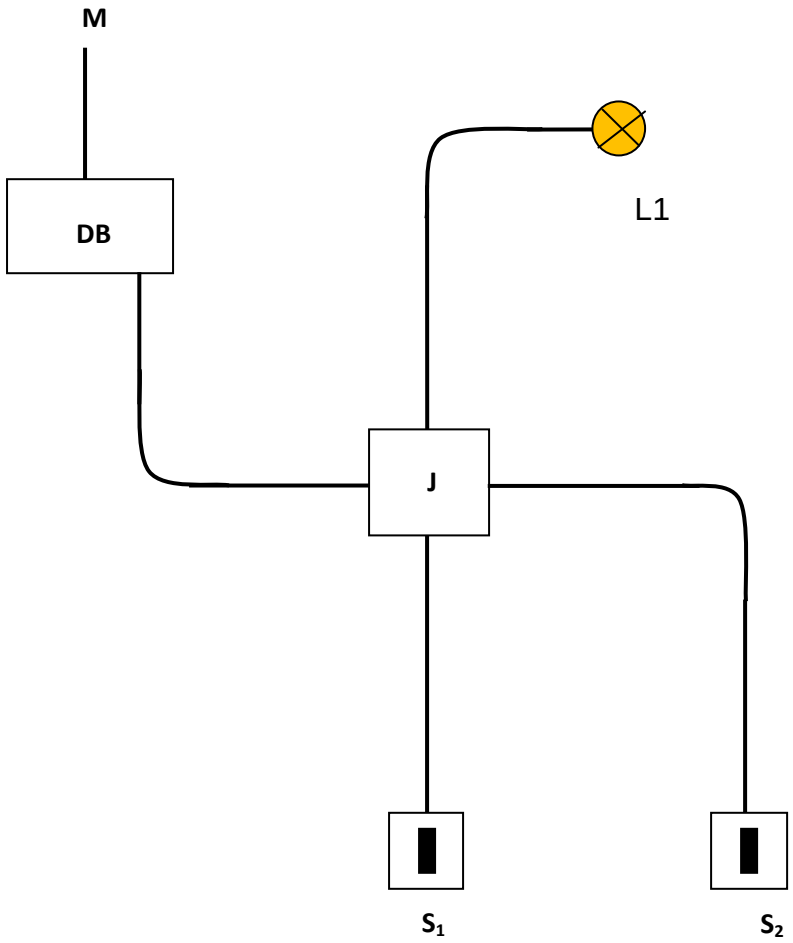
Operation Sheet 2	Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations

Title: - Making connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Loop – in system.**

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 14:- To connect the supply with installation circuit

Step 15:- Check the whole installation circuit after connect the power supply.

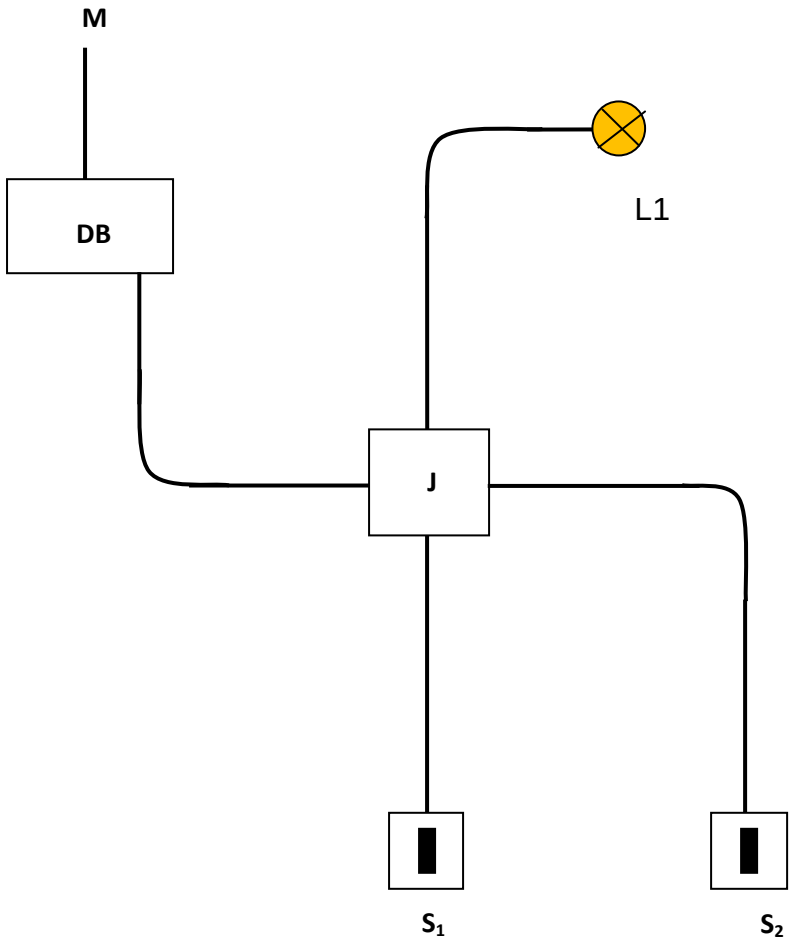
Operation Sheet 3	Making connections with specifications and IEE wiring regulations / Standard for Electrical Installations

