TVET CERTIFICATE III in DOMESTIC ELECTRICITY

ELECTRICAL POWER SYSTEM PROTECTION

ELCEP302 Install electrical power system protection

Competence

Learning hours 70

Credits: 7

Sector: Energy

Sub-sector: Domestic Electricity

Module Note Issue date: June, 2019

Purpose statement

Purpose statement this module describes the skills, knowledge and attitude required to install electrical power system protection. It is intended for learners who have successfully completed the 9 years' basic education or its equivalent and pursuing TVET Certificate III in Domestic electricity or other related qualifications. At the end of this module, learners will be able toanalyze protection system according to the types of load, install protective devices, install earthing system, Install lightening arrestors system. Qualified learners deemed competent to this competency may work alone or with others on routine tasks in various places such as Home buildings, shops, warehouses, supermarket, hospitals, pharmacies, banks, schools, garage, market, home, churches, and hotels under minimum supervision

Table of Contents

	size and composition of material and the installation to be protected	
	3.5. Proper application of installation techniques for different earthing system in accordance with the standards	
	3.6. proper connection of surge arrestor based on protection area/zone surge current	
	3.7.Effective use of color code based on wire standard requirements	
4. <u>Learning unit 4</u> Install lightening arrestors system	4.1. Appropriate Implementation of hazard control and safety measures related to the installation of lightening arrestor system	115
	4.2. Appropriate selection of materials, tools and equipment in accordance with the installation to be done	
	4.3. Proper selection of lightening arrestor system based on the area to be protected	
	4.4. Proper installation of lightening arrestor system in accordance with the standards	
	4.5. Proper checking of lightening arrestor system in accordance with the standards	
	4.6. Appropriate arrangement of tools, materials and equipment in working place	

Learning unit 1: Analyze protection system according to the types of loads

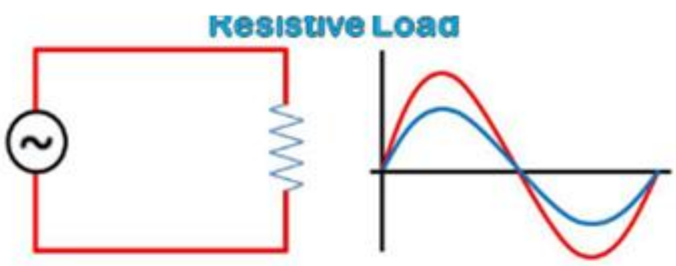
LO.1.1. Identify types of electrical loads in accordance with their characteristics.

Electrical Load Definition:

Electrical Load is the part or component in a circuit that converts electricity into light, heat, or mechanical motion. Examples of loads are a light bulb, resistor, or motor.

- Topic/ Content 1 : The types of electrical loads

    - ✓ **Resistive** loads:



-A resistive load is any electrical device that consisting of heating element, and working based on the Resistances working principle.

-Resistive loads only consumes Active Power , and does not cause changes in the value of the power factor , so the value of the power factor remains, which is equal to one.

-Resistive loads do not affect voltage and current waves , so the position of the voltage and current waves remains in phase.

Example of any electrical devices that including types of resistive loads:

- Incandescent lamps
- Heater
- Rice cooker
- Electric iron

- Electric Soldering
- Electric Kettles
- Toasters
- Etc

Because the electrical equipment which is included in the types of resistive load does not affect the power factor (Cosphi = 1), the powe formula of resistive loads is :

$$P = V \times I$$

Where **P:** Power (Watt) ; **V**: Voltage(Volt) and **I**: Intensity or Current (Ampere)

-Resistive loads resist current flow linearly and cause heat and light (potentially desirable or undesirable). For example, an incandescent light bulb produces light (desirable) but also heat (undesirable).

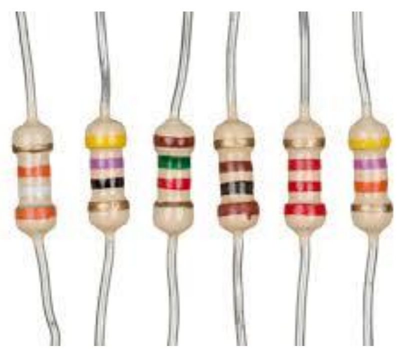
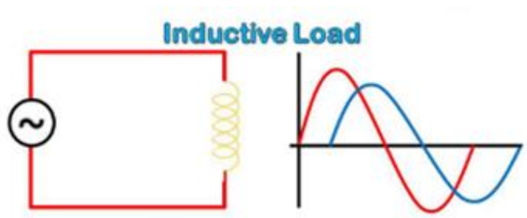


Fig: resistor images

A space heater's element produces heat (desirable) but may also glow. Resistance is measured in ohms for resistive loads, and power is measured in watts.

- ✓ **Inductive loads:**



Inductive loads: Resist *changes* in current and as such, when you measure the current, it lags (is behind) the voltage.

Inductive load is any Electrical device that consisting of wire coil (winding), or working based on magnetic induction working principle.

Inductive loads consume Active Power and produces Reactive Power, Inductive loads causes the current rate to be blocked, resulting in a shift in the position of the wave. The current becomes Lagging from the Voltage Wave.

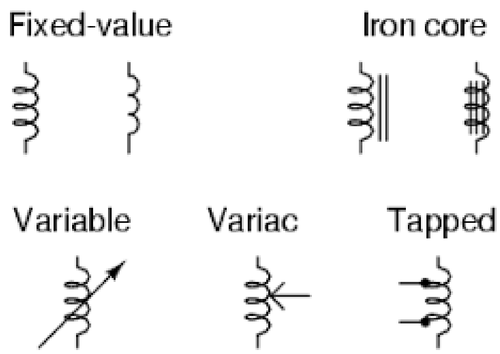


Figure: inductive loads

Electromagnetic fields are the key to inductive loads and as such all motors (fans, pumps, etc), solenoids, and relays are inductive in nature. Inductance is measured in Henrys. The important thing to remember about inductive loads is that they have *two* types of power, **real** power and **reactive** power.

The real power is based on the work done by the device (such as what a motor is rotating). The reactive power is that which is drawn from the source to produce magnetic fields. The total power consumed is real and reactive power combined, which is measured in VAR (volts-amps-reactive). It's rather a complicated topic,

Example of any electrical devices that including types of inductive Loads:

- Electric motor
- Electric welding Machine
- Transformer (Travo)
- Inductor
- Solenoid coil
- Energy saving lamp
- Air conditioner
- Fans
- Washing machine
- Air compressor
- Etc

Single phase power formula for inductive loads

$$\boldsymbol{P = V \times I \times Cosphi}$$

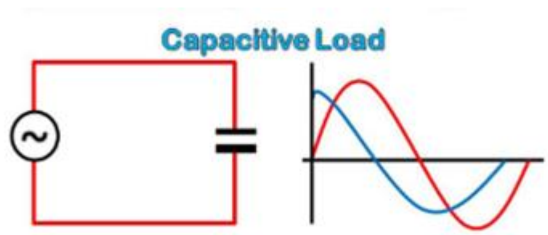
Where P: Power (Watt) ; V: Voltage (Volt) ; I: Intensity or Current (Ampere) and Cosphi (Power factor)

Three phase power formula for inductive loads

$$P = V \times I \times Cosphi \times \sqrt{3}$$

Where P: Power(Watt); **V**: Voltage (Volt); **I**: Intensity or Current (Ampere) and Cosphi (Power factor)

- ✓ **Capacitive loads:**



Capacitive load is any Electrical device that has the ability to capacitance, namely the ability to absorb electrical energy in a moment , Capacitive loads consume Active Power, and emit Reactive Power, so it can be used to correct power factors within certain limits.

Capacitive loads causes the Voltage rate to be blocked , resulting in a shift in the position of the current wave leading to the voltage wave, Electrical devices that including types of capacitive Loads is Capacitors (Condensers).

Capacitive loads are for many purposes, the opposite of inductive loads. They resist *changes* in voltage, and as you'd expect, the voltage lags the current (or more commonly said "current leads voltage").

A capacitor is two conductive surfaces separated by a insulator, which store charge.

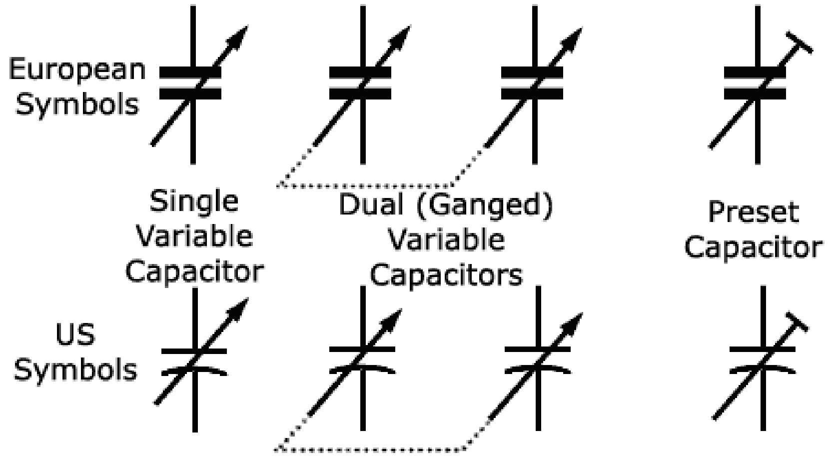


Fig: capacitor images

When power is first applied, current is very high, but drops as the voltage of the charge reaches that of the applied voltage. Capacitance is measured in farads. Like inductive loads, capacitive loads also have **reactive** power, but it's opposite the polarity of an inductive load. Therefore, a capacitive load has a negative VAR. Capacitive loads are not very common, but things like flashbulb

LO.1.2. Calculate the rating current according to the cable carrying capacity

- **Content / topic 1: Cable carrying capacity**

Through this article we will see some of the important factors that determine selection of Power Cables.

✓ **Supply voltage**

It is necessary to select a **power cable** capable of supporting a particular system voltage. In case of AC system, the rated voltage of power cable should always be equal to or greater than the system voltage.
E.g. for 3.3 kV system voltage, a 6.6 kV rated voltage cable should be selected.

✓ **Load current**

Each power cable is designed to operate under certain temperature conditions. Current carrying capacity of power cable is also dependent on conductor material (Copper / Aluminium)and insulation type.
Thus, Copper conductor cable has greater current carrying capacity than Aluminium.

✓ **Distance**

Check for voltage drop with the cable size chosen.The voltage drop from transformer to the load (lighting, motor) should not exceed 5%.Also, if it is a motor load, the voltage drop for motor starting has to be checked. It has to be less than 15%.

- ✓ **Cross section area and Cable diameter**

The voltage drop ***Δ V*** formula with the specific resistance (resistivity) *ρ* (rho) is:

$$\Delta V = I \times R = I \times (2 \times l \times \rho / A)$$

I =Current in ampere
l = Wire (cable) length in meters (times 2, because there is always a return wire)
ρ = rho, electrical resistivity (also known as specific electrical resistance or volume resistivity) of **copper** = 0.01724 ohm×mm²/m (also Ω×m)
(Ohms for *l* = 1 m length and *A* = 1 mm² cross section area of the wire) *ρ* = 1 / *σ*
A = Cross section area in mm²
σ = sigma, electrical conductivity (electrical conductance) of copper = 58 S·m/mm²

Quantity of resistance	
$R = \rho \cdot \frac{l}{A}$	
R = resistance	Ω
ρ = specific resistance	Ω×m

l = double length of the cable M *A* = cross section mm^2

The derived SI unit of electrical resistivity ρ is Ω × m, shortened from the clear Ω × mm²/m. The reciprocal of electrical resistivity is electrical conductivity. The increasing or decrease cross section are proportional diameter in cable

✓ Resistivity

The derived SI unit of electrical resistivity ρ is Ω × m, shortened from the clear Ω × mm² / m. The reciprocal of electrical resistivity is electrical conductivity.

Electrical conductor	**Electrical resistivity Specific resistance**
Silver	***ρ* = 0.0161** Ohm·mm²/m
Copper	***ρ* = 0.0172** Ohm·mm²/m
Gold	***ρ* = 0.0244** Ohm·mm²/m
Aluminium	***ρ* = 0.0277** Ohm·mm²/m

- **Content / topic 2:** Apply IEE/RSB regulation

✓ Operating temperature

This is the temperature rating that most cable users think of first. It is usually defined as the maximum continuous temperature that the wire can withstand during its lifetime. It is generally limited by the thermal aging characteristics of the polymers, i.e., the plastics used to insulate and/ or jacket the wire. The metallic components of the wire seldom limit the temperature rating except in high-temperature wire where oxidation of the metal begins to become a significant factor at approximately 250° C.

✓ Current carrying capacity and voltage drop

The voltage drop of any insulated cable is dependent upon the route length under consideration (in meters), the required current rating (in amperes) and the relevant total impedance per unit length of the cable. The maximum impedance and voltage drop applicable to each cable at maximum conductor temperature and under a.c.

✓ **Cross section area.**

Standard nominal cross-sectional areas in circular mils and square millimetres shall be calculated in accordance with the following equations and shall be rounded in accordance with Section 4 to the same number of significant figures as used in expressing the standard diameters, but in no case to less than three significant figures:

$$\text{Area, cmil} = d^2$$
$$\text{Area, mm}^2 = d^2 \times 5.067 \times 10^{-4}$$

where: d = diameter of the wire in mils. Standard nominal cross-sectional areas in circular mils and square millimetres .

✓ Flexible conductors

Flexible cables, or 'continuous-flex' cables, are electrical cables specially designed to cope with the tight bending radii and physical stress associated with moving applications, such as inside cable carriers.

✓ Rigid conductors.

Advantages: Less surface area to corrode can be rigid and strong
Disadvantages: Not good if flexed repeatedly, can break if flexed in the same spot
not practical for high voltage.

LO.1.3. Select protective devices based on the installation to be protected

- **Content / topic 1:Types of installation systems**

✓ **Power socket systems**

What are the characteristics of a power circuit?

Power circuits usually supply socket outlets but may also supply individual permanent appliances. They can be wired in two ways:

Ring-final wiring

This has traditionally been the main method of wiring socket circuits in the UK, and allows a high number of outlets adjacent to their loads. In ring-final circuits, loads are shared by two parallel conductors which helps improve voltage drop because having the conductors run parallel reduces resistance.

Ring-final wiring is not suitable for permanent loads, such as immersion heaters and care should be taken whilst using them when installing in kitchens – loads must be equally distributed around the circuit.

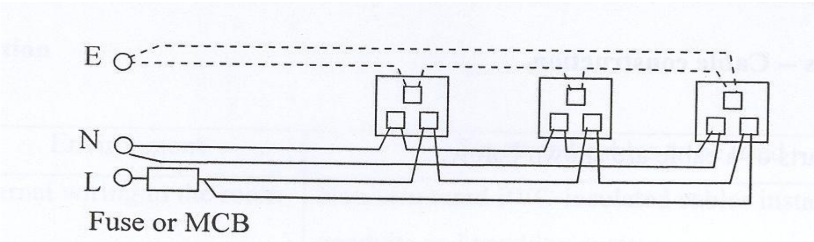


Figure: Ring – final wiring circuit

Radial wiring

This is a mains power circuit of an appropriately rated cable which feeds into each power point and moves onto the next into one big line. The circuit ends with the last point on it. This form of wiring is becoming more popular with designers because it is much easier to determine faults than in a ring-final circuit,in a radial circuit if there is a break anywhere along the cable all the circuits after the break will stop working, while in a ring-final circuit even in case of fault all sockets will have power distributed to them , this makes for a risk of faults not being picked up, conductors being overloaded and then sparking an electrical fire.

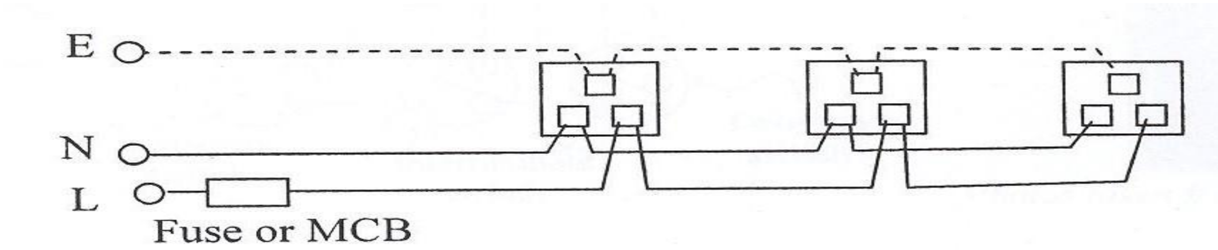


Figure: Radial circuit

- ✓ **Control lighting system**

A lighting control system is an intelligent network-based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are widely used on both indoor and outdoor lighting of commercial, industrial, and residential spaces. Lighting control systems serve to provide the right amount of light where and when it is needed.

Lighting control systems are employed to maximize the energy savings from the lighting system, satisfy building codes, or comply with green building and energy conservation programs. Lighting control systems are often referred to under the term Smart Lighting.

A controlled lighting system can help you save money on your energy costs by allowing you to manually or automatically control the number of lights that are “on” at any given moment and the intensity of those lights. According to Energy.gov, installing certain types of sensors can help you cut your lighting bills by as much as 30 percent.

There are five types of Lighting control systems

1. **Basic Lighting Controls**

Basic lighting controls consist of a manual on/off switch. In order to save money with these types of lighting controls, the individuals in the building must remember to turn them on when they enter the room and turn them off when they leave. Using energy-efficient light bulbs, like LEDs and CFLs, with basic switches can help reduce electric bills.

2. **Dimmer Switches**

Dimmer switches are a slightly more advanced way to control room lighting. These switches allow an individual to slide the switch to their desired level of lighting, which uses less electricity than a switch that is either fully on or fully off. When combined with LED light bulbs, dimmer switches can help control your building’s energy costs.

3. **Motion Sensors for Outdoor Lighting**

To reduce lighting costs, you may want to consider installing motion sensors on your outdoor lights, especially your security lighting. Outdoor and security lights only need to come on at night when a person or vehicle comes into the area. With a motion sensor, the light turns on when movement is detected and turns off after a certain number of minutes have passed without motion. In order for this to work well, the outdoor light bulbs need to produce light as soon as the light starts receiving power.

4. **Occupancy Sensors for Indoor Lighting**

Occupancy sensors are designed to turn on the lights as soon as someone enters a room and turns off after a certain number of minutes of no movement. Occupancy sensors are great for bathrooms, break rooms, recreational room and conference rooms.

5. **Networked Lighting Control Systems**

The most advanced type of lighting control system is a networked system, which can be part of a Building Automation System (BAS) package or designed as a stand-alone system. Networked lighting control systems allow the operators to control the lights from their computers or handheld devices that contain the lighting system software. Operators can turn lights on and off and set timers to control the lights. Advanced software programs can even store data and create usage charts so that energy usage can be precisely monitored.

- **Content / topic 2: Types of protective devices**

✓ **Electrical Circuit Breaker**

Electrical circuit breaker is a switching device which can be operated manually and automatically for controlling and protection of electrical power system respectively. As the modern power system deals with huge currents, the special attention should be given during designing of circuit breaker for safe interruption of arc produced during the operation of circuit breaker. This was the basic definition of circuit breaker.

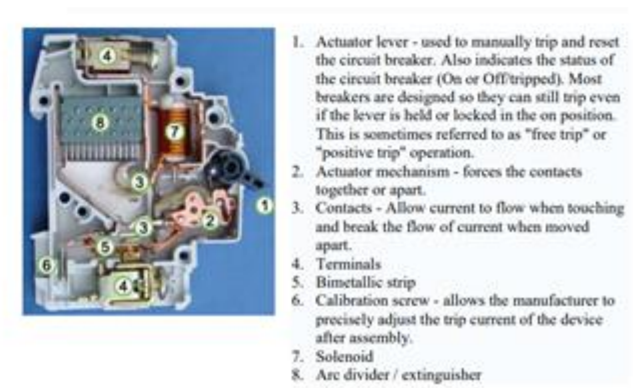
Working Principle of Circuit Breaker

There are two arrangement of operation of circuit breaker. One due to thermal effect of over current and other due to electromagnetic effect of over current. The thermal operation of circuit breaker is achieved with a bimetallic strip whenever continuous over current flows through CB, the bimetallic strip is heated and deflects by bending. This deflection of bimetallic strip releases mechanical latch. As this mechanical latch is attached with operating mechanism, it causes to open the circuit breaker contacts. But during short circuit condition, sudden rising of current, causes electromechanical displacement of plunger associated with tripping coil or solenoid of CB. The plunger strikes the trip lever causing immediate release of latch mechanism consequently open the circuit breaker contacts.

Types of circuit breaker

- Miniature circuit breaker (MCB)
- Molded case circuit breaker (MCCB)
- ***Residual-current device (RCD) or*** **Earth Leakage Circuit Breaker or ELCB**
- **Surge protective devices**

a. What is MCB?



Miniature circuit breakers (MCB) are characterized by their low current ratings and fixed trip settings. Normally, MCBs have current ratings below 100 Amperes and, as their name implies, they have a compact size. There are three main types of MCBs, classified according to the current range at which they trip instantly.

Type B - Trips at 3 to 5 times rated current, suitable for resistive or slightly inductive loads.

Type C - Trips at 5 to 10 times rated current, suitable for moderate inductive loads.

Type D - Trips a t 10 to 20 times rated current, suitable for loads with a high inductive component.

These MCBs are characterized by ease of installation. As their name implies, they just have to be plugged into a compatible electric panel. Plug-in MCBs are suitable for applications that use circuit breakers exclusively- typically residential and commercial electrical distribution systems

The MCB has some advantages compared to fuse.

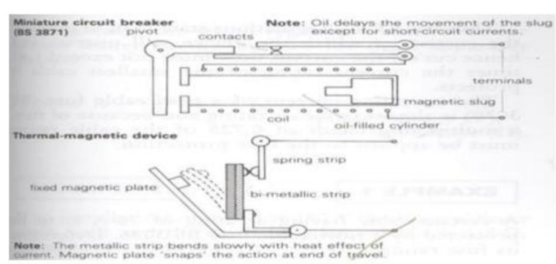
- Automatically switches off the electrical circuit during abnormal condition of the network means in over load condition as well as faulty condition. The fuse does not sense but miniature circuit breaker does it in more reliable way. MCB is much more sensitive to over current than fuse.