Title: - Making connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Conduit wiring system.**

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 14:- To connect the supply with installation circuit

Step 15:- Check the whole installation circuit after connect the power supply.

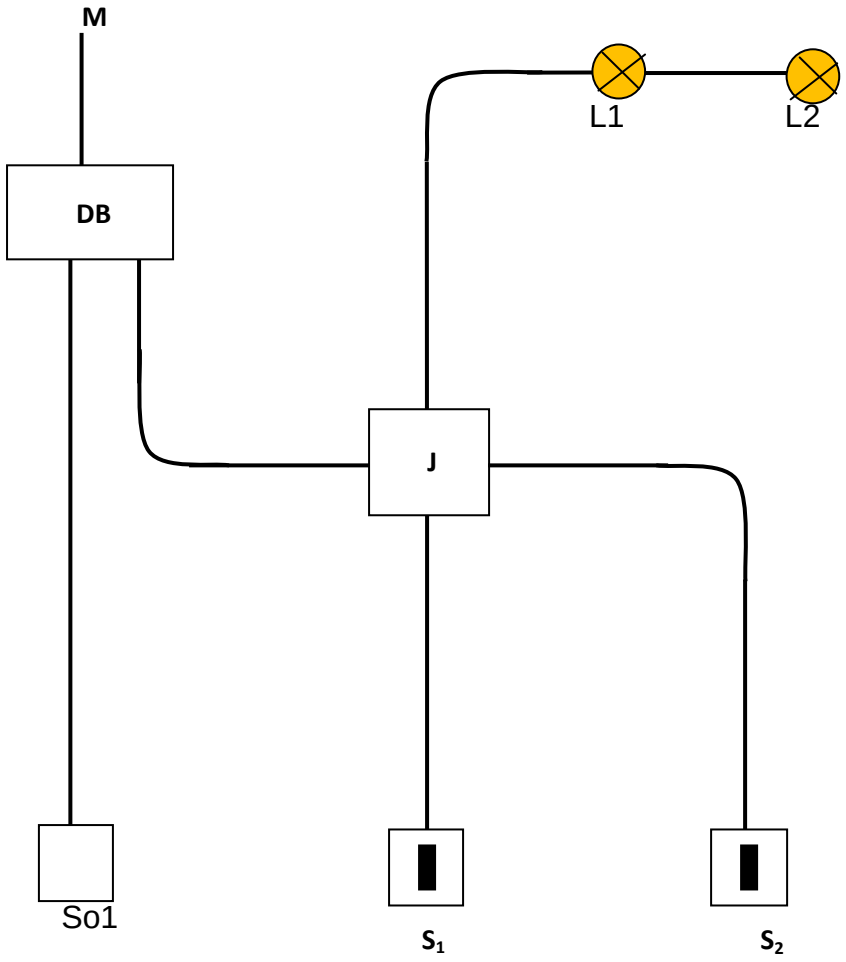
Operation Sheet 4	Checking the connection

Title: checking the connections for two lamps controlled by two positions on 220V/50Hz.supply,