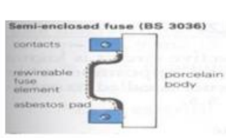
- Another advantage is, as the switch operating knob comes at its off position during tripping, the faulty zone of the electrical circuit can easily be identified. But in case of fuse, fuse wire should be checked by opening fuse grip or cutout from fuse base, for confirming the blow of fuse wire.
- Quick restoration of supply can not be possible in case of fuse as because fuses have to be renewable or replaced for restoring the supply. But in the case of MCB, quick restoration is possible by just switching on operation.

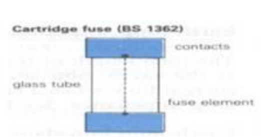
- Handling MCB is more electrically safe than fuse. Because of to many advantages of MCB over fuse units, in modern low voltage electrical network, miniature circuit breaker is mostly used instead of backdated fuse unit.

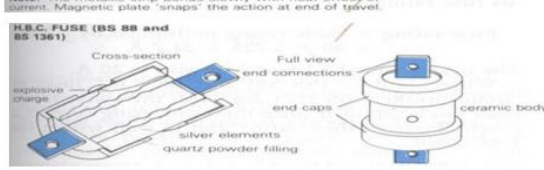
- **Only one disadvantage of MCB** over fuse is that this system is more costlier than fuse unit system.

b. Molded Case Circuit Breakers (MCCB).









Molded case circuit breakers (MCCB) work on the same principles of thermal-magnetic protection, but they offer some additional features that are not available with MCBs:

MCCBs have adjustable trip settings, so they are suitable when the rated current of a circuit breaker must be fine-tuned according to the actual site conditions.

MCCBs have a much wider range of current ratings: they can be found from ratings below 100 Amps to ratings above 2500 Amps.

Compared with MCBs, molded-case circuit breakers are much larger, given that they must accommodate an adjustable trip mechanism and, in many cases, larger contacts for high-current applications.

An MCCB provides protection by combining a temperature sensitive device with a current sensitive electromagnetic device.

The traditional molded-case circuit breaker uses electromechanical (thermal magnetic) trip units that may be fixed or interchangeable. An MCCB provides protection by combining a temperature sensitive device with a current sensitive electromagnetic device. Both these devices act mechanically on the trip mechanism.

Depending upon the application and required protection, an MCCB will use one or a combination of different trip elements that protect against the following conditions:

- Thermal overloads
- Short circuits
- Ground faults

Thermal Overload

In an overload condition, there's a temperature buildup between the insulation and conductor. If left unchecked, the insulation's life will drastically reduce, ultimately resulting in a short circuit. This heat is a function of the square of the rms current (I squared), the resistance in the conductor (R), and the amount of time the current flows (t).

Short-Circuit Condition

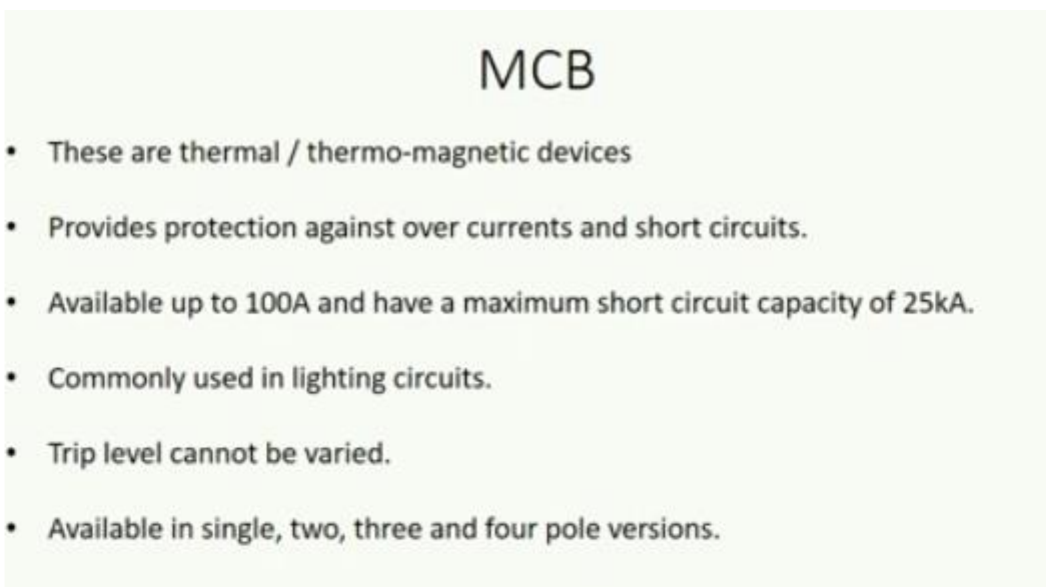
Usually, a short circuit occurs when abnormally high currents flow as a result of the failure of an insulation system. This high current flow, termed short-circuit current, is limited only by the capabilities of the distribution system. To stop this current flow quickly so that major damage can be prevented, the short circuit or instantaneous element of an MCCB is used.

Ground Fault Condition

A ground fault actually is a type of short circuit, only it's phase-to-ground, which probably is the most common type of fault on low-voltage systems (600V or less).

Usually, arcing ground-fault currents are not large enough to be detected by the standard MCCB protective device. But, if left undetected, they can increase sufficiently to trip the standard protective device. When this happens, it usually is too late, and the damage is already done. An example of this is a motor having an internal insulation failure. While the current flow may be small, it must be detected and eliminated before major motor damage takes place.

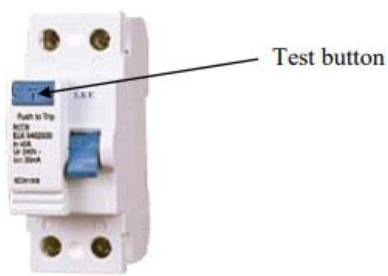
Difference between MCB & MCCB



MCCB

- May be of Thermal/ Thermo-Magnetic/ Electronic trip type.
- Primarily provide protection against overcurrent and short circuit.
- Can provide protection against Earth Fault, Residual Currents, Under voltage etc.
- Available up to the range of 2500A.
- Trip level can be varied in adjustable trip type MCCBs.
- Remote ON/OFF is possible with additional accessories
- Commonly used is loads over 100A and in motor protection.
- Some MCCBs are microcontroller based.
- Available in single, two, three and four pole versions.

c. ***Residual-current device (RCD) or*** **Earth Leakage Circuit Breaker or ELCB**



A residual-current device (RCD), or residual-current circuit breaker (RCCB), is a device that instantly breaks an electric circuit to prevent serious harm from an ongoing electric shock. Injury may still occur in some cases, for example if a human falls after receiving a shock.

If any current leaks from any electrical installation, there must-be any insulation failure in the electrical circuit, it must be properly detected and prevented otherwise there may be a high chance of electrical shock if-anyone touches the installation. An earth leakage circuit breaker does it efficiently. Means it detects the earth leakage current and makes the power supply off by opening the associated circuit breaker.

An RCD helps to protect against electric shock when current flows through a person from a phase (live / line / hot) to earth

A combined RCD+MCB are known as a RCBO (residual-current circuit breaker with over current protection).

. A current of around 30 mA is potentially sufficient to cause cardiac arrest or serious harm if it persists for more than a small fraction of a second. RCDs are designed to disconnect the conducting wires quickly enough to prevent serious injury from such shocks, commonly described as the RCD being "tripped".

RCDs are often used or integrated as a single product along with some kind of circuit breaker, such as a fuse or miniature circuit breaker (MCB), which adds protection in the event of excessive current in the circuit (the resulting RCD with over current protection called an RCBO).

A ground fault circuit interrupter circuit breaker (GFCI breaker in USA and Canada) and residual-current breaker with overload (RCBO in Europe) are devices that combine the functions of a residual-current device with a circuit breaker. They detect both unbalanced supply and overload current.

Limitations

A residual-current circuit breaker cannot remove all risk of electric shock or fire. In particular, an RCD alone will not detect overload conditions, phase-to-neutral short circuits or phase-to-phase short circuits (see three-phase electric power). Over-current protection (fuses or circuit breakers) must be provided.

Testing of correct operation

RCDs can be tested with built-in test button to confirm functionality on a regular basis.

d. Surge protective devices

Surge protective devices (SPD) assist in the protection of valuable electrical and electronic equipment against transients, originating from lightning and also from switching sources.

The choice of a surge protective device depends upon:

- The exposure of the building to lightning transients
- The sensitivity and value of the equipment that requires protection (it is recommended that the contractor should discuss the installations requirements with the customer)
- The location and therefore the exposure level of the installation

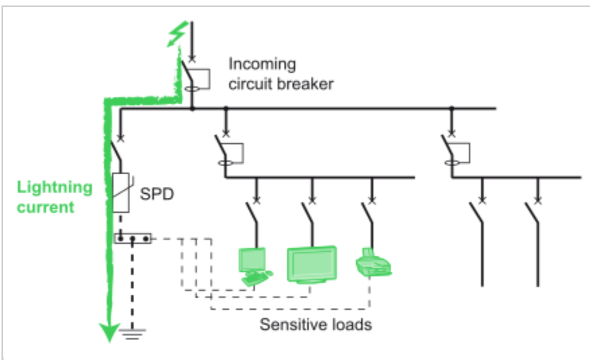
• The equipment used within the installation and whether this equipment could generate switching transients.

Surge protection devices are classified according to their standard into different types:

• Type 1 - SPD which can discharge partial lightning current with a typical waveform 10/350 µs. Usually employs spark gap technology.

• Type 2 - SPD which can prevent the spread of over-voltages in the electrical installations and protects equipment connected to it. It usually employs metal oxide v arrestor (MOV) technology and is characterized by an 8/20 µs current wave.

• Type 3 – These SPDs have a low discharge capacity. They must therefore only be installed as a supplement to Type 2 SPD and in the vicinity of sensitive loads. Type 3 SPD's are characterized by a combination of voltage waves (1.2/50 µs) and current waves (8/20 µs).



✓ Electrical Fuse

In electronics and electrical engineering, a fuse is a type of low resistance resistor that acts as a sacrificial device to provide over current protection, of either the load or source circuit.

It's essential component is: **a metal wire or strip**, that melts when too much current flows through it, interrupting the circuit that it connects.

Excessive current is caused by:

- Short circuits
- overloading
- mismatched loads
- Devices failure

Fuses can be used as alternatives to circuit breakers.

A fuse interrupts an excessive current so that further damage by overheating or fire is prevented. Wiring regulations often define a maximum fuse current rating for particular circuits.

Over current protection devices are essential in electrical systems to:

- limit threats to human life and
- Limit property damage.

A fuse consists of a metal strip or wire fuse element, of small cross-section compared to the circuit conductors, mounted between a pair of electrical terminals, and (usually) enclosed by a non-combustible housing. The fuse is arranged in series to carry all the current passing through the protected circuit. The resistance of the element generates heat due to the current flow

OPERATION

For a normal current the heat produced does not cause the element to attain a high temperature. If too high a current flows, the element rises to a higher temperature and either directly melts, or else melts a soldered joint within the fuse, opening the circuit.

The fuse element is made of:

Zinc, Copper, Silver, Aluminum, or Alloys to provide stable and predictable characteristics. The fuse ideally would carry its rated current indefinitely, and melt quickly on a small excess.

The fuse element may be surrounded by air, or by materials intended to speed the quenching of the arc. Silica sand or non-conducting liquids may be used.

Characteristic parameters

- Rated current (In)
- Speed
- Breaking capacity
- Rated voltage
- Voltage drop
- Temperature rating

Rated current (In)

Rated current is the maximum current that a fuse can continuously conduct without interrupting the circuit.

Speed

The speed at which a fuse blows depends on how much current flows through it and the material of which the fuse is made. The operating time is not a fixed interval, but decreases as the current increases.

Breaking capacity

The breaking capacity is the maximum current that can safely be interrupted by the fuse. Generally, this should be higher than the prospective short circuit current. Miniature fuses may have an interrupting rating only 10 times their rated current.

Rated voltage

Voltage rating of the fuse must be equal to or, greater than, what would become the open-circuit voltage. For example, a glass tube fuse rated at 32 volts would not reliably interrupt current from a voltage source of 120 or 230V. If a 32V fuse attempts to interrupt the 120 or 230 V source, an arc may result.

Voltage drop

A voltage drop across the fuse is usually provided by its manufacturer. There is a direct relationship between a fuse's cold resistance and its voltage drop value.

Temperature rating

Ambient temperature will change a fuse's operational parameters. A fuse rated for 1 A at 25 °C may conduct up to 10% or 20% more current at −40 °C and may open at 80% of its rated value at 100 °C. Operating values will vary with each fuse family and are provided in manufacturer data sheets.

Markings

A sample of the many markings that can be found on a fuse, Most fuses are marked on the body or end caps with markings that indicate their ratings.

- Ampere rating of the fuse.
- Voltage rating of the fuse.
- Time-current characteristic; i.e. fuse speed.
- Approvals by national and international standards agencies.
- Manufacturer/part number/series.
- Interrupting rating (Breaking capacity)
- Packages and materials

FUSE CAPACITY

Fuse wire rating (A)	Cu Wire diameter (mm)
3	0.15
5	0.20
10	0.35
15	0.50
20	0.60
25	0.75
30	0.85
45	1.25
60	1.53
80	1.8
100	2.0

Types of fuse

- Cartridge fuse
- High rupturing capacity(HRC) or High Breaking Capacity(H.B.C)fuse
- Semi-enclosed fuse

✓ **High rupturing capacity (HRC) fuse**

Some fuses are designated High Rupture Capacity (HRC) and are usually filled with sand or a similar material. Fuses for small, low-voltage, usually residential, wiring systems are commonly rated, to interrupt 10,000 amperes. Fuses for larger power systems must have higher interrupting ratings, with some low-voltage current-limiting high interrupting fuses rated for 300,000 amperes. Fuses for high-voltage equipment, up to 115,000 volts, are rated by the total apparent power (megavolt-amperes, MVA) of the fault level on the circuit. **Advantage is that the HRC is widely used in power lines.**

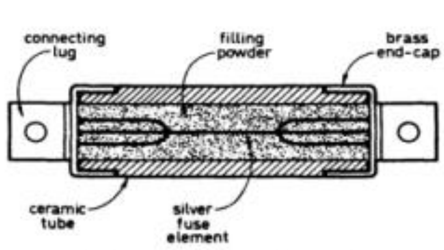


Fig.3 H.R.C. fuse.

✓ **Cartridge fuse**

Cartridge (ferrule) fuses have a cylindrical body terminated with metal end caps. Some cartridge fuses are manufactured with end caps of different sizes to prevent accidental insertion of the wrong fuse rating in a holder, giving them a bottle shape. **Advantage is that the sparking at event of melting a fuse wire is eliminated.**

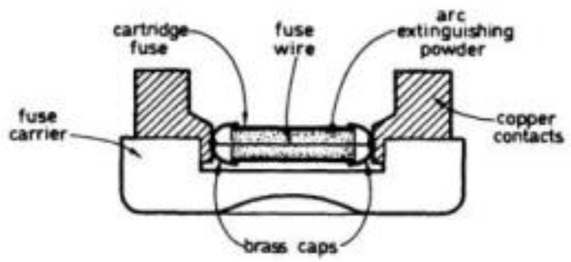


Fig.2 Cartridge fuse.

- **Semi-enclosed fuse**

Semi-enclosed fuses are fuse wire carriers in which the fusible wire itself can be replaced. The exact fusing current is not as well controlled as an enclosed fuse, and it is extremely important to use the correct diameter and material when replacing the fuse wire, and for these reasons these fuses are slowly falling from favor.

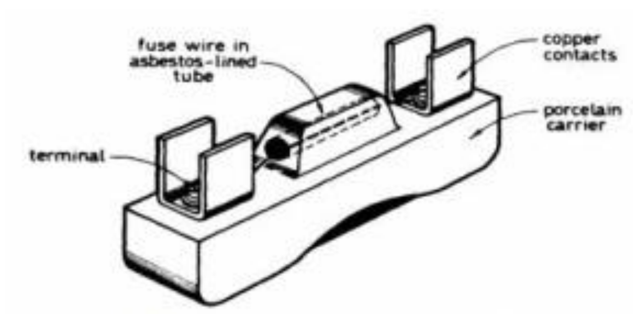


Fig.1 Semi - enclosed (rewirable) Fuse .

- **Content / topic 3: Types of electrical protection**

- **Protection against overload**

Short circuit is a type **of** over-current. Magnetic circuit breakers, fuses and over-current relays are commonly used to provide over-current **protection**. **Overload protection** is a **protection against** a running over-current that would cause overheating **of** the **protected** equipment.

- **Lightning protection**

The function of a lightning protection system is to protect structures from fire or mechanical destruction and to prevent that persons in buildings are injured or even killed. An overall lightning protection system consists of external lightning protection (lightning protection /earthing) and internal lightning protection (surge protection).

Functions of an external lightning protection system

Interception of direct lightning strikes via an air-termination system

- ✓ Safe discharge of lightning current to earth via a down-conductor system
- ✓ Distribution of the lightning current in the ground via an earth-termination system

Functions of an internal lightning protection system

- ✓ Prevention of dangerous sparking in the structure by establishing equipotential bonding or keeping a separation distance between the LPS components and other electrically conducting elements

Lightning equipotential bonding

Lightning equipotential bonding reduces the potential differences caused by lightning currents. This is achieved by interconnecting all isolated conducting parts of the installation by means of conductors or surge protective devices.

- **Protection against electrocution**

The protection of persons against electric shock in various installations must be provided in conformity with appropriate national standards and statutory regulations.

The primary function of such standards is to prevent or dramatically reduce the number of fatalities arising from electric shock. An electric shock occurs when a person comes into contact with an electrical energy source and the resultant current through the body may result in injury or death.

Effects of Electric Current in the Human Body

Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6–25 milliamperes (women)	Painful shock, loss of muscular control*
9–30 milliamperes (men)	The freezing current or " let-go" range.* Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50–150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000–4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

The following equipment include rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets are designed to reduce the risk of electrical accidents like **electric shock**.

- **Protection against Short - circuits**

Definition

A short circuit (sometimes abbreviated to short or s/c) is an electrical circuit that allows a current to travel along an unintended path with no or very low electrical impedance (RESISTANCE).

The electrical opposite of a short circuit is an "open circuit", which is an infinite resistance between two nodes (TERMINALS).

TYPES OF SHORT CIRCUIT

A short circuit in the power system is the result of some kind of abnormal conditions in the system. It may be caused due to internal and or external effects.

- **Internal short circuit**

Internal **short circuit** are caused by breakdown of equipment or transmission lines from deterioration of insulation in a generator, transformer etc. Such troubles may be due to ageing of insulation. Inadequate design or improper installation

- **External short circuit**

External effects causing short circuit include insulation failure due to lightning surges. Overloading of equipment causing excessive heating: mechanical damage by public etc

Effects of Short-Circuit

When a short-circuit occurs, the current in the system increases to an abnormally high value while the system voltage decreases to a low value.

The heavy current due to short-circuit causes excessive heating which may result in fire or explosion. Sometimes short-circuit takes the form of an arc and causes considerable damage to the system. For example, an arc on a transmission line not cleared quickly will burn the conductor severely causing it to break, resulting in a long time interruption of the line**.**

Tracing (identifying) a Short Circuit

Step 1 - Power Down

To trace a short circuit, all the electrical switches should be turned off. All lights and other electric appliances should be unplugged. The tripped circuit breaker should be reset. A replacement should be completed if there is a fuse instead of a circuit breaker.

Step 2 - Check Receptacles or Switches

After resetting the breaker, if it trips again immediately, there is a possibility of a short circuit in a receptacle or a switch.

Step 3 - Narrow it Down

If the circuit breaker does not trip, turn on each switch one at a time until the breaker trips again. When the breaker trips upon turning on a particular switch, it is evident that there is a short circuit in a fixture or receptacle controlled by the switch.

Step 4 - Identify a Particular Electrical Appliance

When the circuit breaker does not trip even after turning all the switches on, then you can conclude that the original problem started with an electrical appliance somewhere inside the home. Return to the electrical appliances and lights and begin plugging them in one by one. As soon as the breaker trips , whichever appliance is plugged in at that moment can be identified as problematic and isolated.

The issue could lie in the plug, the cord, or the appliance itself.

APPLICATION OF SHORT CIRCUIT

Short circuits can produce very high temperatures due to the high power dissipation in the circuit. This high temperature can be utilized in the application.

Arc welding is a common example of the practical application of the heating due to a short circuit. The power supply for an arc welder can supply very high currents that flow through the welding rod and the metal pieces being welded. The point of contact between the rod and the metal surfaces gets heated to the melting point, fusing a part of the rod and both surfaces into a single piece.

TESTING THE CONTINUTY OF PROTECTIVE DEVICE

The testing is done by using multi meter by putting the cursor on testing continuity point and measure if there is a connection between the two terminals of protective devices

After testing the continuity of protective device, and fund it is burned replace it by the new one.

Leaning unity 2. Install protective devices

LO.2.1. Implement hazard control and safety measures related to the installation of protective devices

- **Content / topic 1: Identification of electrical safety hazards**

  ✓ **General electrical hazards**

What is a Hazard?

When we refer to hazards in relation to occupational safety and health the most commonly used definition is 'A Hazard is a potential source of harm or adverse health effect on a person or persons'.

An electrical hazard can be defined as a serious workplace hazard that exposes workers to the following:

- **B**urns
- **E**lectrocution
- **S**hock
- **A**rc Flash/Arc Blast
- **F**ire
- **E**xplosions

Therefore, **BE SAFE** by recognizing, avoiding and protecting against all of these electrical hazards. These BE SAFE terms are defined as:

B = **Burns:**

A burn is the most common shock-related injury. Burns from electricity are one of three types: Electrical, Arc/Flash or Thermal Contact.