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 14:- To connect the supply with installation circuit

Step 15:- Finally, Check the whole installation circuit whether it is working or not

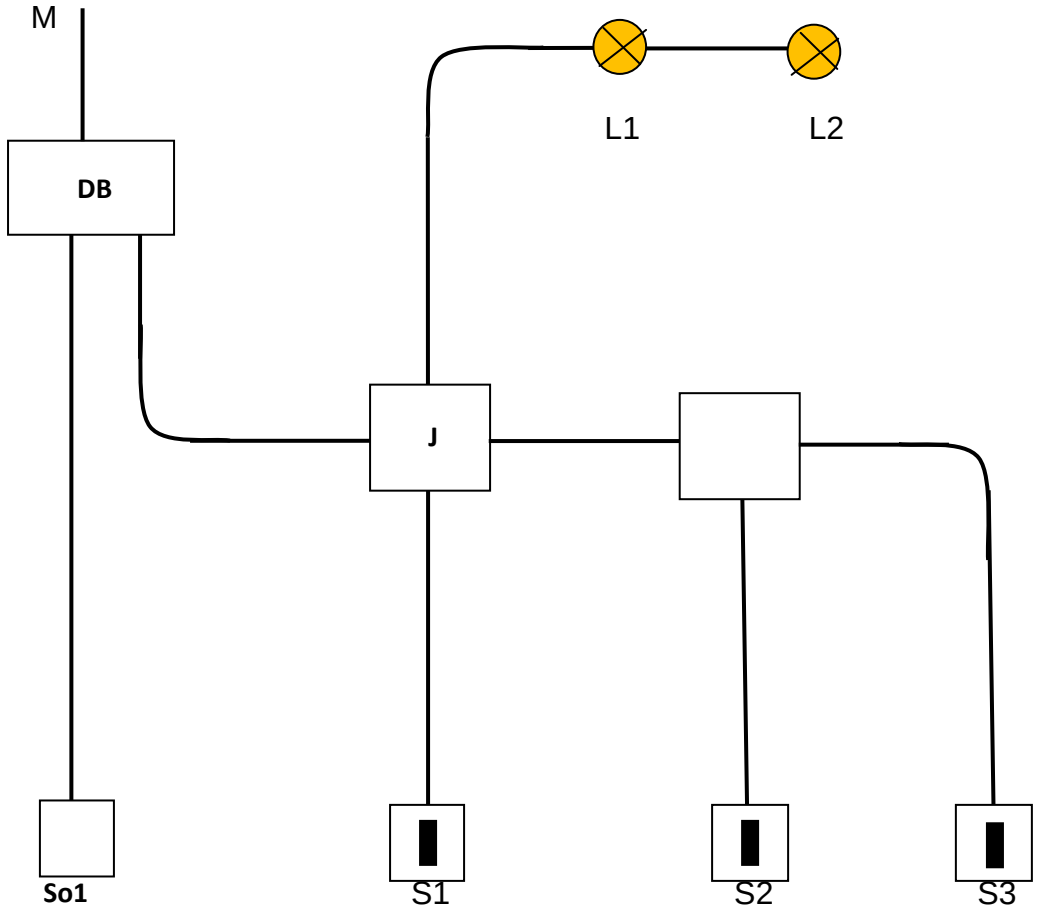
Operation Sheet 5	Identify hazards after connection

Title: Identify hazards after connection two lamps controlled by three positions and connect one mittad socket out let on 220V/50Hz.(single phase) supply,

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 14:- To connect the 220V/50Hz.supply, with installation circuit

Step 15:- Check the whole installation circuit after connect the power supply.

Step 16:- Identify hazards of the whole installation circuit after connect the power supply.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hour.

Task 1: Make connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Joint box system or Tee system.**

Task 2: Make connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Loop – in system.**

Task 3: Make connections for one lamp controlled from two positions on 220V/50Hz.supply using by **Conduit wiring system**.

Task 4: check the connections for two lamps controlled by two positions on 220V/50Hz.supply,

Task 5: Identify hazards after connection two lamps controlled by three positions and connect one mittad socket out let on 220V/50Hz.supply,

BUILDING ELECTRICAL INSTALLATION

NTQF- LEVEL II

Learning Guide-37

Unit of Competence: Connect Wiring Systems and Equipment

Module Title: Connecting Wiring Systems and Equipment

LG Code: EIS BEI2 M10 LO3-LG-37

TTLM Code: EIS BEI2 M10 TTLM 0919v1

LO 3: Inspect and notify completion of work

Instruction Sheet	Learning Guide-37

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

- Performing final checks
- Reporting completion of work for supervisor
- Cleaning, checking and storing tools, equipment and surplus resources and materials

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

- Perform final checks
- Report completion of work for supervisor
- Clean, check and store tools, equipment and surplus resources and materials

Learning Instructions:

13. Read the specific objectives of this Learning Guide.
14. Follow the instructions described below 3 to 6.
15. Read the information written in the information “Sheet 1, Sheet 2, and Sheet 3”.
16. Accomplish the “Self-check 1, Self-check t 2, and Self-check 3” **in page -84, 86, and 88**.
17. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1” **in page -89.**
18. Do the “LAP test” **in page – 91**.

Information Sheet-1	Performing final checks

Testing an electrical installation

The visual inspection is carried out first, to confirm that permanently-wired electrical equipment is compliant with the safety requirements and not visibly damaged, and that fire barrier, protective, monitoring, isolating and switching devices and the relevant documentation are present. Electrical testing may commence after this inspection.

Fig. 1:1 it is essential to use the right tools for testing to IEC standards.

Other methods are not precluded, provided that they give equally valid results. Only with the appropriate experience and training, safe clothing and the right test tools is a person considered competent to test installations to IEC 60364.6.61. When testing is undertaken it should be ensured that adequate precautions are taken to avoid damage or injury to people, equipment or property, and ensured that unauthorized persons are kept away from danger.

1.1.1 Safe working procedures when testing

Whether you are carrying out the test procedure

A. As a part of a new Installation

B. Upon the completion of an extension to an existing installation
C. Because you are trying to discover the cause of a fault on an installation or
D. Because you are carrying out a periodic test and inspection of a building, you must always be aware of your safety, the safety of others using the building and the possible damage which your testing might cause to other systems in the building.

For your own safety:

● always use ‘approved’ test instruments and probes.

● Ensure that the test instrument carries a valid calibration certificate otherwise the results may be invalid.

● Secure all isolation devices in the ‘off’ position.

● put up warning notices so that other workers will know what is happening.

● Notify everyone in the building that testing is about to start and for approximately how long it will continue.

● Obtain a ‘permit-to-work’ if this is relevant.

● Obtain approval to have systems shut down which might be damaged by your testing activities. For example, computer systems may ‘crash’ when supplies are switched off. Ventilation and fume extraction systems will stop working when you disconnect the supplies

For the safety of other people:

● Fix warning notices around your work area.

● Use cones and highly visible warning tape to screen off your work area.

● Make an effort to let everyone in the building know that testing is about to begin. You might be able to do this while you carry out the initial inspection of the installation.

● Obtain verbal or written authorization to shut down information technology, emergency operation or stand-by circuits.

1.2 Digital multi-meter or DMM

A digital multi-meter or DMM is a useful instrument for measuring voltage, current and resistance, and some meters have a facility for testing transistors and capacitors. You can also use it for checking continuity of wires and fuses.

1.2.1 Volts, Amps, Ohms - What does it All Mean?

- **Volts (voltage)**

This is the pressure in an electrical circuit

- **Amps (current)**

This is a measure of the current flowing in an electrical circuit

- **Ohms (Resistance)**

A measure of the resistance to flow in a circuit

- **Voltage Source**

This produces a current flow in a circuit. It could be a battery, portable generator, mains supply to a home, alternator on your car engine or bench power supply in a lab or workshop

- **Load**

A device or component which draws power from a voltage source, this could be an electronic resistor, bulb, electric heater, motor or any electrical appliance

- **Ground**

This is usually the point in a circuit to which the negative terminal of a battery or power supply is connected