E = **Electrocution:**

Electrocution is fatal; it means to kill with electricity. Electrocution results when a human is exposed to a lethal amount of electrical energy.

S = **Shock:**

Shock results when the body becomes part of the electrical circuit; current enters the body at one point and leaves at another. Electrical shock is defined as a reflex response to the passage of electric current through the body.

NOTES :

The types of burns from electricity are further defined as:

- Electrical burns result from heat generated by the flow of electric current through the body
- Arc/Flash burns are high temperature burns caused by an electric arc or explosion
- Thermal contact burns occur when skin comes in contact with overheated electric equipment
-

A = **Arc Flash/Blast:**

An arc flash is the sudden release of electrical energy through the air when a high-voltage gap exists and there is a breakdown between conductors. An arc flash gives off thermal radiation (heat) and bright, intense light that can cause burns. Temperatures have been recorded as high as 35,000 °F. High-voltage arcs can also produce considerable pressure waves by rapidly heating the air and creating a blast.

F = **Fire:**
Most electrical distribution fires result from problems with "fixed wiring" such as faulty electrical outlets and old wiring. Problems with cords (such as extension and appliance cords), plugs, receptacles, and switches also cause electrical fires.

E = **Explosions:**
An explosion can occur when electricity ignites an explosive mixture of material in the air.

What is Risk?

When we refer to risk in relation to occupational safety and health the most commonly used definition is 'risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard.'

Categorizing Risk

The level of risk is often categorized upon the potential harm or adverse health effect that the hazard may cause the number of times persons are exposed and the number of persons exposed. For example exposure to airborne asbestos fibres will always be classified as high because a single exposure may cause potentially fatal lung disease, whereas the risk associated with using a display screen for a short period could be considered to be very low as the potential harm or adverse health effects are minimal.

- ✓ **Falling panels**

The Centers for Disease Control and Prevention states that falls can happen in all occupational settings, and "circumstances associated with fall incidents in the work environment frequently involve slippery, cluttered or unstable walking/working surfaces; unprotected edges; floor holes and wall openings; unsafely positioned ladders; and misused fall protection."

To reduce the risk of falling at work, CCOHS recommends paying attention to your surroundings and walking at a pace that's suitable for the surface you're on and the task you're performing. Additionally, walk with your feet pointed slightly outward, make wide turns when walking around corners and use the handrails on stairs.

Flying glass refers to pieces of broken glass (typically from a window) which become sharp missiles projected by the force which broke the glass, along with any strain energy due to tempering. They often cause cut-type injuries.

✓ **Danger of flying glass**

Flying objects are believed to cause the majority of workplace eye injuries, and more than half the objects involved are smaller than the head of a pin.

Hazards might include:

- Fragments
- Chips
- Particles
- Sand and dirt

Depending on operations these objects may be bits of wood, metal, plastic, or other material. Work processes that might put workers at risk of flying object eye and face injuries include:

a) Grinding

b) Machining

c) Masonry work

d) Wood working

e) Sawing

f) Drilling

g) Chiseling

h) Powered fastening

i) Riveting

j) Sanding

Suitable eye protection for flying object hazards depends on the type and extent of the hazard. For example, safety glasses with side shields are appropriate protection for many jobs. On the other hand, safety goggles are preferred for jobs with many flying objects.

Polycarbonate lenses provide the best impact resistance and can also be coated to resist scratches. A face shield should be required for jobs in which flying objects could injure the face as well as the eyes.

✓ **Potential injuries from electric hazards**

i. Electrocution

Electrocution results when a person is exposed to a lethal amount of electrical energy.

Electrical burns can be arc burns, thermal contact burns, or a combination of burns. Electrical burns are among the most serious burns and require immediate medical attention.

They occur when an electric current flows through tissue or bone, generating heat that causes tissue damage. The body cannot dissipate the heat generated by current flowing through the resistance of the tissue therefore, burns occur.

To further illustrate how easily a person can receive a fatal shock, consider a voltage that is common to every location in the United States, 120-volts.

Under average working conditions where the person is perspiring and has a resistance of only 1000-ohms from hand-to-hand, using the simple Ohm's Law formula (current equals the voltage divided by the resistance) the current flow will be 0.12 amperes or 120 mA.

If the power supply to electrical equipment is not grounded or the path has been broken, or if there are live parts or bare wires, a fault current may travel through a worker's body, causing electrical burns or death.

Even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

ii. Electrical shock

Places of work generally have power nominally supplied at 230 volt (single phase) and 400 volt (3 phase) although some larger workplaces will receive electricity at a higher supply voltage. The information below relates to workplaces using 230 and 400 volt supplies.

The main hazards with electricity are:

a) Contact with live parts causing shock and burns

b) Faults which could cause fires

c) Fire or explosion where electricity could be the source of ignition in a potentially flammable or explosive atmosphere, e.g. in a spray paint booth

The risk of injury from electricity is strongly linked to where and how it is used and there is greater risk in wet and/or damp conditions.

Basics of Contact with Electricity

It is the level of voltage the body is exposed to and the resistance to flow of electrical current offered by the body that determines the impact of exposure to electricity. The following factors determine the severity of the effect electric shock has on your body:

a. The level of voltage

b. The amount of body resistance you have to the current flow

c. The path the current takes through your body

d. The length of time the current flows through your body

The table below outlines the effects that various values of electrical current have on the human body.

CONDITION	EFFECTS
1-3mA of current	Mild sensation
10mA of current	Muscles contract, releasing grip may be difficult
30mA of current	Breathing difficult, possible loss of consciousness
30-75mA of current	Respiratory paralysis
100-200mA of current	Ventricular fibrillation
50-300mA of current	Shock (potentially fatal)
Over 1500mA of current	Tissue and organ burn
150˚ F	Cell destruction
200˚ F	Skin experiences “third degree” burns

If a worker has come into contact with electricity the worker may not be able to remove themselves from the electrical source. The human body is a good conductor of electricity. If you touch a person while they are in contact with the electrical source, the electricity will flow through your body causing electrical shock. Firstly attempt to turn off the source of the electricity (disconnect). If the electrical source can not readily and safely be turned off, use a non-conducting object, such as a fibre glass object or a wooden pole, to remove the person from the electrical source.

As an Employer it is YOUR responsibility to ensure:

Extension cables and other flexible leads which are particularly prone to damage to plugs and sockets and to their connections are visually checked, maintained and where necessary replaced before using portable equipment. The ends of flexible cables should always have the outer sheath of the cable firmly clamped to stop the wires (particularly the earth) pulling out of the terminals

- Use the correct cable connectors or couplers to join lengths of cables together and do not allow taped joints.
- Electrical installations are installed and maintained by a competent person and checked regularly
- Socket Outlets are not overloaded by the use of adaptors
- Electrically powered equipment provided is suitable for use
- Fixed electrical equipment should have a clearly identified switch to cut off power in an emergency that portable equipment labelled as being double insulated has had the live and neutral connected properly to the plug by a competent person unless the plug is of a moulded type.

- **Content / topic 2: Safety signs of protective devices.**

During your domestic plumbing career, you will spend time on various domestic building, construction sites. All sites are potential hazard areas.

Any site you enter will display safety signs and Safety signs are designed to keep visitors and workers safe, pass on useful information (regarding exits, fire extinguishers, etc) and to warn personnel about possible dangers they may be exposed to during their time on site.

There are four groups of safety signs:

- Mandatory signs
- Prohibition signs
- Warning signs
- Information signs.

Mandatory signs
These signs are circular and show white symbols on a blue background and it always shows What must be done by all site personnel at the site e.g. wear head protection and many others.

Prohibition signs
These signs are circular and show black symbols on a white background,
The signs also have a red border with a red line passing through the centre of the circle.

Warning signs

These signs are triangular in shape, have a black border and show black symbols on a yellow background and it shows potential dangers, e.g. flammable material.
Meaning: warns of hazard danger

Information signs
These signs are square or rectangular in shape and show white symbols on a green background. And it shows information usually relating to access or health and safety, e.g. first aid.


Mandatory Signs


Prohibition signs


Warning signs


Information signs

1. Warning signs

2. Mandatory Signs

3. Prohibition signs

4. Information signs

- **Content / topic 3: Precautions of working on site**

Below are safety precautions to take when working with electricity

1. Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of electric current.

2. Never use equipment with frayed cords, damaged insulation or broken plugs.

3. If you are working on any receptacle at your home then always turn off the mains. It is also a good idea to put up a sign on the service panel so that nobody turns the main switch ON by accident.

4. Always use insulated tools while working.

5. Electrical hazards include exposed energized parts and unguarded electrical equipment which may become energized unexpectedly. Such equipment always carries warning signs like "Shock Risk". Always be observant of such signs and follow the safety rules established by the electrical code followed by the country you're in.

6. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.

7. Never try repairing energized equipment. Always check that it is de-energized first by using a tester. When an electric tester touches a live or hot wire, the bulb inside the tester lights up showing that an electrical current is flowing through the respective wire. Check all the wires, the outer metallic covering of the service panel and any other hanging wires with an electrical tester before proceeding with your work.

8. Never use an aluminum or steel ladder if you are working on any receptacle at height in your home. An electrical surge will ground you and the whole electric current will pass through your body. Use a bamboo, wooden or a fibre glass ladder instead.

9. Know the wire code of your country.

10. Always check all your GFCI’s once a month. A GFCI (Ground Fault Circuit Interrupter) is a RCD (Residual Current Device). They have become very common in modern homes, especially damp areas like the bathroom and kitchen, as they help avoid electrical shock hazards. It is designed to disconnect quickly enough to avoid any injury caused by over current or short circuit faults.

11. Always use a circuit breaker or fuse with the appropriate current rating. Circuit breakers and fuses are protection devices that automatically disconnect the live wire when a condition of short circuit or over current occurs. The selection of the appropriate fuse or circuit breaker is essential. Normally for protection against short circuits a fuse rated of 150% of the normal circuit current is selected. In the case of a circuit with 10 amperes of current, a 15 ampere fuse will protect against direct short circuits whereas a 9.5 amperes fuse will blow out.

12. Working outside with underground cabling can be dangerous. The damp soil around the cable is a good conductor of electricity and ground faults are quite common in the case of underground cabling. Using a spade to dig at the cable can damage the wiring easily so it is better to dig at the cable by hand while wearing insulated gloves.

13. Always put a cap on the hot/live wire while working on an electric board or service panel as you could end up short circuiting the bare ends of the live wire with the neutral. The cap insulates the copper ends of the cable thus preventing any kind of shock even if touched mistakenly.

14. Take care while removing a capacitor from a circuit. A capacitor stores energy and if it’s not properly discharged when removed it can easily cause an electric shock. An easy way to discharge low voltage capacitor is that after removal from the circuit is to put the tip of two insulated screw drivers on the capacitor terminals. This will discharge it. For high voltage ones a 12 Volts light bulb can be used. Connecting the bulb with the capacitor will light up the bulb using up the last of the stored energy.

15. Always take care while soldering your circuit boards. Wear goggles and keep yourself away from the fumes. Keep the solder iron in its stand when not in use; it can get extremely hot and can easily cause burns.

- **Content / topic 4: Condition of working smart**

When working in the workplace it is necessary to:

- ✓ Wear PPEs
- ✓ Ask what is not clear or new
- ✓ Follow the safety precautions of workplace

- **Content / topic 5: Recovering from electrical accidents**

A person receiving the electric shock may also sustain burns when the current passes through his body. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally-unaided.

Treatment of electric shock:

- Switch off the power.
- Remove the victim from the contact with live conductor.
- Make the patient lie down and rest.
- If possible raise the injured part above the level of the body.
- Apply pressure to the wound.
- Summon assistance.

Safety practice for electrical shock

i) Remove victim from power supply

- The severity of an electric shock will depend on the level of current, which passes through the body, and the length of time of contact in the event of an electrical shock, do not delay, and act at once. Make sure that the electric current has been disconnected, if the casualty is still in contact either by switching off the power, removing the plug or wrenching the cable free. If not, stand on some insulating material such as dry wood, rubber or plastic, or using whatever is at hand to insulate yourself and break the contact by pushing or pulling the person free .

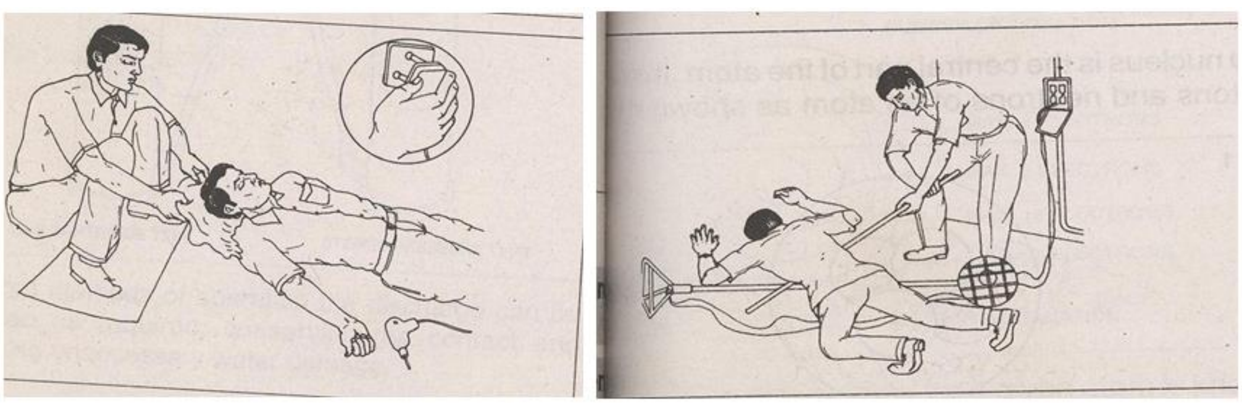


FIGURE: REMOVE VICTIMS FROM POWER SUPPLY

- If you remain un insulated, do not touch the victim with your bare hands or any parts of your body until the circuit is made dead or he is removed away from the equipment. If the victim is loft, measures must be taken to prevent him from falling or at least make him fall safe. Electrical burns on the victim may not cover a big area but may be deep seated. All you can do is to cover the area with a clean sterile dressing and treat the victim for electric shock. Get expert help as quickly as possible.

ii) Artificial breathing

If the victim is unconscious, check the breathing, loosen his clothing and place him on his side; Shout for or signal for medical attention. If breathing has stopped, do not delay; place casualty on his back, loosen neck clothing, remove false teeth (if any) and blow firmly into his mouth at repeated intervals, keeping his nose pinched. Arrangement should be made to get casualty to hospital as soon as possible and full details of the accident should be reported to the relevant personnel.

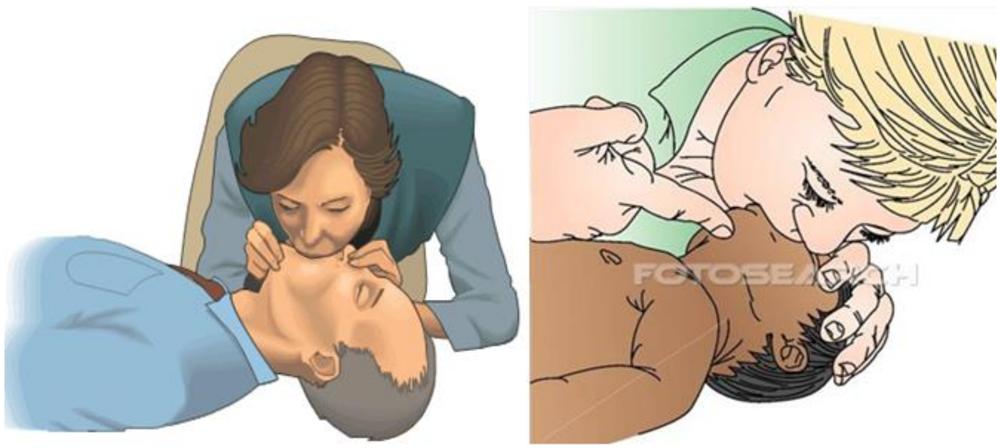


FIGURE: ARTIFICIAL BREATHING

iii) To control severe bleeding

Immediate action: Always in cases of severe bleeding:

- Make the patient lie down and rests
- If possible, raise the injured part above level of the body
- Apply pressure to the wound
- Summon assistance

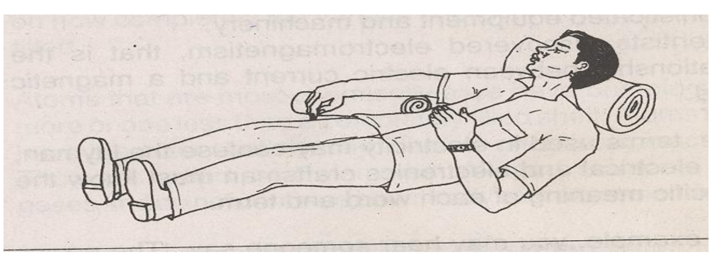


FIGURE: MAKE THE PATIENT LIE DOWN TO REST

Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding. When the bleeding has stopped, put a dressing over the wound, and cover it with a pad of soft material.

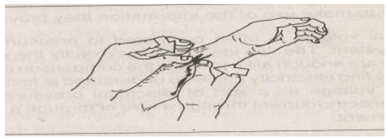


FIGURE: ***SQUEEZE TOGETHER THE SIDES OF THE WOUND***

For an abdominal stab wound, such as may cause by falling on sharp tool, keep the patient bending over the wound to stop internal bleeding.

For a large **wound:** Apply a clean pad (preferably an individual dressing) and bandage firm in place. If bleeding is very severe apply more than one dressing.

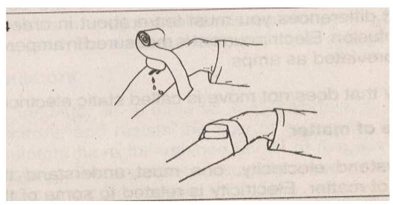


FIGURE: APPLY A CLEAN PAD AND BANDAGE FIRM IN PLACE

LO.2.2. select materials, tools and equipment in accordance with the installation to be done

Content / topic 1: Equipment:

- ✓ **Multimeter**

A digital multimeter is the best choice for your first multimeter, even the cheapest will be suitable for testing simple projects and I recommend this one from Rapid Electronics: Digital Multimeter (basic) This has all the ranges required for testing simple projects: DC voltage, DC current (including a useful 10A range), resistance, diode test and AC voltage.

- ✓ **Lamp tester :**is a piece of electronic testing equipment that is used to carry out essential lighting equipment tests.it is a simple and cost-effective way of safety establishing the presence of voltage in lamps and testing filament continuity.
- ✓ **Phase sequence tester**

Phase sequence meter is used for detecting the sequence of the supply in three-phase electric circuits. Since the direction of rotation of three phase electric motors can be changed by changing the phase sequence of supply. And also the correct operation of measuring instruments like 3 phase energy meterand automatic control of devices also depend on the phase sequence.

✓ **megohmmeter**

A megohmmeter is a high resistance meter dedicated to measure an ohmic value under a direct voltage of great stability

To measure a high value resistance, techniques for measuring a low value current are used. A constant voltage source (DC Voltage) is applied to the resistance to be measured and the resulting current is read on a highly sensitive ammeter circuit that can display the resistance value (in MΩ, GΩ, TΩ)

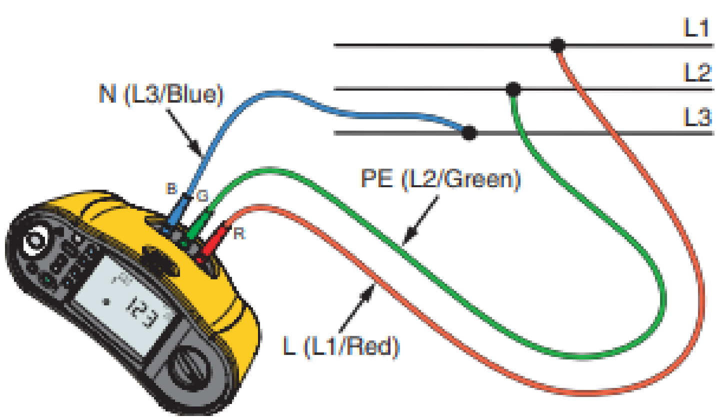
A Megohmmeter is also called a high resistance tester, a teraohmmeter , a megger, a high insulation tester

✓ **Polarity checker plug**

Ensuring that your electronics are connected to the AC line with the correct polarity is essential if you want to realize the full potential of your system. What follows is a simplified explanation of the phenomenon, and a description of a simple method of determining the proper connection of the power cord for any piece of equipment in your system.

- ✓ **Multi-function tester**

  Multi-function tester Is an electronic device used by electricians to test electrical circuit that used the low voltages.



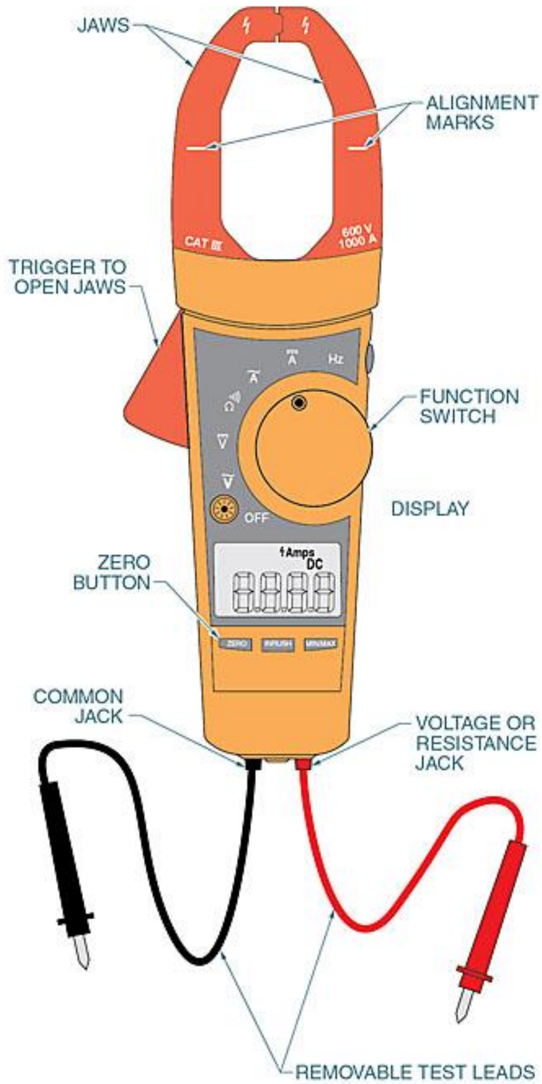
- ✓ **Clap-on ammeter**

A clamp-on ammeter is a meter that measures the current in a circuit by measuring the strength of the magnetic field around a single conductor. Clamp-on ammeters measure currents from 0.01 A or less to 1000 A or more.