- **DC (**Direct current**)**

Current flows only one way from a DC source, an example of which is a battery

- **AC (**Alternating Current**)**

Current flows one way from a source, reverses, and then flows the other way. This happens many times a second at a rate determined by the *frequency* which is typically 50 or 60 hertz. The mains supply in a home is AC

- **Polarity**

A term used to describe the direction of flow of current in a circuit or which points are positive and which are negative writ a reference point

1.2.2 What Does a Multi-meter Measure?

A basic multi-meter facilitates the measurement of the following quantities:

- DC voltage
- DC current
- AC voltage
- AC current (not all basic meters have this function)
- Resistance
- Continuity - indicated by a buzzer or tone

1.2.3 How Do I Setup a Multi-meter to Measure Volts, Amps or Ohms?

Voltage, current and resistance ranges are usually set by turning a rotary selection dial. This is set to the quantity being measured, e.g. AC volts, DC volts, Amp(current) or Ohms (resistance).

1.2.3.1 Voltage, Current and Resistance Ranges

Figure1.5: Voltage, Current and Resistance Ranges

1.2.3.2 How to Measure Voltage

1. Power off the circuitry/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 (see photo below).
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. If the meter has a manual range setting dial, turn this to select AC or DC volts and pick a range to give the required accuracy. So for instance measuring 12 volts on the 20 volt range will give more decimal places than on the 200 volt range.
   If the meter is auto ranging, turn the dial to the 'V' setting with the symbol for AC or DC (see "What Do the Symbols on the Range Dial Mean?" below).
5. A multi-meter 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.
6. 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.

1.2.3.3 How to Measure Current

1. Turn off the power in the circuit being measured.
2. Connect the probe leads as shown in the photo below. Plug the black ground probe lead into the COM socket.
3. 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.
4. A multi-meter must be inserted in series in a circuit in order to measure current. See the diagram below.
5. 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 autoranging, set it to the "A" or mA setting. (See the photo above for an explanation of symbols used).
6. Turn on the power.
7. If the range is too high, you can switch to a lower range to get a more accurate reading.
8. 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).

1.2.3.4 How to Measure Resistance

1. If the component is on a circuit board or in an appliance, turn off the power
2. Disconnect one end of the component if it's in a circuit. This may involve pulling off spade leads or de soldering. This is important as there may be other resistors or other components having resistance, in parallel with the component being measured.
3. Connect the probes as shown in the photo below.

4. Turn the dial to the lowest Ohm or Ω range. This is likely to be the 200 ohm range or similar.
5. Place a probe tip at each end of the component being measured.
6. If the display indicates "I", this means that resistance is greater than can be displayed on the range setting you have selected, so you must turn the dial to the next highest range. Repeat this until a value is displayed on the LCD.

1.2.3.5 How to Check Continuity and Fuses

A multi-meter is useful for checking breaks in flexes of appliances, blown filaments in bulbs and blown fuses, and tracing paths/tracks on PCBs

1. Turn the selecting dial on the meter to the continuity range. This is often indicated by a symbol which looks like a series of arcs of a circle (*See the photo showing symbols used on meters above).*
2. Connect the probe leads to the meter as shown in the photo below.
3. If a conductor on a circuit board/ a wire in an appliance needs to be checked, make sure the device is powered down.
4. Place the tip of a probe at each end of the conductor or fuse which needs to be checked.
5. If resistance is less than about 30 ohms, the meter will indicate this by by a beep tone or buzzing sound. The resistance is usually indicated on the display also. If there is break in continuity in the device being tested, an overload indication, usually the digit "1", will be displayed on the meter.

1.3 Clamp Ammeter

It is sometimes called “clamp-on” is used to measure current without any direct electrical contact with the circuit.

Figure 1-2 ***Clamp Ammeter***

1.2.4 General testing checklist

Let us look then at the general content of the checklist:

Check #1 **– Connection of conductors**

Are terminations electrically and mechanically sound? Is insulation and sheathing removed only to a minimum to allow satisfactory termination?

Check #2 **– Identification of conductors**

Are conductors correctly identified in accordance with the regulations?

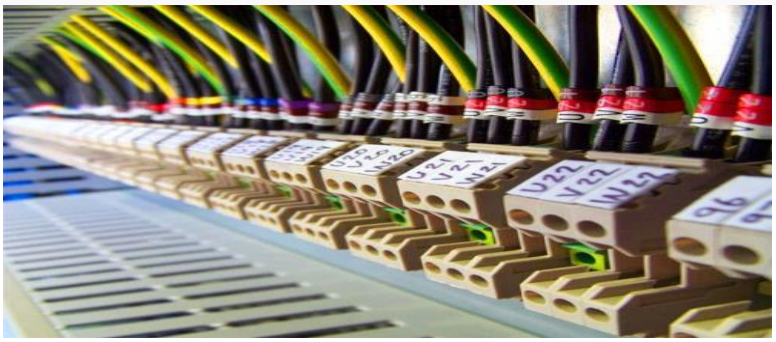


Figure1-3 Identification of conductors

Check #3 – **Routing of cables**

Are cables installed such that account is taken of external influences, such as mechanical damage, corrosion and heat?

Check #4 – **Conductor selection**

Are conductors selected for current carrying capacity and voltage drop in accordance with the design?

Check #5 – **Connection of single pole devices**

Are single pole protective and switching devices connected in the line conductor only?

Figure 1-4 Electrical panel (photo credit: electricianstruro.com)

Check #6 **– Accessories and equipment**

Are all accessories and items of equipment correctly connected?

Check #7 **– Thermal effects**

Are fire barriers present where required and protection against thermal effects provided?

Check #8 ***– Protection against shock***

What methods have been used to provide protection against electric shock?

Check #9 ***– Mutual detrimental influence***

Are wiring systems installed so that they can have no harmful effect on non-electrical systems or so that systems of different currents or voltages are segregated where necessary?

Check #10 ***– Isolation and switching***

Are the appropriate devices for isolation and switching correctly located and installed?

Check #11 – **Under voltage**

Where under voltage may give rise for concern, are there protective devices present?

Check #12 – **Protective devices**

Are protective and monitoring devices correctly chosen and set to ensure automatic disconnection and/or overcurrent?

Figure 1-5 Protective devices – Miniature circuit breakers (photo credit: electricalsafetycertificate.co.uk)

Check #13 – Labeling

Are all protective devices, switches (where necessary) and terminals correctly labeled?

Check #14 – **External influences**

Have all items of equipment and protective measures been selected in accordance with the appropriate external influences?

Check #15 – Access

Are all means of access to switchgear and equipment adequate?

Check #16 – Notices and signs

Are danger notices and warning signs present?

Figure 1-6 Circuit breaker lockout tag (photo credit: lockoutstore.com)

Check #17* – *Single line diagrams / Wiring schemes

Are diagrams, instructions and similar information relating to the installation available?

Check #18 – **Erection methods**

Have all wiring systems, accessories and equipment been selected and installed in accordance with the requirements of the Regulations? Are fixings for equipment adequate for the environment?

Self-check Test 1	**Performing final checks**

Instructions: - choose the correct answer from the given alternative.

1. Which of the following is a basic multi-meter facilitates of measurement? (2 point)
   C. AC voltage C. Resistance
   D. AC current D. All
2. _____ is sometimes called “clamp-on” is used to measure current without any direct electrical contact with the circuit. (2 point)

A. Clip-on ammeter

B. Meager tester

C. Test light

E. None

3. _____is a useful instrument for measuring voltage, current and resistance, and some meters have a facility for testing transistors and capacitors. You can also use it for checking continuity of wires and fuses. (2 point)

A. Voltage source
B. digital multi-meter
C. meager tester
D. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Information Sheet-2	Reporting completion of work for supervisor

2.1 Reporting completion of work for supervisor

Supervisor is a Person in the first-line management who monitors and regulates employees in their performance of assigned or delegated tasks. Supervisors are usually authorized to recommend and/or effect hiring, disciplining, promoting, punishing, rewarding, and other associated activities regarding the employees in their departments.