A clamp-on ammeter is normally used to measure current in a circuit with over 1 A of current and in applications in which current can be measured by easily placing the jaws of the ammeter around one of the conductors.

Most clamp-on ammeters can also measure voltage and resistance. To measure voltage and resistance, the clamp-on ammeter must include test leads and voltage and resistance modes.

CLAMP-ON AMMETERS



- **Content / topic 2: Materials**

Wires	Lamps	Lamp holder	Conduit
 Used to conduct current	 Used for lighting purpose	 Accommodate lamps and permit	 Used to provide mechanical

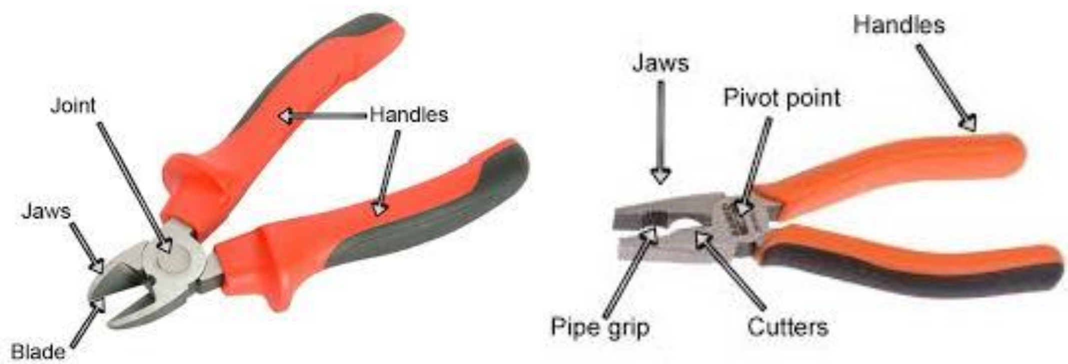
		connection between lamp and wires.	protection of wires and cables
Cable  Used to conduct electrical power	**Switches**  Used to switch the follow of current in electrical installation	**Outlet socket**  Used to power the electrical appliance	Junction box  Provide cover where wire are connected together
Trunking  Used to provide mechanical protection of wires and cables	**Wire clips**  Used to hold wires on wall or on wood in surface installation	**Wooden screws**  Used to fix different accessories like junction box, switches, circuit breakers and so on securely	**Insulation tape**  Used to insulate the wires after their connection to avoid short circuit between live and neutral and electrocution
Circuit breakers 	Fuse 		

Used for electrical installation protection	Used for electrical installation protection		

- **Content / topic 3.Hand tools:**

  - ✓ **Pliers**

Figure: Parts of pliers



- ✓ **Wire strippers**

- Stripping insulation from conductors
- Cutting small conductors
- Crimping wire lugs

- ✓ **Side cutter pliers** (Lineman's pliers)

- Cutting large conductors
- Forming loops on large conductors
- Pulling and holding large conductors

- ✓ **Diagonal pliers** (dykes)

- Cutting small conductors

- Cutting conductors in limited spaces

✓ **Needle-nose pliers**

- Forming loops on small conductors
- Cutting and stripping small conductors

✓ **Combination pliers:**

- Cutting and gripping wires

✓ **Screwdrivers**

Screwdrivers and nut drivers

Electricians need several screwdrivers and nut drivers to work with various types of fasteners and applications.

Categories of screw drivers

Figure: Parts of screw driver

a) Flat-blade screwdriver

Installing and removing slot-head screws

b) Phillips screwdriver

Installing and removing phillips-head screws

c) Rotating speed screwdrivers

Used for trim work, installing switch and receptacles

d) **Star screwdrivers:**

Installing and removing special screws with special heads

- ✓ **Electrical knife**

- Opening paper cartons
- Stripping cables and large conductors

- ✓ **Measuring tape**

- Measuring conduit and cable

- ✓ **Sprit level**

Indicate whether a surface is level on horizontal and vertical planes

- **Content / topic 4: Power tools: Crimping tools**

- ✓ **Drilling machine**

- ✓ **Electrical screw driver**

LO2.3. fix consumer control unit according to the standard height

Content / topic 1. Different Types of Consumer Unit

We will deal with the two main types of consumer unit found in the home today.

- ✓ **Single Load Board**

The first one is a single load fuse board where the power coming in is taken through a double pole switch to a live bus bar. Each fuse, or MCB, is clipped onto a DIN bar and the "teeth" of the bus bar are inserted into the MCB's. The cables to the house circuits are connected to the other side of the MCB's.

A consumer unit can use an RCD as the main switch. This will protect all circuits but if the RCD trips, so do all circuits.

An RCBO consumer unit has one main switch but each circuit is protected by an RCBO which is a combination of an MCB and an RCD. This allows protection in full for all individual circuits and if one trips, all others will still work. As this option is expensive it is only usually used where space is tight for the enlargement of a consumer unit as has to happen when updating to a dual RCD unit.

- ✓ **Split Load Board**

A split load board is designed for total safety and incorporates an RCD (Residual Current Device, The split board which has one RCD is a simple version to show the user how the board works.

An RCD is a manually operated isolator switch, but it is also an automatic safety device that will trip and cut off as soon as it senses an earth fault.

There are a number of different ratings for current and sensitivities to current leakage available, so you will need to understand which are the appropriate ratings for your home. RCD's also work by detecting an imbalance between the Live and the Neutral conductors and this feature is a requirement for all Class 2 double insulated equipment.

- ✓ **High Integrity Boards**

A high integrity consumer unit works simply through the circuits being separated through three natural bars. These neutral bars mean that two RCDs can be used along with a bank of RCBO's.

This design is particularly useful for the home owner as non-mission critical circuits such as lighting can run through the RCD's while protecting mission critical circuits via the RCBO's. For example if there was a problem with an appliance such as the freezer this will have no affect the smoke detectors in the home.

- ✓ **Garage consumer units**

The phrase "garage consumer unit" is merely given to small consumer units and is not solely confined to the garage. It basically implies that any environment that has a small number of circuits would use a garage consumer unit such as garages, sheds and outhouses as they do not need a large fuse board that would be used in a house.

The garage consumer unit itself usually is between two and five way depending on what they are needed for. For example a shed with a few sockets and some lighting would use a two way unit however a larger building such as a workshop with lots of tools and lights would need a five way unit.

• Content / topic 2:.Steps for fixing CCU

- ✓ **Measuring**

Electrical measurements are the methods, devices and calculations used to **measure electrical** quantities. **Measurement** of **electrical** quantities may be done to **measure electrical** parameters of a system. ... **Electric** current. **Electrical** resistance and **electrical** conductance

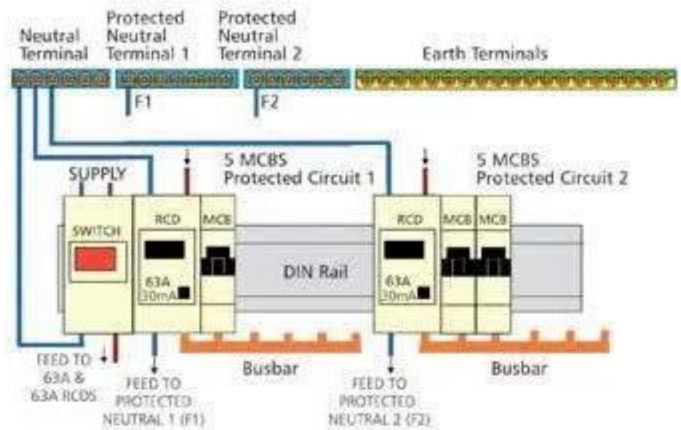
- ✓ **Marking**

Mounting bracket for marking tape
With the mounting bracket you attach the marking strip for sector limitation easily and quickly on the lawn. We recommend a distance of about 2 meters between the angles.

- ✓ **Fixing**

All the cables and connections in your consumer unit need to be checked and tested by a qualified electrician, and you should not remove or replace your unit if you are not qualified to proper regulatory standards. That said, the basics of installation can be handy to learn if you need to identify any problems, and it always helps qualified professionals to have something to turn to.

1. Firstly, make sure you disconnect the power supply, then review the following simple diagram outlining the basic setup of a split load board and take heed of the following basic instructions for connections.



2. The mains double pole isolating switch is clipped into place along the DIN bar using separate teeth of the bus bar. The MCBs are then inserted themselves, and the bus bar is then placed into the live terminal at the bottom, thereby providing a live feed to all the MCBs and to all the circuits across your property that they control.
3. The live and neutral wires come into the main double pole switch from your electricity meter. Taken together, these two cables are referred to as 'tails'; their size will vary, which is just one reason why it should be considered so important for consumer units to be fitted by professional electricians. The earth cable also extends from the meter, but this cable will be screwed into the earth terminal block as opposed to the mains switch.
4. A circuit cable can then be introduced to the consumer unit. The live cable is fixed into the top of an MCB, while the neutral cable is screwed into the RCD neutral terminal block. The earth cable is then fed into the consumer unit and connected up to the appropriate MCB.

Again, it must be stressed that these instructions should only be followed by a certified electrician. Trying to install or rewire your own consumer unit without proper certification is not a step you can take; beyond the legal ramifications, you will put yourself at risk of shock and possibly put your property in danger by accidently removing proper safeguards.

Consumer units are a small part of a residential property, and one that is seldom noticed until the electricity mysteriously turns off. Armed with the information provided above, you'll now be able to diagnose the problem and probably sort it out by yourself without needing to call on the services of a professional. Of course, you'll also understand when a certified electrician needs to be contacted and why performing certain consumer unit jobs yourself is more than a little unwise.

LO.2.4: Fix distribution box according to the standard height

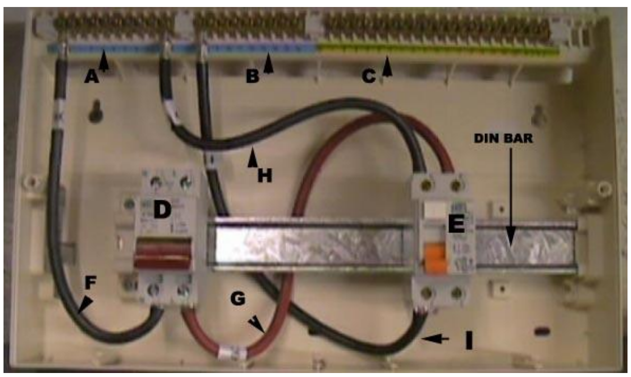
Content / topic 3: Types of distribution board

- ✓ **Single load board**

In the single load board, The first one is a single load fuse board where the power coming in is taken through a double pole switch to a live bus bar. Each fuse, or MCB, is clipped onto a DIN bar and the "teeth" of the bus bar are inserted into the MCB's. The cables to the house circuits are connected to the other side of the MCB's.

All of this is explained more thoroughly when we deal with the second type of unit, which is the split load unit.

The figure below is of a split load fuse board. The ordinary consumer unit is exactly the same in principle without the RCD.



The key to the above image is:

A: Neutral terminal block for the main isolating switch side of the unit

B: Neutral terminal block for RCD side of the unit

C: Earth terminal block (takes both sides of unit)

D: Main double pole isolating switch

E: Generally 80 – 100 Amp RCD with 30mA (milliamp) sensitivity

F: Neutral link cable from Main switch to terminal block

G: Live feed from main switch to RCD

H: Neutral link cable from main terminal block to RCD

I: Neutral link cable from RCD to RCD neutral terminal block

Under the 17th edition regulations it is required that every socket is protected by an RCD. This can be done in 3 ways. A consumer unit can use an RCD as the main switch. This will protect all circuits but if the RCD trips, so do all circuits. A dual RCD consumer unit can be fitted. This unit has one main switch, two RCDs and each circuit has its own MCB.

This allows the circuit to be divided into two, usually one upstairs, one down.

This protects all areas including showers and cookers, but if one trips the other will ensure at least some lights and some sockets still work.An RCBO consumer unit has one main switch but each circuit is protected by an RCBO which is a combination of an MCB and an RCD.

This allows protection in full for all individual circuits and if one trips, all others will still work.

As this option is expensive it is only usually used where space is tight for the enlargement of a consumer unit as has to happen when updating to a dual RCD unit.

Just as a matter of interest, DIN stands for Deutsche Industry Norm and, originating in Germany, is any of a series of technical standards, used internationally, to designate electrical connections, film speeds and paper sizes.

Shown in the consumer unit casing above, it is a metal, pressed bar, to which the MCB's clip. They simply push on via a spring loaded lock at their back.

- ✓ **Sprit load board**

A split load board is designed for total safety and incorporates an RCD (Residual Current Device, shown as E in the picture above) as well as the double pole switch (D).

The split board shown here has one RCD and is a simple version to show the user how the board works. An RCD is a manually operated isolator switch, but it is also an automatic safety device that will trip and cut off as soon as it senses an earth fault.

There are a number of different ratings for current and sensitivities to current leakage available, so you will need to understand which the appropriate ratings for your home are.

RCD's also worked by detecting an imbalance between the Live and the Neutral conductors and this feature is a requirement for all Class 2 double insulated equipment.

As they are very sensitive, it is not practical to fit one RCD to protect the whole house.

If a fault develops on one circuit, all circuits would be switched off immediately. This would, most often, leave you in the unnecessary position of having no lights or power.

• Content / topic 2: Identification of distribution board

- ✓ **Switchgear distribution board**

Switchgear

Definition: The apparatus used for controlling, regulating and switching on or off the electrical circuit in the electrical power system is known as switchgear. The switches, fuses, circuit breaker, isolator, relays, current and potential transformer, indicating instrument, lightning arresters and control panels are examples of the switchgear devices.

The switchgear system is directly linked to the supply system. It is placed in both the high and low voltage side of the power transformer. It is used for de-energizing the equipment for testing and maintenance and for clearing the fault.

Working principle

When the fault occurs in the power system, heavy current flow through equipment due to which the equipment get damaged, and the service also get interrupted. So to protect the lines, generators, transformers and other electrical equipment from damage automatic protective devices or switchgear devices are required.

The automatic protective switchgear mainly consists of the relay and circuit breaker. When the fault occurs in any section of the system, the relay of that section comes into operation and closes the trip circuit of the breaker which disconnects the faulty section. The healthy section continues supplying loads as usual, and thus there is no damage to equipment and no complete interruption of supply.

Switchgear has two types of components:

Power-conducting components: These conduct or interrupt the power flow; such as switches, circuit breakers, fuses, isolators, relays, lightning arrestors, and so on.

Control systems: These monitor, control and protect the power-conducting components; such as control panels, current transformers, potential transformers, associated circuitry, and so on.

Although the circuit breaker is the main component, it is the combination of equipment within the switchgear enclosure that allows high voltage currents to be interrupted.

Switchgear is directly linked to the supply system and, based on the voltage level, can be classified as either:

- Low voltage switchgear (LV).
- Medium voltage switchgear (MV).
- High voltage switchgear (HV).

Switchgear can be a simple open-air isolator switch or can be insulated in another substance such as oil, pressurized sulphur hexafluoride gas, or insulated in a vacuum.

Lower voltage switchgear can be enclosed within a building, however, higher voltages (approximately over 66 kV) usually require the switchgear to be externally mounted and insulated by air.

- ✓ **Without switchgear distribution board**

The switchboard refers to a large single panel, assembly of panels, a structural frame or assembly of structural frames, on which buses, switches, and protective and other control devices may be mounted. The mounting may be done on the face, the back side, or both.

The electrical distribution equipment is designed to redirect and control the flow of electricity from one or multiple sources, to several different sections or loads. A switchboard can therefore be used to distribute power to individual loads, control equipment, transformers, panel boards etc.

The main role of the switchboard is to allow the incoming electric power to be divided into smaller independent circuits according to their current requirements. The circuit breakers as well as over current protection devices for each of the sections are selected according to the load current.

Once the currents are divided, they are then distributed according to the load i.e. lighting loads, sockets etc. Some switchboards such as those used in residential apartments have an option of metering to see the amount of power used by individual circuits.

- **Content / topic 3 : Steps for fixing distribution board**

✓ **Measuring**

Electrical measurements are the methods, devices and calculations used to measure electrical quantities. Measurement of electrical quantities may be done to measure electrical parameters of a system. ... Electric current. Electrical resistance and electrical conductance

✓ **Marking**

Mounting bracket for marking tape
With the mounting bracket you attach the marking strip for sector limitation easily and quickly on the lawn. We recommend a distance of about 2 meters between the angles.

✓ **Fixing**

The neutral is also further distributed to various sides from the neutral link. One or two spare sub circuits of the same capacity should be provided on each distribution board and branch distribution board for future requirement.

The current rating of circuit, size of fuse element and detail of circuits controlled by each distribution board should also be marked.

Strip the wire only enough to make the connection to the main breaker terminal lugs. The black and red wines are the feeder wires in this photo with the black wires being one of the hot feeds and the red wires being the other.

Steps to Install electrical distribution board

- You must have to install the feeder pipe at first.
- Install the connector into the panel

- If you’re using metal pipe, place a plastic bushing over the connector threads.
- Level the panel and insert screws through the holes provided in the back of the panel
- Using a tape, pull the electrical feeder wires through the feeder pipe.
- Leave enough wire to get to the opposite side of the panel.
- Bend the two black wires to shape them for easy installation to the main breaker.
- Excess bare wire leaves a safety hazard where the wires can come in contact with other wires and cause a short circuit.
- Connect the neutral wire to the neutral buss. The neutral buss is located on either side of the breakers. It is a silver-colored bar with many smaller screws and connection points
- Connect all of the green and bare copper wires to the ground buss bar.
- If you bend the wires ahead of time, you’ll have a nice, neat wire installation that looks uniform.
- Next, install the circuit feeds to the branch circuit breakers.
- Connect the appropriate sized wire to the correctly rated breaker. Bend the wires so that they keep a neat appearance when the installation is complete

L.O 2.5: Install the fuses and circuit breakers based on the wiring diagram

- **Content / topic 1.connecting fuses and circuit breakers**

  ✓ **Installation procedure**

  1. **Selection of circuit breaker and fuse**

The selection of fuse and/or Circuit Breaker will depend on preferences and on the installation in question. Sometimes it is necessary to combine the two. Fuses A nonrenewable fuse interrupts excessive current by clearing. Fuses are selected to allow passage of normal current and of excessive current only for short periods. After clearing, the fuse must be replaced.

Selecting the proper sized circuit breaker is an important step in this process. The control wiring is dependent on the circuit protective device to protect it from overload. Sizing the breaker is based on the circuit load and ampacity of the wire. The load is typically much less than the ampacity of the wiring. Therefore, the load will typically determine the size of the circuit protective device.

2. Locate circuit breaker or fuse mounting points

The main panel also includes some type of mechanical device for disconnecting the house's electrical circuits from the incoming power. In most contemporary systems, this device is a circuit breaker or simply "breaker." A circuit breaker is a switch that may be shut off manually or be tripped automatically by a failure in the electrical system—usually an overload that could cause the wires to heat up or even catch fire.

Main electrical panel contains primary circuit breakers and individual breakers.

Other types of disconnects utilize levers and fuses—you pull down on a lever or pull out a fuse block to shut off the power to the house's circuits.

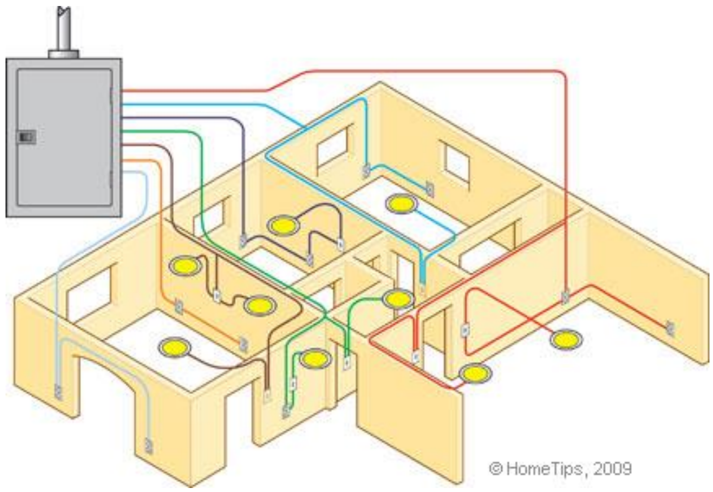
The maximum amperage that a service panel may deliver at one time is marked on the main breaker. For most homes, a 100-amp main is sufficient to handle all electrical needs; however, many new-home builders now install 150-amp or 200-amp services to ensure plenty of capacity. Electrical service panels rated at 60 amps or lower are undersized for contemporary needs.

Every circuit breaker is rated for the type of wire and load required by its circuit. The most typical capacities for lighting and receptacle circuits are 20-amp and 15-amp. Standard breakers for 120-volt circuits take one slot.

Breakers for 240-volt circuits take two slots. Though the typical 220 breaker is twice as fat as a standard breaker, some manufacturers make extra-thin breakers that take only half the space of standard breakers. Large-capacity circuit breakers are used for electric appliances such as ovens, water heaters, clothes dryers, and air conditioners, which draw a lot of power.