2.2 Duties of an electrical supervisor

The electrical supervisor's duties include:

- ensuring all work carried out in relation to electrical equipment and installations in their area of responsibility is adequately supervised — this includes electrical staff, contractors and labor hire employees
- ensuring electrical equipment or installations in their area of responsibility are installed and tested in accordance with the Mine Safety and Inspection Regulations 1995 and maintained in a safe working condition
- regularly checking that the electrical nominee or electrical contractor has reviewed and inspected uncertified installations, and signed the electrical log book entries
- investigating, recording in the electrical log book and reporting to the manager
  - any electrical shock or burn received by a person
  - any fire suspected to be caused by electricity
  - Any dangerous occurrence involving electricity that could have caused injury to a person.

2.2.1 The electrical supervisor's duties for maintaining electrical equipment include ensuring:

- maintenance systems are in place in their area of responsibility so that electrical equipment and installations are maintained in a safe working order — electrical supervisors must continually monitor the maintenance system to ensure it remains up to date
- contractors have entered their work in section 1 of the area's electrical log book and it has been certified by the nominee
- All electrical installing work is inspected and tested in accordance with the regulations.

Self-check Test 2	**Written Test**

Instructions: - choose the correct answer from the given alternative.

1. _____is a Person in the first-line management who monitors and regulates employees in their performance of assigned or delegated tasks.(2 point)

   A. Supervisor C. Contractor

   B. Electrician D. All

2. Write Duties of an electrical supervisor?(4 point)

Note: **Satisfactory rating - 4 points** **Unsatisfactory - below 4 points**

Information Sheet-3	**Cleaning, checking and storing tools, equipment and surplus resources and materials**

3.1 Cleaning, checking and storing tools, equipment and surplus resources and materials

Cleaning *is* the process of removing unwanted substances, such as dirt, infectious agents, and some items and ***materials*** require specialized ***cleaning*** techniques, due to their shape. Tools and equipment should be cleaned and checked after using them for draining and dewatering construction sites. Both hand tools and equipment needs regular cleaning before storing them in their proper space. And plant should be cleaned regularly.

3.2 Maintaining and storing plant, tools & equipment standard work practices

Maintain mean, to keep in a condition of good repair, efficiency or to keep in an existing state, preserve or retain.

3.2.1 Maintaining and storing of tools and equipment

- A number of electrical tools and equipment's including hand tools used in draining and dewatering construction sites. These tools and equipment's should be maintained regularly and stored at their appropriate places.
- This activity is used to use our resources for a long period of time and increases the safety of tools and equipment's.
- Performing good housekeeping

3.2.2 Work Area Clearance

- Work area is cleared and materials disposed of or recycled in accordance with project environmental management plan.
- After the accomplishment of the project, the area should be cleaned up according to the project quality requirement.

Self-Check -3	Written Test

Directions: answer the following questions briefly.

1**. What mean Maintaining and storing?** (4 points)

2. Explain **Cleaning and checking tools and equipment mean:** (4 points

Note: **Satisfactory rating – 4 and above points Unsatisfactory - below 4 points**

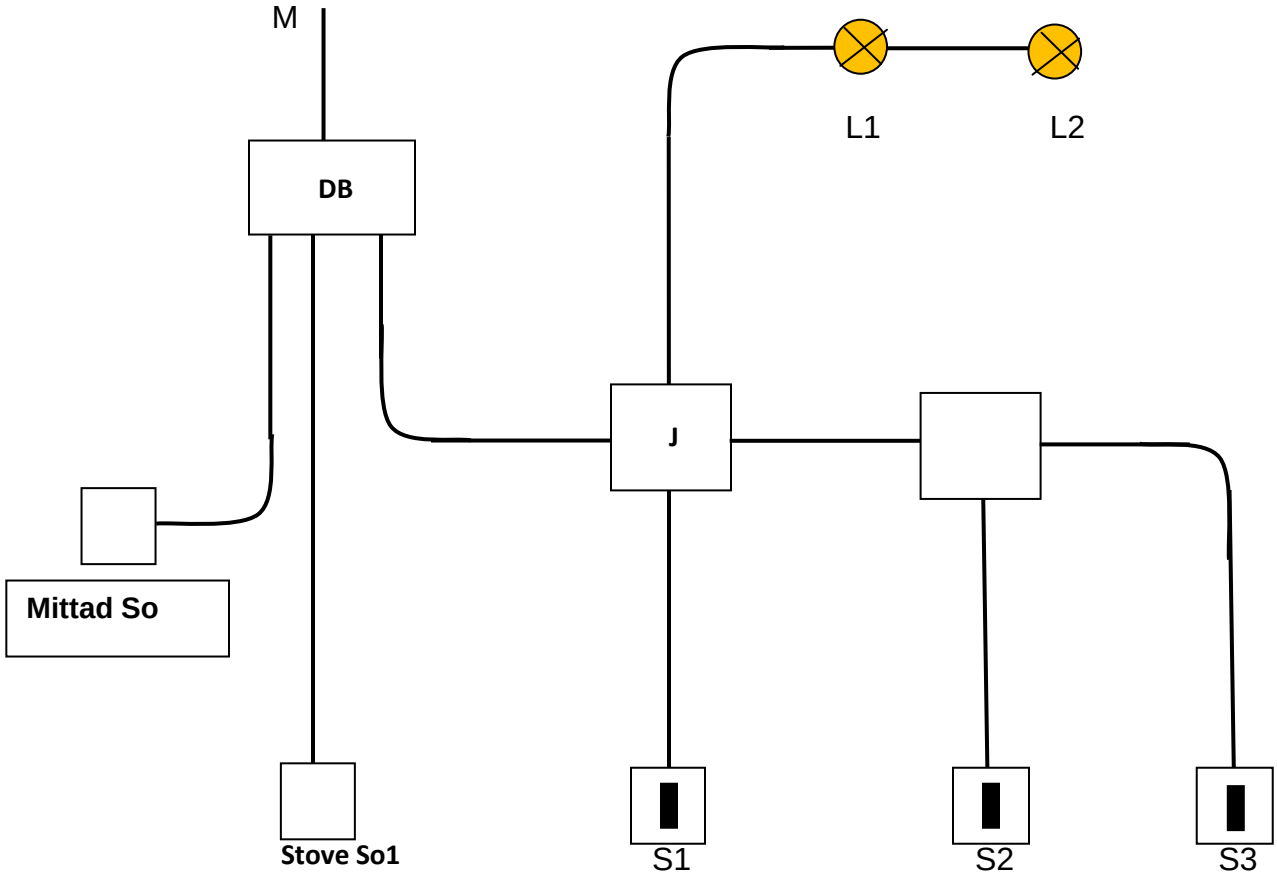
Operation Sheet 1	Performing final checks

Title: Performing final checks for two lamps controlled by three positions and connect electrical stove and mittad socket out let on 220V/50Hz.(single phase) supply,

Procedure:

Step 1:- wear PPE.

Step 2:- Draw schematic diagram using the given lay out diagram.



Step 3:- Draw wiring diagrams using the given lay out diagram.

Step 4:- select required tools and materials

Step 5:- Check the material and equipment

Step 6:- install conduit and connection box using by lay out diagram for Conduit wiring system.

Step 7:- Prepare conductors and start inserting it to the PVC conduit while being pulled on the other end until the conductors reaches the panel board for Conduit wiring system.

Step 9:- The wire allowance for termination in utility and junction boxes at least 150 mm and provide an ample length of the conductor.

Note: - Wire allowance in the panel board must be longer enough to reach the designated circuit breaker upon termination.

Step 10:- On the Junction box strip off at least 30 mm from the end of the wires and make a connections of electrical wire using by wiring diagram.

Note: You have an option which conductor you want to join first as long as you follow the wiring diagram in order to ensure correct circuit operation.

Step 11:- Connect the components from the source to final circuit

Step 12:- Check the whole installation circuit and connections

Step 13:- Check the continuity test of installation circuit and connections

Step 14:- To connect the 220V/50Hz.supply, with installation circuit

Step 15:- Check the whole installation circuit after connect the power supply.

Step 16:- Check the voltage and current of installation circuit and connections

LAP Test	Performing final checks

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hour.

Task 1: Performing final checks for two lamps controlled by three positions and connect electrical stove and mittad socket out let on 220V/50Hz.(single phase) supply,

Reference

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