Subpanels and Branch Circuits

Larger circuit breakers may also connect to secondary panels, called subpanels. Subpanels have their own set of circuit breakers and power specific appliances or areas of the house. A subpanel is often located in a different part of the house. You might, for example, find one near your home's air conditioner.



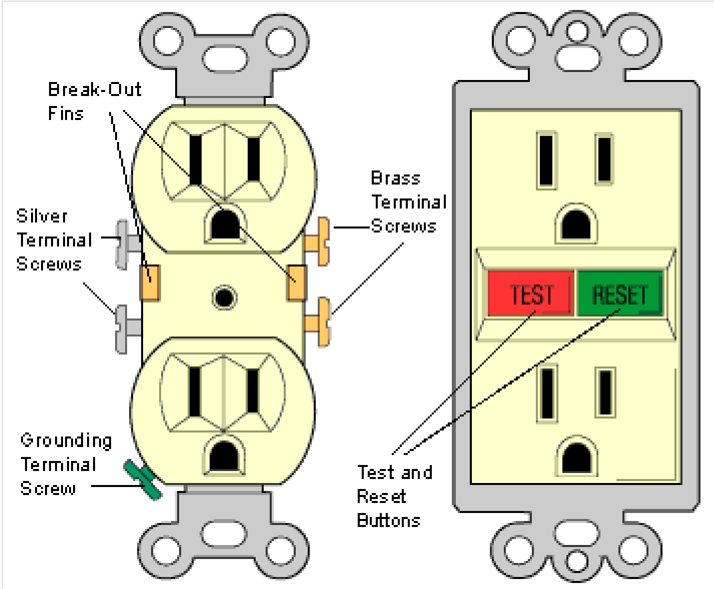
A Typical Home's Branch Circuits

The circuits that deliver electricity to the various areas of a home are referred to as branch circuits. Branch circuits originate at a service distribution panel—either a main panel or a subpanel.

For a deeper dive into electrical panels, see **Electrical Service Panels and Circuit Breakers: How They Do Their Job**. For information on wiring, see **Home Electrical Wiring**.

Outdoor Circuits

Outdoor, kitchen, and bathroom electrical receptacles should be protected by a special ground-fault circuit interrupter (GFCI) circuit breaker to guard against electrocution. Because it is highly sensitive to any short, this type of breaker may need resetting more frequently than standard breakers and should be tested periodically.



Standard Outlet (left) and GFCI Outlet (right)

If a home electrical circuit it supplying power to just a few outdoor receptacles, you can protect those receptacles by installing special GFCI receptacles.

However, **do not keep replacing a fuse if it blows immediately after you replace it.** In these instances, call a qualified biomedical equipment technician to service the equipment.

A fuse is essentially a short piece of wire of a selected diameter and composition so that it conducts current up to a certain level, but melts or 'fuses' if the current rises above that level. It becomes an open circuit when it blows, interrupting the flow of current and preventing damage.

In most cases, the fuse wire is mounted inside a small glass or ceramic tube, fitted with metal end caps. The glass tube forms a physical guard for the fuse, so that when it blows the molten metal does not cause damage or injury. A glass tube allows you to see when the fuse has blown: there will be a gap in the wire or a metallic smear on the inside of the glass

3. **Connect the circuit breaker or fuse**

Basic Steps for Installing a Circuit Breaker

The main reason for installing a new circuit breaker in an existing home is to take some of the load off of another circuit breaker. If one circuit breaker connects to too many electrical devices then it's best to simply install another circuit breaker to split the burden.

Here is a step-by-step on how to install a circuit breaker:

a. **Shut Off the Power at the Main Panel**

It is extremely important to make sure the circuit breaker panels or sub-panels do not have any live wires

b. **Open the breaker panel once the power is shut off**

The large black wires that feed the main breaker will still be live. Therefore, you need to test the incoming wires with an electrical tester to make sure there is no electrical current in the wires that you will be touching. This will help you make sure it is safe to begin installation.

c. **Install a New Cable Clamp**

Locate the knockout around the panel and use a screw driver to hammer one of the knockouts so that you can screw the cable clamp in

Next, run the new wire to the circuit panel and cut the wire off the jack to the circuit clamp

d. **Connect the Ground Wire into the Ground Bar**

The ground wire is the wire without insulation. The tightening should be done carefully in order to prevent the wire from breaking

e. **Place the Neutral Wire into the Neutral Bus**

Cut off the insulation around the end of the wire and slide the bare wire into the neutral bus, tightening it gently

f. **Install the Actual Circuit Breaker Device**

Loosen the screw on the bottom of the breaker and place the last wire under the screw – this wire will be black

When the black wire is in place, tighten the screw and hold the wire in place. Use the three prongs on the backside of the circuit breaker to hold it in position

Align the breaker in the space and push the prongs in. Make sure the breaker is secure

g. **Remove the knockouts from the panel cover.**

Place it over the circuit panel in order to secure and protect all of the circuit breakers.

4. Remove all foreign objects

During installation of CB (e.g.: air circuit breaker)

- Do not use the interlock in areas that are subject to high temperatures, high humidity, dusty air, corrosive gasses, strong vibration and shock. Using the interlock in these conditions may cause a malfunction.
- Care should be taken to prevent foreign objects (such as debris, concrete powder, dust, chippings), oil and rainwater from entering the interlock. Using the interlock in these conditions may cause a malfunction.

5. Test the circuit breaker or fuse

Circuit Breaker Tester: Multi-meter

The multi-meter circuit breaker tester combines the characteristics of a voltmeter and the ohmmeter in one. This multipurpose circuit breaker testing device has multiple functions. Like the voltmeter it measures the level of voltage in the circuit and also measures the continuity and resistance level (ohmmeter). Obtaining information about both electrical readings can help pinpoint circuit breaker problems quickly and accurately so that repairs can be made.

6. Label all circuit breaker or fuse

Why it is Necessary to Label the Circuit Breaker Box?

Whether you've rented an apartment or own a home, it is very important that you understand the fundamentals of the electrical system installed in your home. You should know what to do in case something goes wrong. This information is crucial when you need to shut off a circuit for repair, when you need to reset the circuit breaker after it has tripped or in case of an emergency. The circuit breaker is your main component to begin with because it controls the supply of power to the different areas of your property.

When the power trips in just one area of your home, the cause is a tripped breaker panel. If you take a closer look at the circuit breaker box, you will see that one switch has flipped in the other direction. Labeling a circuit breaker will help you confirm which circuit breaker has tripped without having to play the guessing game and resetting everything.

The Basic Procedure for Circuit Breaker Box Labeling

If the circuit breaker panel has an index and it is old, pull it out. Do not try to erase or rewrite as it will only create confusion. The things you will need for circuit breaker labeling include sticky labels, paper, tester, and a felt-tipped marker.

Step 1 – Number Every Circuit Breaker

Assign a number to each circuit breaker inside the breaker panel. Start with #1 from your top left and proceed down until you reach the end. Once you reach the end, start again from the top right and go to the bottom.

Use a 1-inch square sticky label and write each number with a marker right next to the breaker it refers to. Draw a diagram on a paper with dimensions 8 X 11 and arrange the numbers exactly as they are on the panel and write a description next to each number.

Step 2 – Locate all the Devices on the Circuit Breaker Box

Shut down all the circuit breakers and start with the first circuit. Check each and every outlet and light fixture installed in your home to determine which one is controlled by which circuit breaker. Tape every outlet and light fixture that has been checked so you don't get confused. Once you have identified all the outlets and fixtures controlled by the first circuit, move on to the next one and repeat the same procedure.

Step 3 – List down the Results

Make a list of all the outlets and fixtures that run with the aid of power when a certain breaker is turned on. Do not assume that every device on a specific circuit breaker will be located in the same room or area. It can also terminate at a receptacle located outdoor and at the same time power your kitchen lights.

By the time you reach to the end of your list, you should have each and every wall switch, light fixture, and outlet identified by its corresponding circuit including the ones that are in your basement and garage.

Step 4 – Test all the Appliance Circuits

As you work your way through the circuit breakers, you will realize that certain circuit breakers are paired. The paired sets control a 240-volt appliance like your furnace, air conditioner, stove, electric dryer, and water heater. Test each paired set to check which appliance is powered by that circuit breaker.

Certain single-pole circuit breakers also power dedicated home appliances like oven, refrigerator, dishwasher, garbage disposer, and microwave. Always use a non-contact voltage tester when you are checking for power because it the easiest and the safest way to do it.

Step 5 – Make an Index

Collate your findings into a comprehensive description of each circuit breaker and label it next to the corresponding number. When describing the areas on the index, make sure you use terms that can be easily understood by a future homeowner. For instance, instead of writing kids bedroom, write southwest bedroom and tape the index on the inside of the breaker panel.

Finally, draw a floor plan that shows the exact location of all the fixtures, outlets and hardwired home appliances so anyone who is working on your home's electrical system finds the information useful in identifying anomalies and making repairs

Leaning unity .3. Install earthing system

LO.3.1. implement hazard control and safety measures related to the installation of earthing system.

- **Content /topic1: Controlling electrical hazards**

To effectively control and prevent hazards, employers should:

a) Involve workers, who often have the best understanding of the conditions that create hazards and insights into how they can be controlled.
b) Identify and evaluate options for controlling hazards, using a "hierarchy of controls."
c) Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.
d) Develop plans with measures to protect workers during emergencies and non-routine activities.
e) Evaluate the effectiveness of existing controls to determine whether they continue to provide protection, or whether different controls may be more effective. Review new technologies for their potential to be more protective, more reliable, or less costly.

Most dangerous consequences of using electricity are electric shock and electric fire. They are usually caused by damaged insulation, overheating of cables or damp conditions.

✓ **Damaged insulation**

- Rubber is used as insulation for the current-carrying conductors of most electrical appliances.
- Rubber insulation is prone to damage due to regular bending and twisting. (Common appliances that bend/twist during usage: Hair dryer and Iron) The rubber insulation might break apart and expose the wire.
- This damaged insulation would result in

1. Electric shock resulting in serious injury or even death to users.
2. Short circuit in the current path by connecting exposed current-carrying conductors together resulting in the wires heating up fire hazard.

✓ **Damaged tools and equipment**

Electrical tools can be extremely hazardous if they become damaged enough to cause the user to contact exposed live wires.

Check the plug carefully, too. If the plug is the three-prong type and a prong is missing or loose, take the tool out of service until it can be repaired by an electrician.

Before using the tool, check the area carefully for objects with sharp edges and other areas where the cord could be pinched, scraped or cut. Avoid these areas whenever possible. If you can't avoid them, take precautions to protect the cord, such as chaffing gear.

Store electric power tools in a waterproof toolbox when they are not in use. Remember that the cords and other parts of tools become weather beaten if not stored properly and insulation can rot away exposing the wire.

Inspect each tool carefully before you use it. If there are cracks, cuts or abrasions on the cord take the tool out of service until an electrician can replace the cord. Don't try to fix it yourself unless qualified to do so.

✓ **Wet conditions**

- Effective body resistance drop drastically from 100 kΩ to 100 Ω under damp condition (wet environment condition). Activities like sweating, bathing and etc lower the effective resistance of our body.
- This damp condition, coupled with unsafe usage of electrical appliances, would result in large currents flowing through our body causing electrical shock and leading to serious injury or even death.

✓ **Overload circuit**

Anytime a load is lifted, the potential for overload is present. Accurate measurement of the load is critical to preventing dangerous overloads. Constant load monitoring provides an additional layer of protection to existing safety protocols and can protect you from overloads that may occur even when the load is known.

An overloaded crane can lead to very dangerous and expensive accidents. Ron Crane Scales can help to control overload and prevent it.

There are few scenarios where catastrophic overloads can occur, even when the load is known:

a. Attempting to lift equipment which has not been separated from its anchor points.
b. Lack of communication between staff members responsible for lifting.
c. Addition of equipment after the load has been calculated and approved.
d. Uneven distribution in a multiple lifting point scenario. Even if the total load does not exceed the total Safe Working Load of all the lifting points together, some of the lifting points may carry less load while others are overloaded.Off-center loading

An overloaded crane can lead to very dangerous and expensive accidents!

Ron Crane Scales help to detect an overload and prevent it, by using Ron load monitoring systems, such as crane scales with overload warning systems, that can be preset to a predetermined weight load which would stop (trigger E-stop) the operation as registered in the system.

- **Content /topic2: Accident prevention:**

✓ Use Personal protective equipment (PPE)

a. Overcoat: designed for the **purpose** of keeping the wearer clearly in view, they make abundant **use** of colors that can always be seen and glow in the dark.

b. Overall: **Overalls** are a type of **safety** clothing made of tough cotton, denim or linen and usually used as protective clothing while working

c. Gloves: a covering for the hand worn for protection against cold or dirt and typically having separate parts for each finger and the thumb.

d. Safety shoes: a **shoe** with a reinforced toe cap to minimize foot injuries caused by dropped articles. With a sole of material incapable of sparking for work near combustibles or explosives.

e. Helmet: are one of the most frequently used forms of PPE. **Safety Helmets** will protect the user's head against: impact from objects falling from above, by resisting and deflecting blows to the head

f. Earmuff: are objects designed to cover a person's **ears** for **hearing protection** or for warmth. They consist of a thermoplastic or metal head-band, that fits over the top or back of the head, and a cushion or cup at each end, to cover the external **ears**.

g. Goggles: are forms of *protective* eyewear that usually enclose or protect the area surrounding the *eye* in order to prevent particulates, water or chemicals from striking the eyes.

h. Nose protection mask: are loose-fitting **masks** that cover the **nose** and mouth, And have ear loops or ties or bands at the back of the head.

- ✓ **Inspect tools and equipment**

The inspection of tools and equipment is a must in order to work safely, that is why a worker, company or organization have to make sure if there is:

✓ Adequate supply of tools and equipment for inspection

✓ Appropriate PPE for inspection according to each job specification.

Overheating of cables.

- Especially thin wire conductors, when very large currents are made to flow through these conductors, these wire conductors will heat up and produce very high temperatures. Short-circuit or overloading of cables are conditions that lead to such large currents.
- This overheating of cables would result in melting of the insulation and catching fire.

LO.3.2: select materials, tools and equipment in accordance with the installation to be done

- **Content /topic1: Equipment:**

✓ **Multimeter**

A digital multimeter is the best choice for your first multimeter, even the cheapest will be suitable for testing simple projects and I recommend this one from Rapid Electronics: Digital Multimeter (basic) This has all the ranges required for testing simple projects: DC voltage, DC current (including a useful 10A range), resistance, diode test and AC voltage.

- **Lamp tester :**is a piece of electronic testing equipment that is used to carry out essential lighting equipment tests.it is a simple and cost-effective way of safety establishing the presence of voltage in lamps and testing filament continuity.

- **Phase sequence tester**

Phase sequence meter is used for detecting the sequence of the supply in three-phase electric circuits. Since the direction of rotation of three phase electric motors can be changed by changing the phase sequence of supply. And also the correct operation of measuring instruments like 3 phase energy meterand automatic control of devices also depend on the phase sequence.

- **megohmmeter**

A megohmmeter is a high resistance meter dedicated to measure an ohmic value under a direct voltage of great stability

To measure a high value resistance, techniques for measuring a low value current are used. A constant voltage source (DC Voltage) is applied to the resistance to be measured and the resulting current is read on a highly sensitive ammeter circuit that can display the resistance value (in MΩ, GΩ, TΩ)

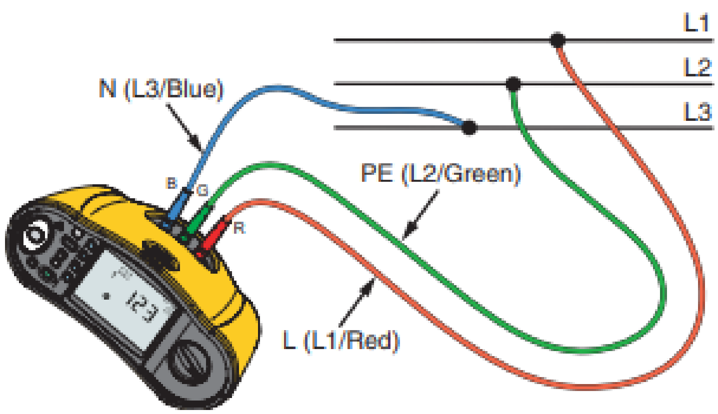
A Megohmmeter is also called a high resistance tester, a teraohmmeter , a megger, a high insulation tester

- **Polarity checker plug**

  Ensuring that your electronics are connected to the AC line with the correct polarity is essential if you want to realize the full potential of your system. What follows is a simplified explanation of the phenomenon, and a description of a simple method of determining the proper connection of the power cord for any piece of equipment in your system.

✓ **Multi-function tester**

Multi-function tester Is an electronic device used by electricians to test electrical circuit that used the low voltages.

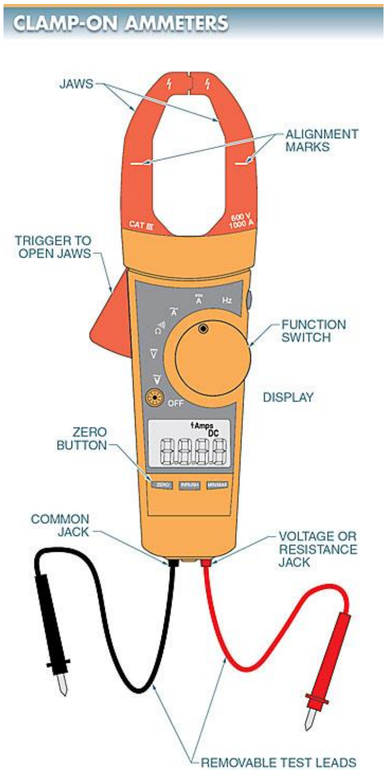


✓ **Clap-on ammeter**

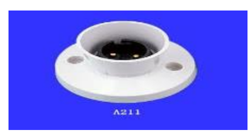
A clamp-on ammeter is a meter that measures the current in a circuit by measuring the strength of the magnetic field around a single conductor. Clamp-on ammeters measure currents from 0.01 A or less to 1000 A or more.

A clamp-on ammeter is normally used to measure current in a circuit with over 1 A of current and in applications in which current can be measured by easily placing the jaws of the ammeter around one of the conductors.

Most clamp-on ammeters can also measure voltage and resistance. To measure voltage and resistance, the clamp-on ammeter must include test leads and voltage and resistance modes.



- **Content / topic 2 :.Materials :**

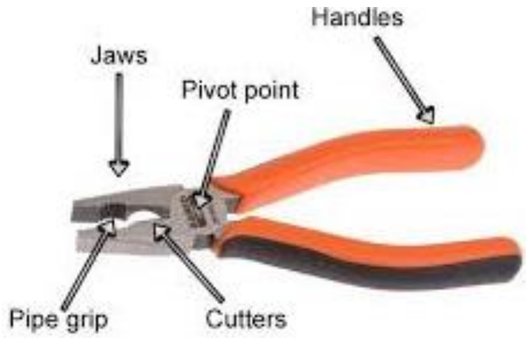
Wires  Used to conduct current	**Lamps**  Used for lighting purpose	**Lamp holder**  Accommodate lamps and permit connection between lamp and wires.	**Conduit**  Used to provide mechanical protection of wires and cables
Cable 	**Switches** 	**Outlet socket** 	Junction box 

Used to conduct electrical power	Used to switch the follow of current in electrical installation	Used to power the electrical appliance	Provide cover where wire are connected together
Trunking  Used to provide mechanical protection of wires and cables	**Wire clips**  Used to hold wires on wall or on wood in surface installation	**Wooden screws**  Used to fix different accessories like junction box, switches, circuit breakers and so on securely	**Insulation tape**  Used to insulate the wires after their connection to avoid short circuit between live and neutral and electrocution
Circuit breakers  Used for electrical installation protection	Fuse  Used for electrical installation protection		

- **Content / topic 3.Hand tools:**

  - ✓ **Pliers**

Figure: Parts of pliers



✓ **Wire strippers**

- Stripping insulation from conductors
- Cutting small conductors
- Crimping wire lugs

✓ **Side cutter pliers** (Lineman's pliers)

- Cutting large conductors
- Forming loops on large conductors
- Pulling and holding large conductors

✓ **Diagonal pliers** (dykes)

- Cutting small conductors
- Cutting conductors in limited spaces

✓ **Needle-nose pliers**

- Forming loops on small conductors
- Cutting and stripping small conductors

✓ **Combination pliers:**

- Cutting and gripping wires

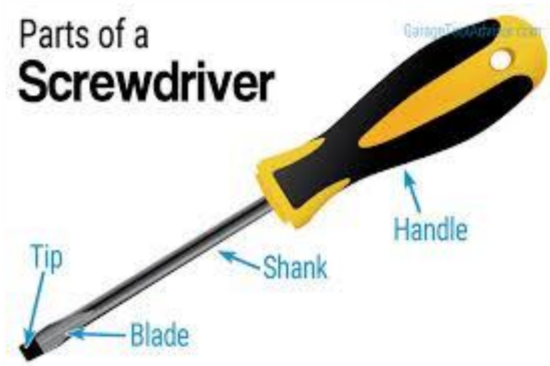
✓ **Screwdrivers**

Screwdrivers and nut drivers

Electricians need several screwdrivers and nut drivers to work with various types of fasteners and applications.

Categories of screw drivers

Figure: Parts of screw driver



a) Flat-blade screwdriver

Installing and removing slot-head screws

b) Phillips screwdriver

Installing and removing phillips-head screws

c) Rotating speed screwdrivers

Used for trim work, installing switch and receptacles

d) **Star screwdrivers:**

Installing and removing special screws with special heads

LO.3.3: perform measurements related to the system installation

- **Content /topic1:.Methods for measuring earth** Resistance

EARTH ELECTRODE RESISTANCE

If we were to place an electrode in the earth and then measure the resistance between the electrode and points at increasingly larger distance from it, we would notice that the resistance increased with distance until a point was reached (usually around 2.5m) beyond which no increase in resistance was noticed . The resistance area around the electrode is particularly important with regard to the voltage at the surface of the ground .

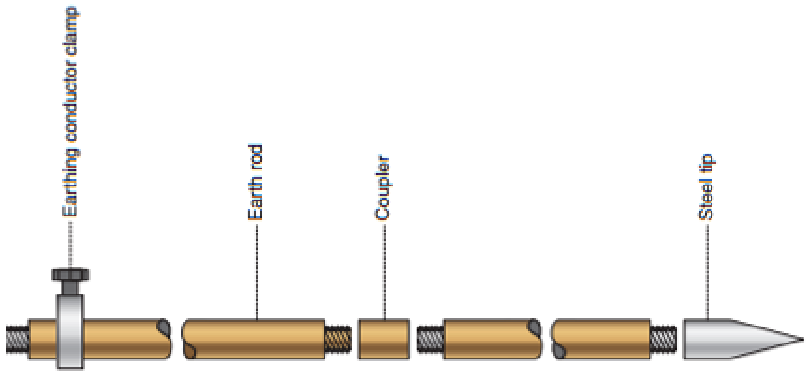


Figure: Earth rod

For a 2m rod, with its top at ground level, 80–90% of the voltage appearing at the electrode under fault conditions is dropped across the earth in the first 2.5 to 3m. This is particularly dangerous where livestock is present, as the hind and fore legs of an animal can be respectively inside and outside the resistance area: a PD of 25V can be lethal. One method of overcoming this problem is to house the electrode in a pit below ground level as this prevents voltages appearing at ground level.

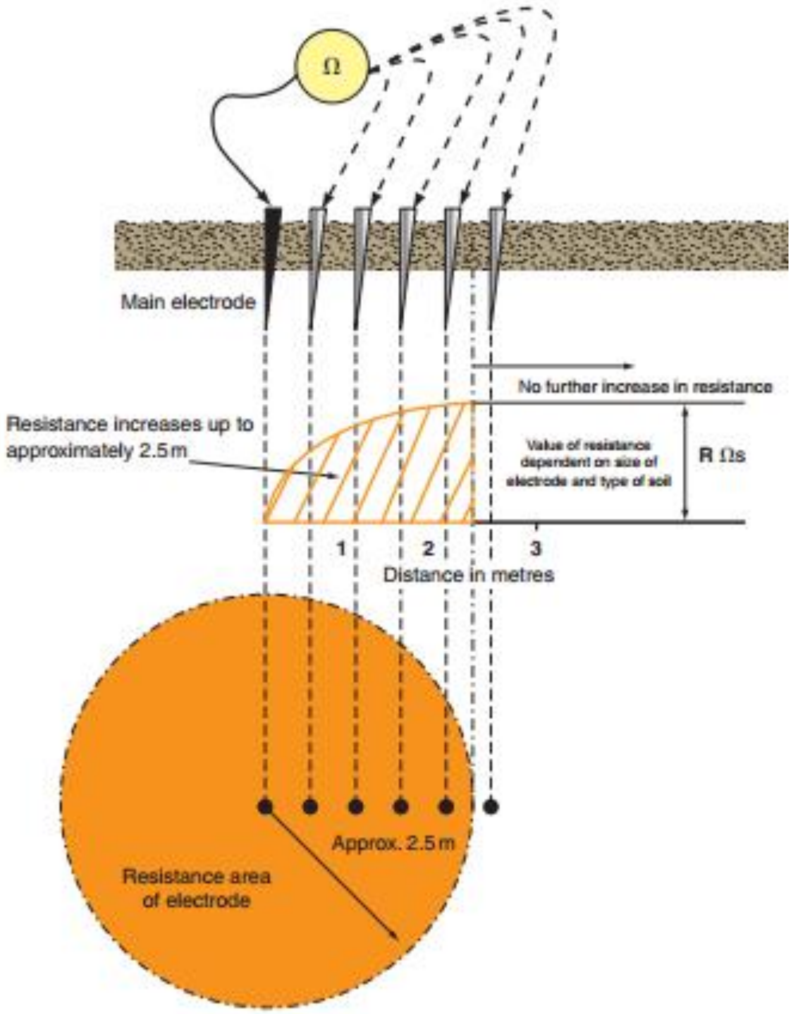


Figure: Earth electrode resistance area

Measurement of Earth resistance

The earth resistance of an earthing system can be measured in the following two ways:

- Potential drop method
- Earth tester method

Potential drop method

In this method, the potential between the earth point and an auxiliary earth electrode measured by passing a defined amount of current through them.

Earth tester method

In this method, earth tester equipment is used for measuring the earth resistance. It has three terminals C, P and E. Terminal E is connected to the earth electrode under testing. Terminal P and C are connected to two auxiliary or temporary earth electrodes.

- ✓ **Single earth electrode**

When an earth electrode system has been designed and installed, it is usually necessary to measure and confirm the earth resistance between the electrode and "true Earth". The most commonly used method of measuring the earth resistance of an earth electrode is the 3-point measuring technique shown in Figure 1.

The most common methods of measuring the resistance of an earth electrode

This method is derived from the 4-point method, which is used for soil resistivity measurements.

The 3-point method, called the **"fall of potential" method**, comprises the Earth Electrode to be measured and two other electrically independent test electrodes, usually labelled P (Potential) and C (Current). These test electrodes can be of lesser "quality" (higher earth resistance) but must be electrically independent of the electrode to be measured.

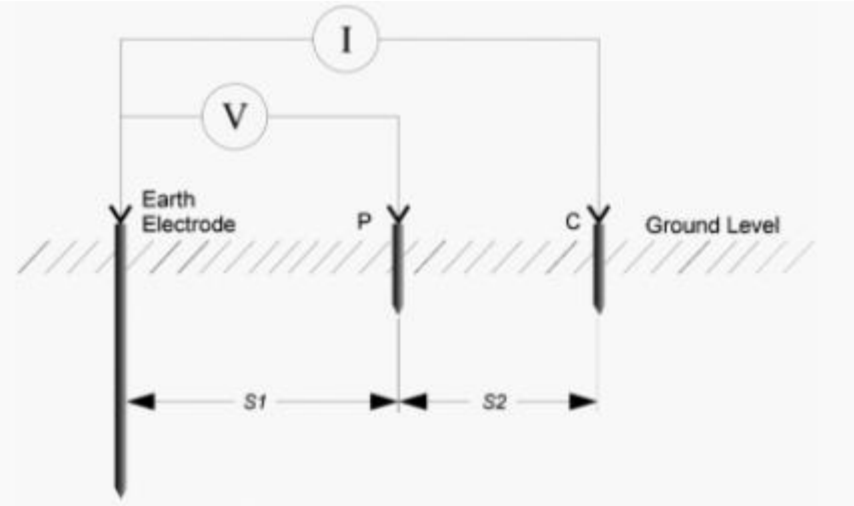


Figure 1 – The 3-point Method of Earth Resistance Measurement

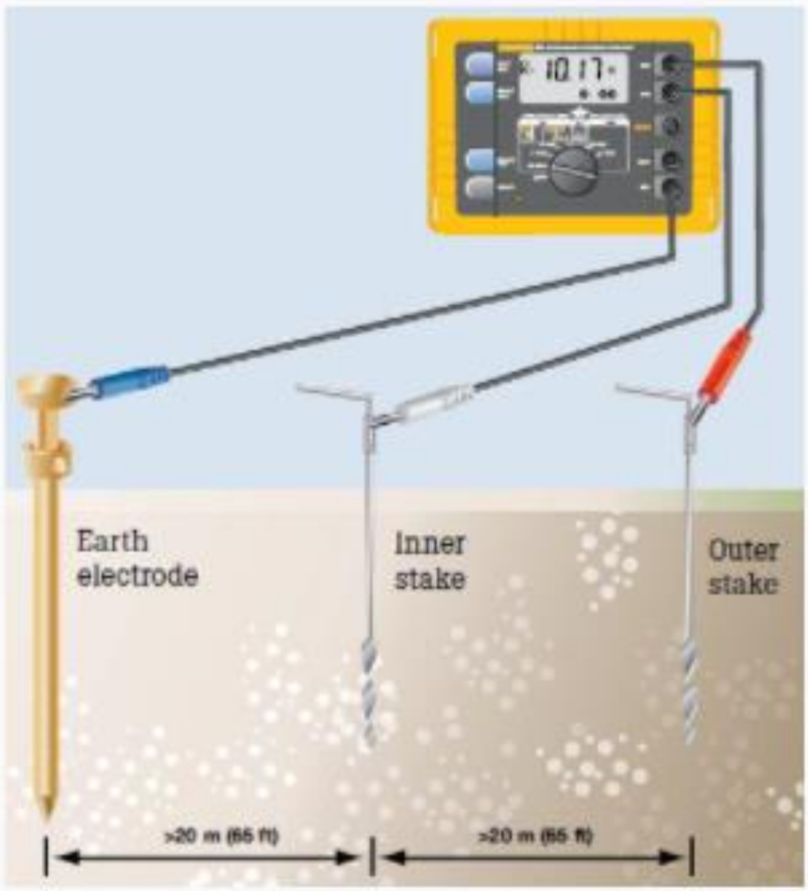
An alternating current (I) is passed through the outer electrode C and the voltage is measured, by means of an inner electrode P, at some intermediary point between them.

The Earth Resistance is simply calculated using Ohm's Law: ***Rg = V/I.***

Other more complex methods, such as the Slope Method or the Four Pole Method, have been developed to overcome specific problems associated with this simpler procedure, mainly for measurements of the resistance of large earthing systems or at sites where space for locating the test electrodes is restricted.

Fall of Potential Method

This is one of the most common methods employed for the measurement of earth resistance and is best suited to small systems **that don't cover a wide area**. It is simple to carry out and requires a minimal amount of calculation to obtain a result.



Measuring earth resistance with fall of potential method (photo credit: eblogbd.com)

This method is generally not suited to large earthing installations, as the stake separations needed to ensure an accurate measurement can be excessive, requiring the use of very long test leads (refer to Table 1).

Normally, the outer test electrode, or current test stake, is driven into the ground 30 to 50 metres away from the earth system, (although this distance will depend on the size of the system being tested – refer to Table 1) and the inner electrode, or voltage test stake, is then driven into the ground mid-way between the earth electrode and the current test stake, and in a direct line between them.

Table 1 – Variation of current and voltage electrode separation with maximum earth system dimensions, in metres

Maximum dimension across earth system	Distance from 'electricalcentre' of earth system to voltage test stake	Minimum distance from 'electrical centre' of earth system to current test stake
1	15	30
2	20	40
5	30	60
10	43	85
20	60	120
50	100	200
100	140	280

Other Test Methods

Many other methods exist for taking earth resistance measurements. Many of these methods have been designed in an attempt to alleviate the necessity for excessive electrode separations, when measuring large earth systems, or the requirement of having to know the electrical centre of the system.

Three such methods are briefly described below. Specific details are not given here, but instead the reader is referred to the relevant technical paper where these systems are described in detail.

1. The slope method
2. The star-delta method
3. The four-potential method (Wenner method)

- ✓ **Multiple earthing systems in parallel**

When a new earth electrode is installed the installer will know its construction and location and some details of the surrounding soil condition, but its earth resistance can only be determined by a test measurement. During a periodic inspection of an existing earth electrode, the situation is less certain as there are unlikely to be details of its construction or its buried location. In addition, it may well have corroded to some degree and the inspector will have no knowledge of the underlying soil conditions so the resistance can only be ascertained by measurement.

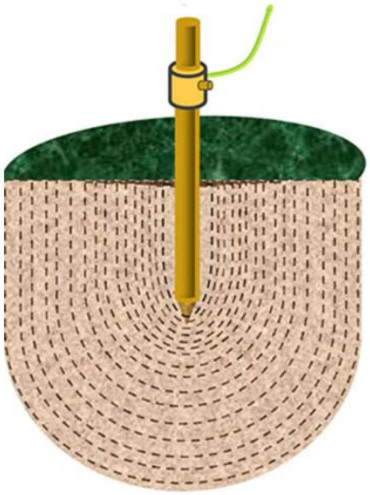


Figure : A simple earth electrode

The simplest earth electrode used in the UK is a straight rod driven into the ground (see Figure 1). Item 1 is the rod and item 2 identifies the rod/soil contact surface. Initially this contact surface area is quite small and is the surface area of the rod in contact with the soil, but it should be noted that as the current travels away from the rod the surface area 'layers' (item 3) of the soil can be considered to get larger in area. As the resistance at a point is inversely proportional to the area at that point, the electrode resistance can be considered to be in the form of:

$$R = \frac{\rho L}{A}$$

where:

R = electrode resistance in Ohms.
ρ = soil resistivity in Ohm meters (assuming a uniform soil).
L = length of electrode buried in soil in meters.
A = area in square meters.

From the above, if the soil resistivity is known then the theoretical resistance of a single vertically driven earth rod can be approximately calculated using the formula below.

$$R = \frac{\rho}{2\pi L}\left[1n\left(\frac{8L}{d}\right) - 1\right]$$

Where: d is the diameter of earth rod in meters *other terms are as noted above.*

The above formula can only give an approximate value as there are always other factors to consider. For example, the soil resistivity is unlikely to be known with any accuracy and it may vary with depth. Seasonal changes in moisture content will also have an effect. The depth that the rod can be driven will depend on the soil conditions (rocks etc.) and the need to get to soil of suitable resistivity. For example, in the Middle East it is usual to drive a rod to below the level of the summer water table as the dry ground above has an extremely high resistivity.

It should also be noted that the length of the rod has significantly more effect on the electrode resistance value than the rod diameter.

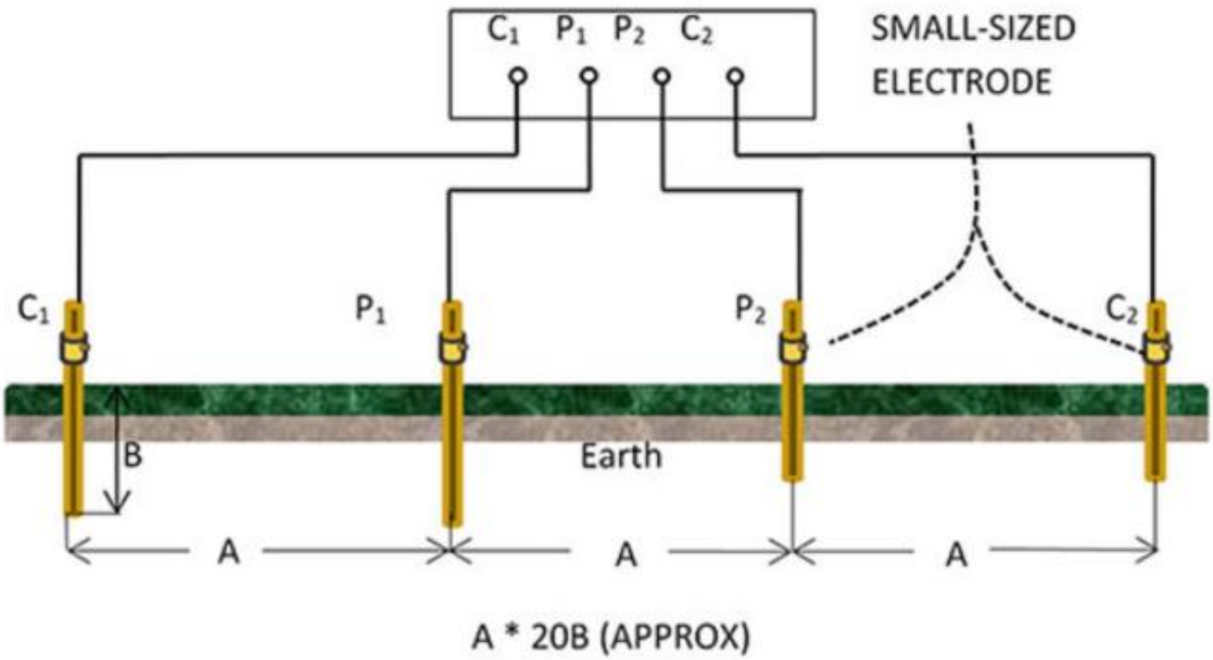


Figure 2 – Four-terminal method of measuring earth resistivity

From these basic electrode calculations it can be seen, as detailed in Figure 2, that if the spacing (A) between the actual installed electrode C_1, the temporary C_2 test electrode and the intermediate P1 and P2 test electrodes was large compared with the driven depth (B) of the installed electrode C_1 (say, A is more than 20 x B) the general soil resistivity can be calculated from:

$$\rho = 2\pi AR$$

where:
ρ is the resistivity in Ohm metres.
R is the earth electrode resistance reading in Ohms.
A is the spacing in metres between the test electrodes.

This is known as the ‘fall of potential’ method and it can be seen in Figure 3 below that most of the voltage is dropped around the electrodes where, as outlined above, the soil ‘layers’ are small around the electrode and therefore holds the majority of resistance. In the area between the electrodes there are a multitude of current ‘paths’ and the area (A) is very large so the change in resistance is very small.

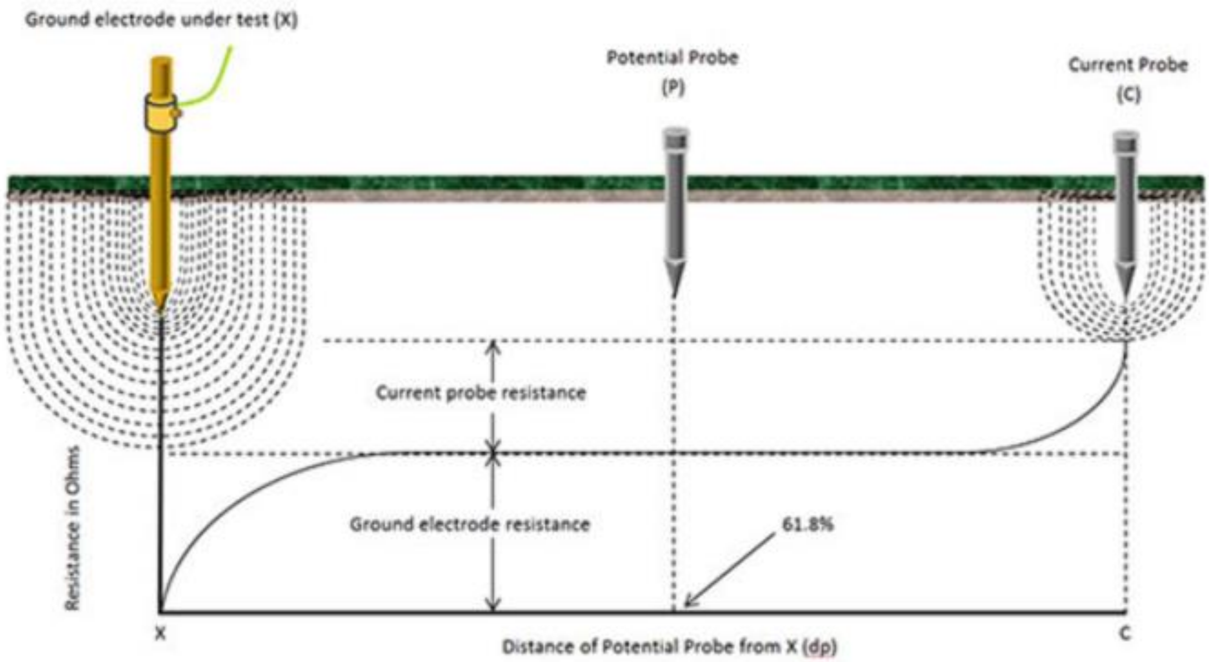


Figure 3 – Illustration of the fall of potential method of electrode resistance measurement

Modern testing equipment works on this principle but it is designed by instrument manufacturers to be more compact and easier to use.

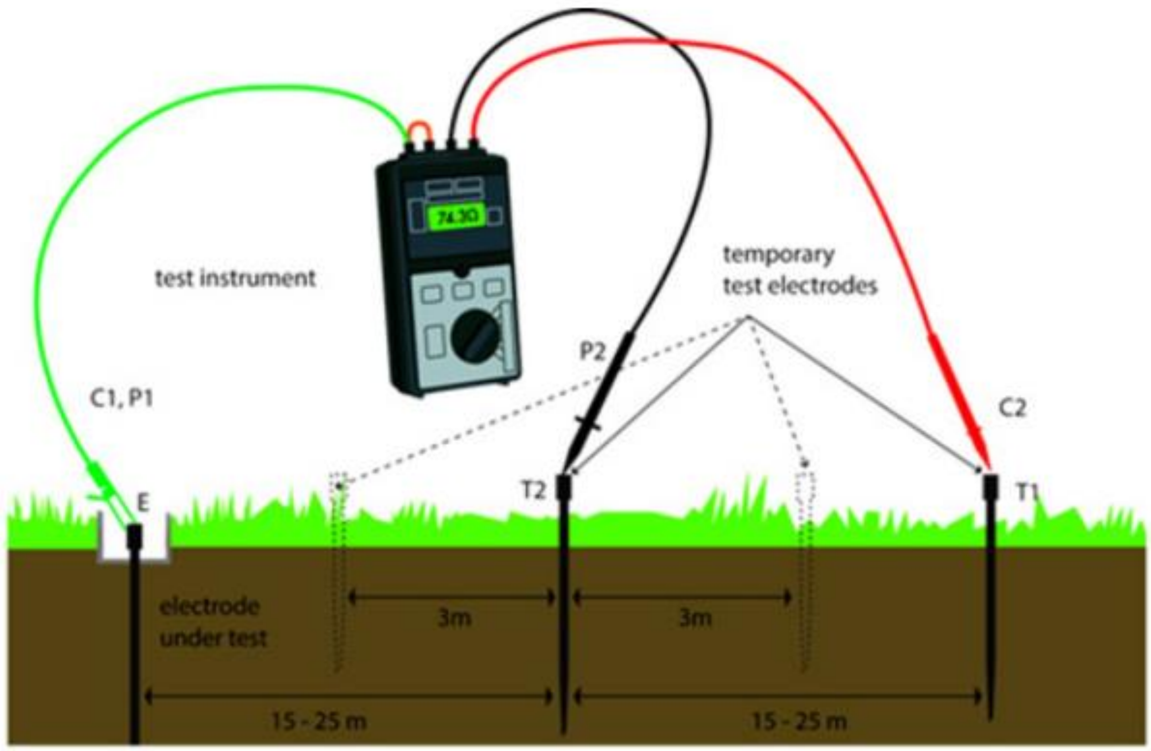


Figure 4 – Typical earth electrode test using a three or four terminal tester

Content /topic2: Reduction of earthing resistance

Methods of reducing earth resistance

Lesser is the earth resistance, better will be the earthing. Theresistance of anearthing system can be reduced in the following manners:

1. By pouring water
2. By increasing the plate area
3. By increasing the depth of the electrode
4. By connecting many earth electrodes in parallel

By pouring water

The earth resistance can be reduced by pouring water in the pipe of the earthing system. Especially, during summer season, an earthing may require water due to the loss of its dampness.

By increasing the plate area

The earth resistance may also be reduced by using large size copper plates. A large size plates will have more area in contact with the damp earth, thus it will reduce the earth resistance

.

- ✓ **Lengthen the earth electrode in the earth**

By increasing the depth of the electrode

The depth of the damp bed of earth varies in accordance with the season. Therefore, by increasing the depth, the earth electrode will remain in contact with the damp earth as required, therefore, the resistance will be reduced.

- ✓ **Use multiples rods**

By connecting many earth electrodes in parallel

The earth resistance is can be reduced by connecting a number of separately installed earth electrodes in parallel.

In this way by connecting more earth electrodes in parallel, the earth resistance can be reduced, further.

- ✓ **Treat the soil**

- Marconite powder

Marconite is the world's premium electrically conductive aggregate material – the synthetic material is manufactured specifically for use in earthing applications and unlike **Bentonite**, it is not a naturally occurring mineral or ore.

Marconite enables electrical earthing system designers and installers to achieve permanent, stable and low resistance earthing solutions, even in difficult ground conditions when used as a backfill to enhance the effects of copper earth electrodes or **earth rods**.

Specifically developed and manufactured for the needs of the earthing industry, Marconite has allowed engineers for over 40 years to tackle the toughest conditions and achieve the satisfactory earthing of installations including substations across the globe.

Dark grey in colour and of a granular consistency, Marconite earthing replaces traditional sand and aggregate materials. The mix ratios should be 3 parts of Marconite to 1 part cement by weight with the addition of 1 litre of water per 4 Kg of total mix. For example:

- 3 x 25 Kg bags of Marconite
- 1 x 25 Kg bag of Cement
- 25 litres (25 Kg) of Water

When mixed as described above Marconite forms a relatively dry material with an 'as poured' density of around 1300 Kg / m³. The water content may be adjusted as the application requires but this will affect the concretes final compressive strength and the drying times accordingly. Typically, Marconite concretes are touch dry within hours but can be several days before being fully cured.

Figure : Marconite

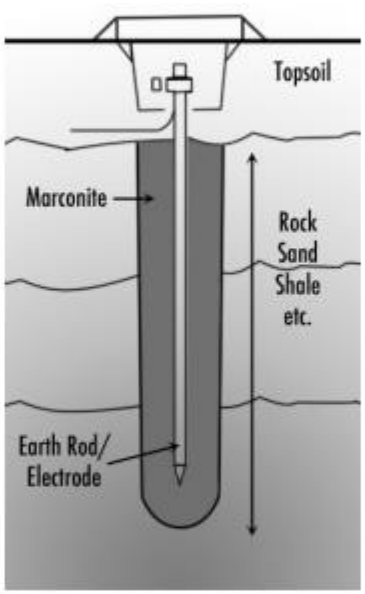
Marconite is also available in the form of a 'premix' – this is a standard 25 Kg poly sack which contains pre-weighed amounts of Marconite and cement powder in the correct ratio to form the preferred concrete.

With the addition of 5 litres of water each bag can then be mixed independently and used without the need to carry additional cement powder.

MARCONITE – THE BENEFITS

- **Low resistivity** : 0.001 ohm.m is extremely low (Bentonite 3 ohm.m)
- **Versatile** : suits most ground conditions and becomes a permanent, solid structure that it is not prone to shrinking, drying out or being washed away
- **Cost effective** : permanent solution with no need to remove and replace or 'maintain' periodically with additional water / salts in order to achieve the desired earth values
- **Chemically inert** : Marconite is non-corrosive to steel or copper, does not attack cement structures and has a pH within the neutral range
- **High strength** : can be used as part of the building structure itself and achieve strengths higher than Grade 25 concrete

- **Easy to use** : forms a concrete like material achieving a low resistance earth, no need to wait or return to test



Marconite is a granulated electrically conductive aggregate which replaces sand in mixes with cement, thereby providing electrically conductive concrete.

L.O.3.4: identify types of earthing rods, electrodes, earthing plate and earthing grid based on size and composition of material and the installation to be protected

Content /topic1: Types of earthing copper rods:

Copper is the optimal choice of earth electrode material and underground conductor.

- ✓ **Solid copper**

is recommended for high fault current installations whereas copper bonded rods are usually installed for smaller sections.

- ✓ **Copperbonded**

steel core earth rods are the most specified due to electrical and mechanical strength, resistance to corrosion as comparatively lower cost compared to solid copper or **stainless steel**

types – the lowest cost galvanised rods for usually installed non-critical, short-term or temporary earthing requirements.

Type of Earth Rod	Features & Benefits
Copperbond	Optimum Economic Efficiency * High Corrosion Resistant * Very High Tensile Strength * Extendable
Solid Copper	Excellent Corrosion Resistance * Aggressive Soil Applications (eg high salt) * Extendable
Stainless Steel	Maximum Corrosion Resistance * Resist Galvanic Corrosion * Highest Material Cost * High Life Expectancy
Galvanised Steel	Lowest Electrical Conductivity * Lowest Cost * Lowest Corrosion Resistance * Poor Current Carrying Capacity

Copper bond Earth Rods

Solid Copper Earth Rods

✓ **SOLID OR BONDED COPPER RODS**

Steel cored copper bond earthing rods are manufactured by molecularly bonding 99.9% pure electrolytic copper onto a low carbon steel core – copper bonded steel rods provide high mechanical tensile strength and corrosion resistance at comparatively lower cost than **solid copper** or **stainless steel rods** with a higher corrosion resistance typically for high salt and high resistivity soil condition earthing applications.

Copper bonded rods and electrodes are suitable for deep driving into most ground conditions and provide a low resistance path to ground. Soil resistivity tests should be conducted prior to installing the earth rods to ensure acceptable soil resistivity readings – to reduce resistivity additional rods can be driven into the ground to increase density.

Earth rods manufactured from stainless steel are installed to prevent galvanic corrosion which occurs between buried dissimilar metals in close proximity.

Earth Rods – Copperbond Type (Threaded) – Selection Table							
Order Code	Earth Rod Diameter	Length	Thread Size (UNC-2A)	Shank (D)	Length 1	Unit Weight	Pack Quantity
ERB 412	1/2"	1200mm	9/16"	12.7mm	30mm	1.18kg	5
ERB 415		1500mm				1.55kg	5
ERB 418		1800mm				1.76kg	5
ERB 424		2400mm				2.36kg	5
ERB 112	5/8"	1200mm	5/8"	14.2mm	30mm	1.53kg	5
ERB 115		1500mm				1.88kg	5
ERB 118		1800mm				2.29kg	5
ERB 124		2400mm				3.00kg	5
ERB 130		3000mm				3.79kg	5
ERB 212	3/4"	1200mm	3/4"	17.2mm	35mm	2.19kg	5
ERB 215		1500mm				2.73kg	5
ERB 218		1800mm				3.27kg	5
ERB 224		2400mm				4.35kg	5
ERB 230		3000mm				5.44kg	5

- **Content /topic2: Types of electrodes**

  ✓ **Ufer ground or concrete**

The **Ufer ground** is an electrical earth grounding method developed during World War II. It uses a concrete-encased electrode to improve grounding in dry areas. The technique is used in construction of concrete foundations.

During World War II, the U.S. Army required a grounding system for bomb storage vaults near Tucson and Flagstaff, Arizona. Conventional grounding systems did not work well in this location since the desert terrain had no water table and very little rainfall. The extremely dry soil conditions would have required hundreds of feet of rods to be driven into the earth to create a low impedance ground to protect the buildings from lightning strikes.

In 1942, Herbert G. Ufer was a consultant working for the U.S. Army. Ufer was given the task of finding a lower cost and more practical alternative to traditional copper rod grounds for these dry locations. Ufer discovered that concrete had better conductivity than most types of soil. Ufer then developed a grounding scheme based on encasing the grounding conductors in concrete. This method proved to be very effective, and was implemented throughout the Arizona test site.

Equipment grounding conductors are bonded to the system grounded conductor **(neutral)** to provide a low impedance path for fault current that will facilitate the operation of over current devices under ground-fault conditions."

The Grounding Electrode System is installed to provide surge protection and voltage to ground stabilization. This system is required at each building or structure on the premises. There are numerous methods described in the code. The most common is the Concrete Encased Electrode or UFER and the Driven Rod Electrode. The CEC allows the use of metal underground water pipe. This method requires a supplemental electrode be provided. This requirement is based on the practice of using plastic pipe for replacement when the original water pipe fails.

- ✓ **Ufer ground or building Foundations**

Few buildings, even those under construction today are built to take advantage of the Ufer ground. It is common to see the use of "Ufer grounding" in military installations, computer rooms, and other structures with very specific grounding specifications. It is not common in most industrial plants, office buildings and homes. More common today is grounding to national and local electrical codes. This will involve one or more driven ground rods connected (bonded) to the neutral wire of the electrical service entrance. The purpose of this bond is what is known as life safety ground. It is used for many other things but the code required life safety ground is why it is there to begin with.

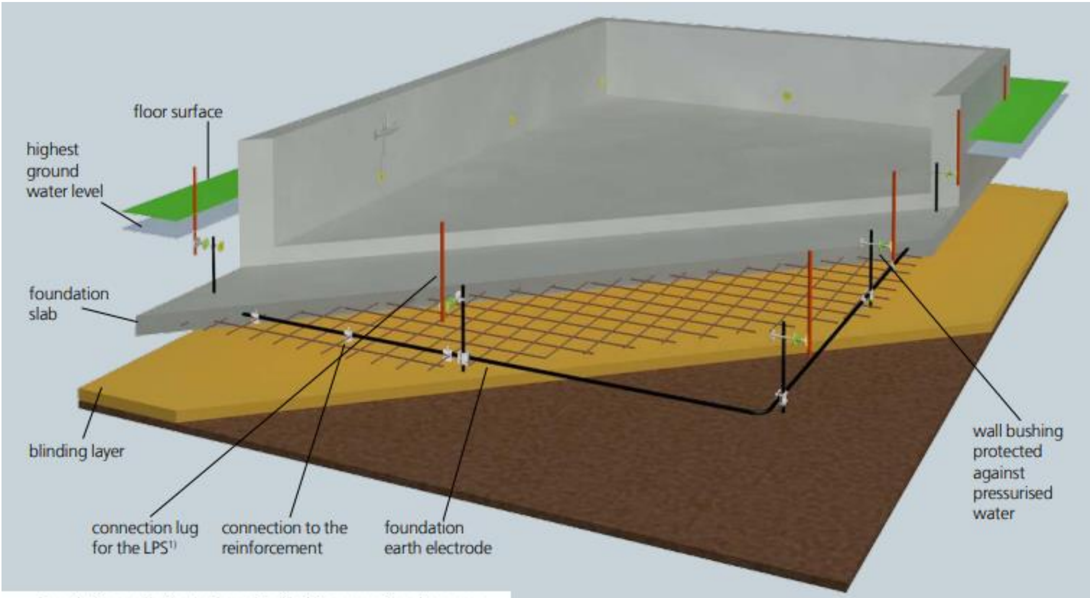
Ground rods come in many forms, but the most common used in electrical service grounding are galvanized steel ground rods. Please remember, the best day a ground rod will normally see (resistivity) is the day it is installed. Corrosion, glazing, etc., all are factors that lessen the effectiveness of ground rods.

Function of foundation earth electrodes With a foundation earth electrode, a functioning and maintenance-free earth-termination system is installed throughout the building's lifecycle. Foundation earth electrodes are embedded in the concrete foundation and covered by a concrete layer of at least 5 cm.

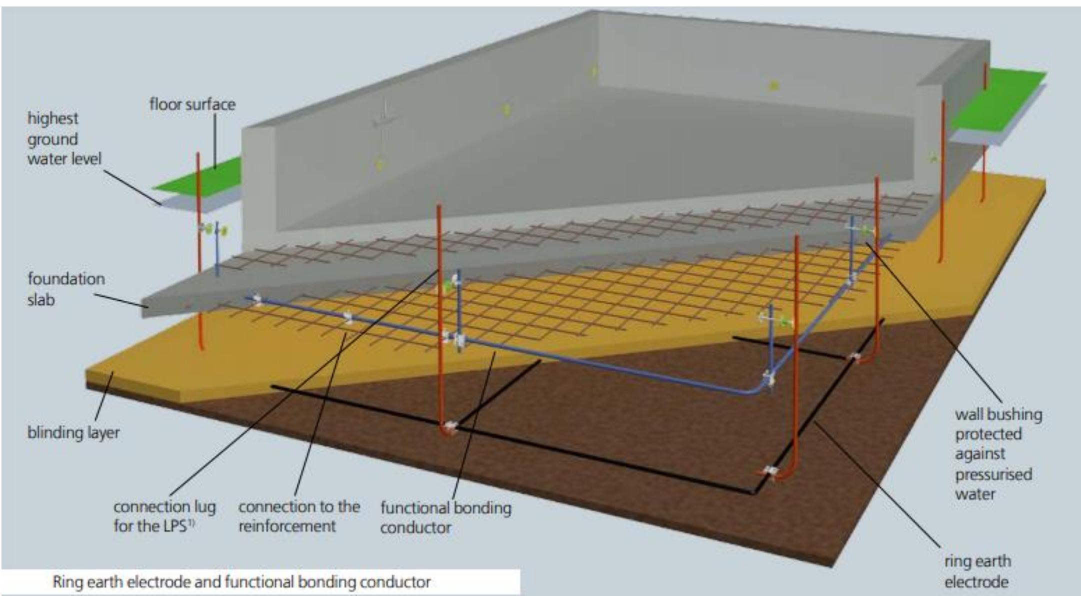
Consequently, two requirements are fulfilled:

- The concrete conserves the earthing material, corrosion effects are not to be expected
- The typically moist concrete on the outside of the foundation establishes a conductive connection between the systems mentioned above and the ground.

However, another type of earthing was required since various structural measures no longer ensured conductive connection with the ground. A ring earth electrode installed outside the concrete foundation can be used to solve this problem.



Foundation earth electrode embedded in conventional concrete



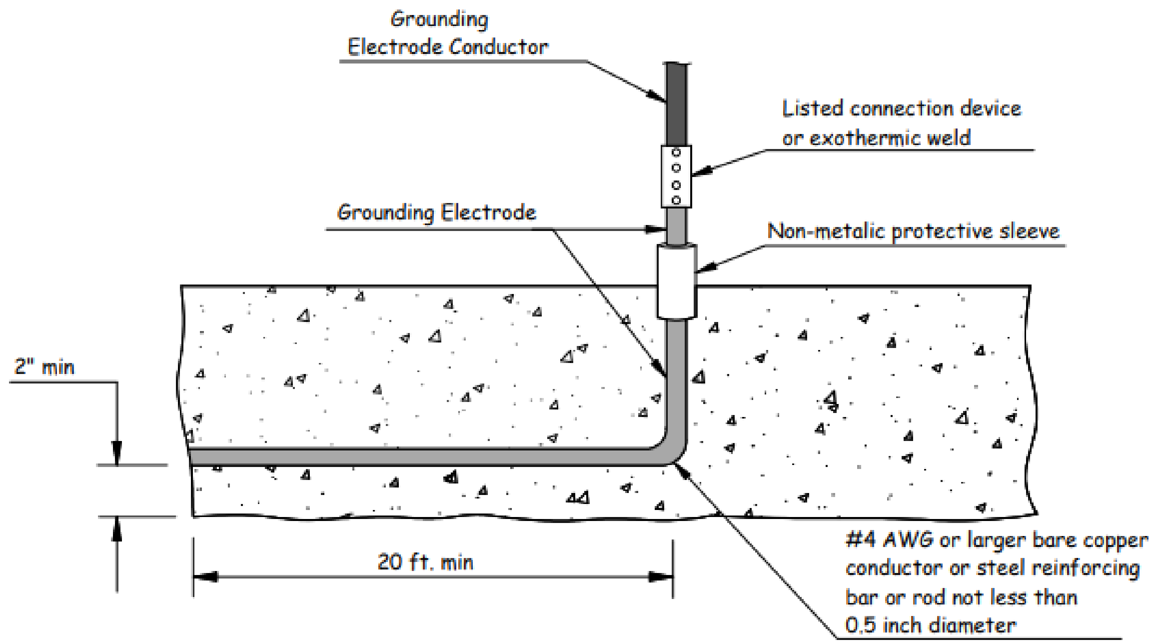
Ring earth electrode and functional bonding conductor

- ✓ Encased electrodes
- ✓ **Concrete encased electrode**

Concrete Encased Grounding Electrode. A concrete encased electrode shall be bonded to other grounding electrodes, to form the grounding electrode system. A concrete encased electrode shall be encased by at least 2" of concrete, be located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth, consist of at least 20' of one or more bare or zinc coated reinforcement bars of at least ½" diameter, or consisting of at least 20 feet of bare copper conductor not smaller than 4 AWG.

Exception: *Concrete encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcement bars or rods are not accessible for use without disturbing the concrete.*

Note that where the structural drawings do not require reinforcement bars in the concrete foundation or footer, the NEC does not require that this electrode be installed.



An existing electric service grounding electrode conductor is not required to be bonded to a new concrete encased electrode of an addition, provided the grounding of the existing electric service has been installed and maintained to the requirements of the NEC when installed.

It is not necessary for the minimum required length of 20 feet of steel reinforcing to be installed in one continuous piece. Properly spliced and connected pieces of reinforcing may be added together to satisfy the 20 foot requirement. Lengths of splices shall be a minimum of 30 times the diameter of the reinforcing steel, and may be connected together with steel tie wire.

4. **Electrolytic electrode**

Technical Details:

Rod Length(L)(ft)	Conductor size(mm²)	Conductor Length(mm)	Rod Type
8	95	500	Vertical
10	95	500	Vertical
12	95	500	Vertical
15	95	500	Vertical
8	95	500	Horizontal
10	95	500	Horizontal
12	95	500	Horizontal
15	95	500	Horizontal

Application	Suitable for disperse current into the earth in critical soil area
Material	Type K Copper pipe

Content /topic3: Types of earthing plate

- ✓ **Grounding plates**

A metallic electrode or plate which is buried in the earth (underground) and it is the last part of the electrical earthing system. In simple words, the final underground metallic (plate) part of the earthing system which is connected with earthing lead is called earth plate or earth electrode.A metallic plate, pipe or rode can be used as an earth electrode which has very low resistance and carry the fault current safely towards ground (earth)

- ✓ **Earthing grid based**

Types of Earthing

Earthing can be done in many ways. The various methods employed in earthing (in house wiering or factory and other connected electrical equipment and machines) are discussed as follows:

1). Plate Earthing:

2). Pipe Earthing:

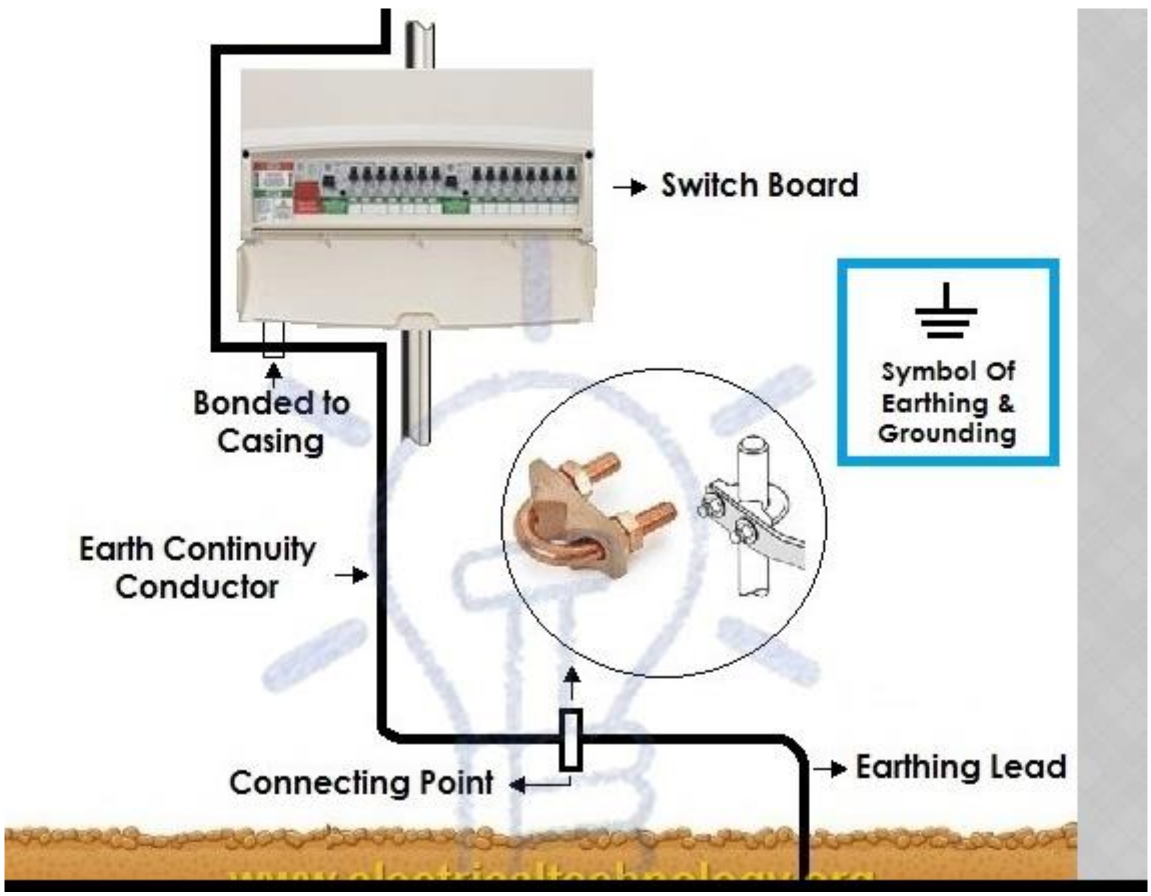
3). Rod Earthing

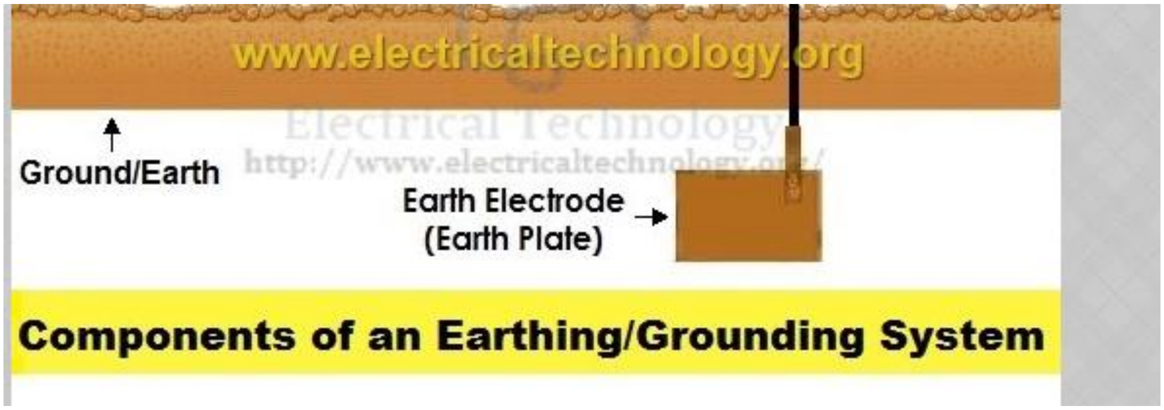
4). Earthing through the Waterman

5). Strip or Wire Earthing:

1). Plate Earthing:

In plate earthing system, a plate made up of either copper with dimensions 60cm x 60cm x 3.18mm or galvanized iron (GI) of dimensions 60cm x 60cm x 6.35 mm is buried vertical in the earth (earth pit) which should not be less than 3m from the ground level.





For proper earthing system, follow the above mentioned steps:

- A pit is dug in the ground
- Tight together plate with earth wire with the help of bolts and nuts
- Put the plate in the pit
- Take out the earth wire through a pipe
- Put the mixture of coal and lime around the plate to maintain the damp soil
- Put the soil
- Put water on the soil until the soil become wet
- Construct the pit earth chamber at the top of the pit and make its cover.

2). Pipe Earthing:

A galvanized steel and a perforated pipe of approved length and diameter is placed vertically in a wet soil in this kind of system of earthing. It is the most common system of earthing.

The size of pipe to use depends on the magnitude of current and the type of soil. The dimension of the pipe is usually 40mm in diameter and 2.75m in length for ordinary soil or greater for dry and rocky soil. The moisture of the soil will determine the length of the pipe to be buried but usually it should be 4.75m.

3). Rod Earthing

It is the same method as pipe earthing. A copper rod of 12.5mm diameter or 16mm diameter of galvanized steel or hollow section 25mm of GI pipe of length above 2.5m are buried upright in the earth manually or with the help of a pneumatic hammer. The length of embedded electrodes in the soil reduces earth resistance to a desired value.

For proper earthing system, follow the above mentioned steps:

- A pit is dug in the ground
- A copper rod of galvanized steel of length above 2.5m is buried upright in the earth manually or with a hammer.
- Tight together earth rod with earth wire with the help of bolts and nuts
- Take out the earth wire through a pipe
- Put the mixture of coal and lime around the rod to maintain the damp soil
- Put the soil
- Put water on the soil until the soil become wet
- Construct the pit earth chamber at the top of the pit and make its cover.

4). Earthing through the Waterman

In this method of earthing, the waterman (Galvanized GI) pipes are used for earthing purpose. Make sure to check the resistance of GI pipes and use earthing clamps to minimize the resistance for proper earthing connection.

If stranded conductor is used as earth wire, then clean the end of the strands of the wire and make sure it is in the straight and parallel position which is possible then to connect tightly to the waterman pipe.

5). Strip or Wire Earthing:

In this method of earthing, strip electrodes of cross-section not less than 25mm x 1.6mm is buried in a horizontal trenches of a minimum depth of 0.5m. If copper with a cross-section of 25mm x 4mm is used and a dimension of 3.0mm^2 if it's a galvanized iron or steel.

INTERNATIONAL STANDARDS (SPECIFICATIONS) FOR EARTHING

Various specifications in respect to earthing as recommended by Indian Standards are given below. Here are few;

- ✓ An earthing electrode should not be situated (installed) close to the building whose installation system is being earthed at least more than 1.5m away.
- ✓ The earth resistance should be low enough to cause the flow of current sufficient to operate the protective relays or blow fuses. Its value is not constant as it varies with weather because it depends on moisture (but should not be less than 1 Ohm).
- ✓ The earth wire and earth electrode will be the same material.
- ✓ The earthing electrode should always be placed in a vertical position inside the earth or pit so that it may be in contact with all the different earth layers.

LO.3.5: apply installation techniques for different earthing system in accordance with the standards

- **Content /topic1:.Checking soil status**

Proper grounding proves to be an important issue when designing and installing power and lightning protection systems. The goal of any grounding system is to provide a low-impedance path for fault and lightning-induced currents to enter the earth, ensuring maximum safety from electrical system faults and lightning.

A properly installed grounding system not only helps protect buildings and equipment from damage caused by unintentional fault currents or lightning surges, but more importantly, it also protects people.

Grounding is a very complex subject. The proper installation of grounding systems requires knowledge of national and international standards, grounding conductor materials and compositions, and grounding connections and terminations. However, designers and installers of grounding systems should not overlook another important factor—soil conditions.

Below, we explore what soil resistivity is, how it is determined and the ways in which grounding systems are affected by various soil resistivity.

What Is Soil Resistivity?

Quite simply, **soil resistivity is how resistive the soil is to the flow of electricity**. In the majority of applications, a low ground resistance is preferred or even require, therefore more often than not a **low resistivity is preferred**. In a number of applications, the ground resistance itself is not as critical as the grounding layout (i.e. grid, mesh, etc.). However, despite this, a **high soil resistivity** still represents challenges to these designs and can exasperate shortcomings or under design.
Preferably, a measurement of the soil resistivity is conducted before the grounding system is designed. A common method to achieve this is the Wenner 4-Point Test, which involves four probes spaced at equal distances to determine the profile of the soil resistivity at various depths. Understanding how the soil resistivity varies with depth is important for the designer, as it can determine if a deep or shallow ground electrode design is desired.

In addition to the type of soil, other factors that can influence soil resistivity are temperature and moisture level. Because of this, change in season or weather patterns can have an impact on soil resistivity, and therefore grounding system performance. For example, soil with low resistivity during humid, warmer seasons may have a higher resistivity during cold (freezing as an extreme) or dry seasons.

Since testing soil resistivity is not always possible, be aware of the factors affecting soil resistivity:

- **Soil type.** Rocky soil or gravel has especially high resistivity.
- **Moisture content level.** Dry ground, like sand in a desert, is highly resistive.
- **Temperature.** Cold or frozen ground will be more resistive than warm ground.
- **Mineral content.** Igneous rocks, for example, are more resistive than ore minerals.
- **Contaminants**. Could be metals, salts or other substances, like oil.
-

The chart below shows some of the ranges in resistance for typical soil types:

SOIL TYPE	Resistivity ohm-cm Average	Min.	Max.
Fills – ashes, cinders, brine wastes	2,370	590	7,000
Clay, shale, gumbo, loam	4,060	340	16,300
Clay, shale, gumbo, loam with varying proportions of sand and gravel	15,800	1,020	135,000
Gravel, sand, stones, with little clay or loam	94,000	59,000	458,000

U.S. Bureau of Standards Technical Report 108

**Typical resistivity for various soil types*

- **Content /topic2: Type of earth system**

Different Terms used in Electrical Earthing

Earth: The proper connection between electrical installation systems via conductor to the buried plate in the earth is known as Earth.

Earthed object: When an electrical device, appliance or wiring system connected to the earth through earth electrode, it is known as earthed device or simple "Earthed".

Solidly Earthed: When an electric device, appliance or electrical installation is connected to the earth electrode without a fuse, circuit breaker or resistance/Impedance, It is called "solidly earthed".

Earth Electrode: When a conductor (or conductive plate) buried in the earth for electrical earthing system. It is known to be Earth Electrode. Earth electrodes are in different shapes like, conductive plate, conductive rod, metal water pipe or any other conductor with low resistance.

Earthing Lead: The conductor wire or conductive strip connected between Earth electrode and Electrical installation system and devices in called Earthing lead.

Earth Continuity Conductor: The conductor wire, which is connected among different electrical devices and appliances like, distribution board, different plugs and appliances etc. in other words, the wire between earthing lead and electrical device or appliance is called earth continuity conductor. It may be in the shape of metal pipe (fully or partial), or cable metallic sheath or flexible wire.

Sub Main Earthing Conductor: A wire connected between switch board and distribution board i.e. that conductor is related to sub main circuits.

Earth Resistance: This is the total resistance between earth electrode and earth in Ω (Ohms). Earth resistance is the algebraic sum of the resistances of earth continuity conductor, earthing lead, earth electrode and earth.

What is an earthing system?

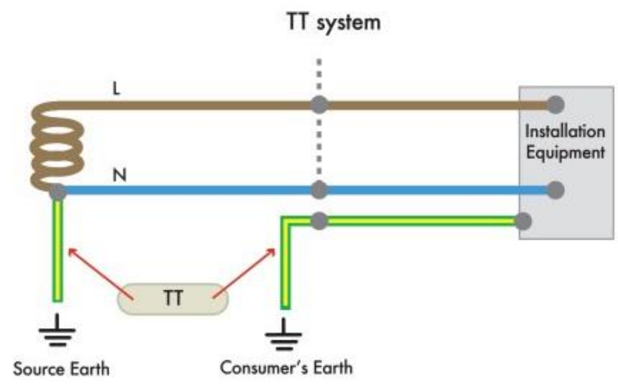
At its simplest, an earthing system is the arrangement by which an electrical installation is connected to a means of earthing. This is usually for safety purposes although sometimes also for functional purposes, for example in the case of telegraph lines which use the earth as a conductor to save the cost of a return wire over a long circuit. If there is a fault in an electrical installation, a person could get an electric shock by touching a live metal part, because electricity uses the body as a path to the earth. Earthing provides an alternate path for a fault current to flow to earth.

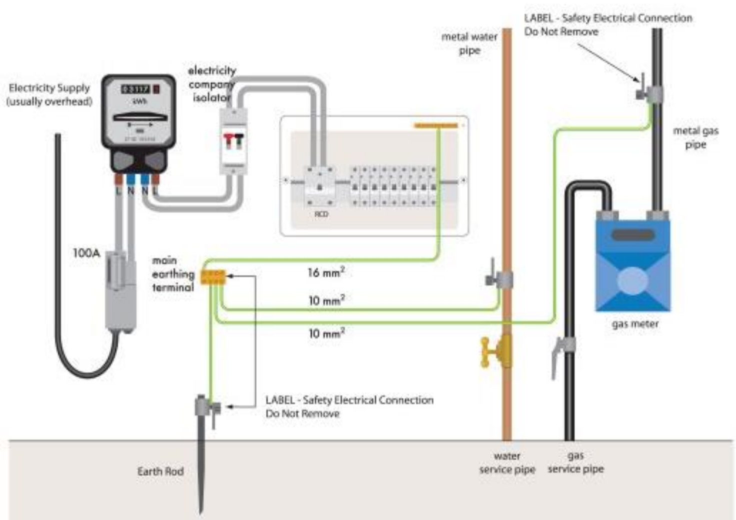
There are three main earthing systems in the UK used for non-specialist installations and defined in the IET Wiring Regulations, two are TN systems (where the distribution network operator (DNO) is responsible for earthing) and the other is a TT system (which does not have its own earth connection):

Key: T = Terre (earth), N = neutral, C = combined, S = separate

- ✓ **TT system**

This is configured in a similar way to the TN-S system but doesn't give consumers their own individual earth connection. Instead, consumers must supply their own earth, for example by burying rods or plates underground to provide a path of low impedance. Often TT systems are used where TN-C-S arrangements can't be (eg in the petrol station example above) or in rural areas where supply is provided on overhead poles. Shock protection measures such as RCDs are often used to provide automatic disconnection of supply where different soil types that may cause external earth fault loop impedance values exist.

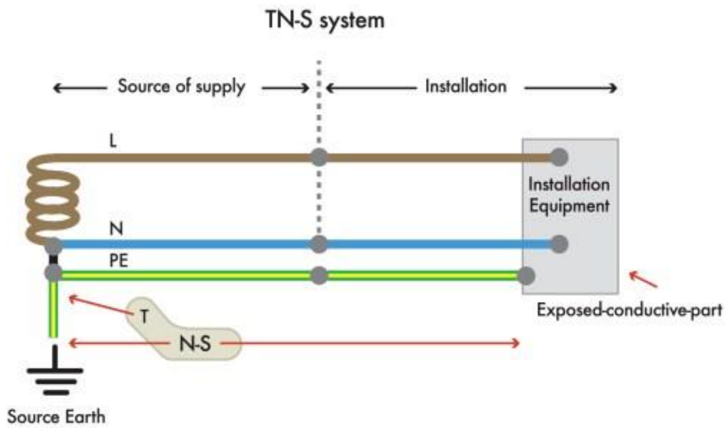


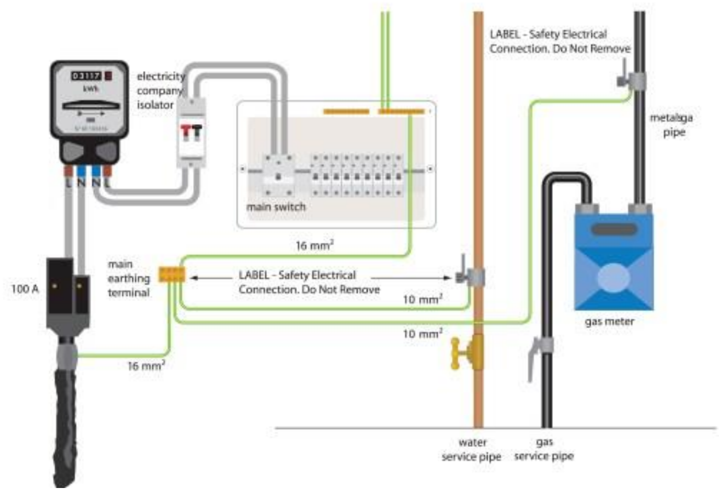


TT Earthing system

- ✓ **TN-S system**

TN-S systems have a single neutral-to-earth connection, placed as near as possible to the supply transformer and separate supply cables throughout. In low voltage supplies the transformer can even be connected to the sheath of the supply cable which will give a separate route back to the sub-station transformer. The DNO's maximum external earth fault loop impedance in these configurations is normally 0.8 Ω.



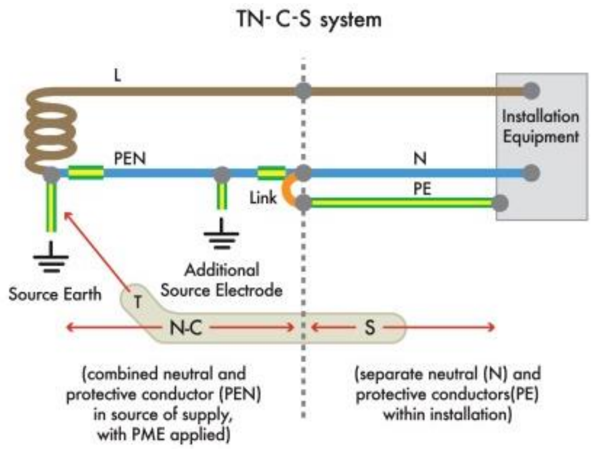


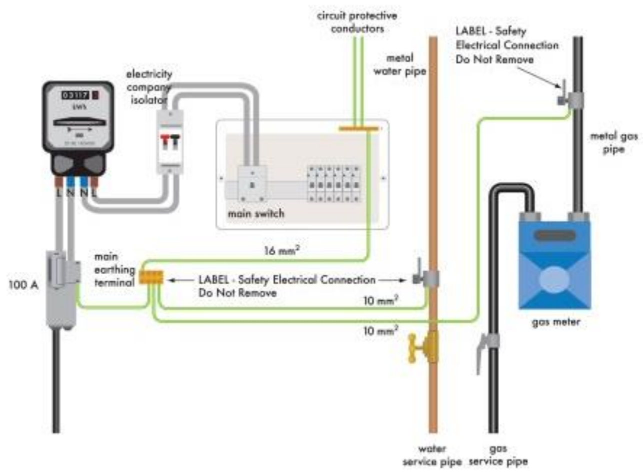
TN-S Earthing system

- ✓ **TN-C-S system**

This is the most common configuration used in the UK. It can also be known as protective multiple earthing (PME) and provides low voltage supply with reliable and safe earthing. This system allows multiple users to utilize one supply cable. The resultant rise in current flow creates a voltage rise in the protective earthed neutral (PEN) which needs multiple connection to earth along the supply route. The neutral is earthed close to the source of supply, at the intake of the installation and at necessary points throughout the distribution system. As the DNO uses a combined neutral and PEN return path the maximum external earth fault loop impedance is 0.35 Ω.

Despite its popularity, the TN-C-S arrangement could prove hazardous if the PEN conductor becomes an open circuit in the supply because the current would not have an immediate path back to sub-station level. Because of this, there are certain installations where it is not allowed to be used – including petrol stations, building sites, caravan parks and some outbuildings.





TN-C-S Earthing system

- ✓ **TN-C system**

TN-C: TN-C describes an arrangement where a combined Protective Earth-Neutral (PEN) is connected to the earth at the source. This type of earthing is not commonly used in Australia due to the risks associated with fire in hazardous environments and due to the presence of harmonic currents making it unsuitable for electronic equipment. In addition, as per IEC 60364-4-41 – (Protection for safety- Protection against electric shock), an RCD cannot be used in a TN-C system.

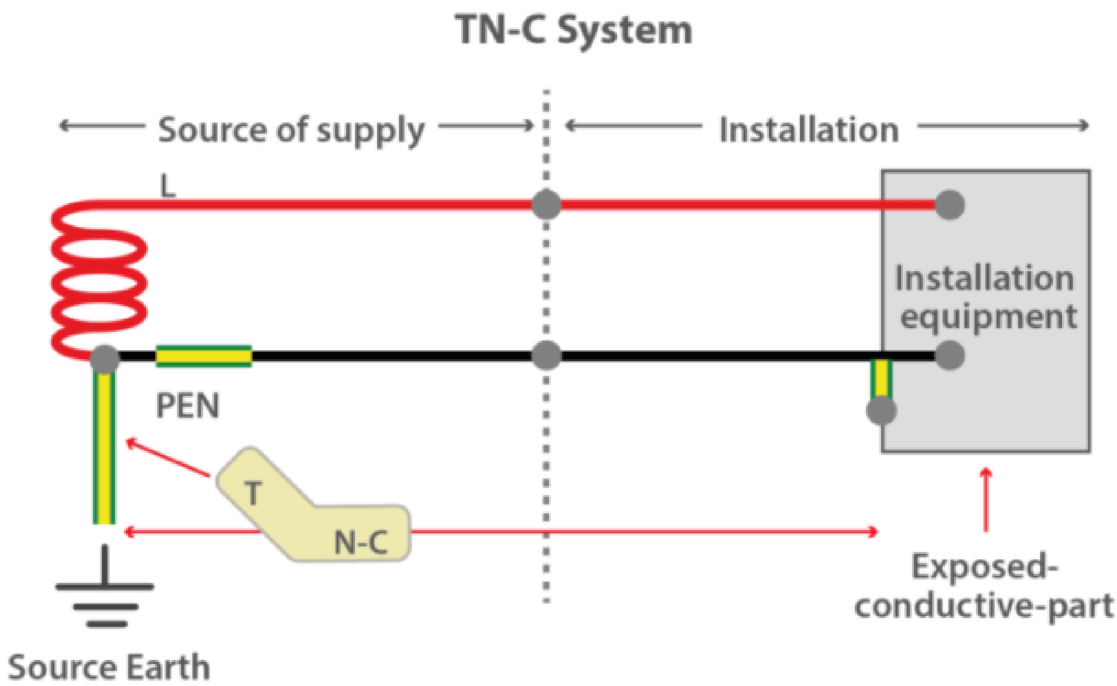


Fig: TN-C System

✓ **IT system**

In an IT earthing arrangement, there is either no earthing at the supply, or it is done via a high impedance connection. This type of earthing is not used for distribution networks but is frequently used in substations and for independent generator-supplied systems. These systems are able to offer good continuity of supply during operation.

- Protection technique:
  - Interconnection and earthing of exposed conductive parts
  - Indication of the first fault by an insulation monitoring device (IMD)
  - Interruption for the second fault using overcurrent protection (circuit-breakers or fuses)

- Operating technique:
  - Monitoring of the first insulation fault
  - Mandatory location and clearing of the fault
  - Interruption for two simultaneous insulation faults

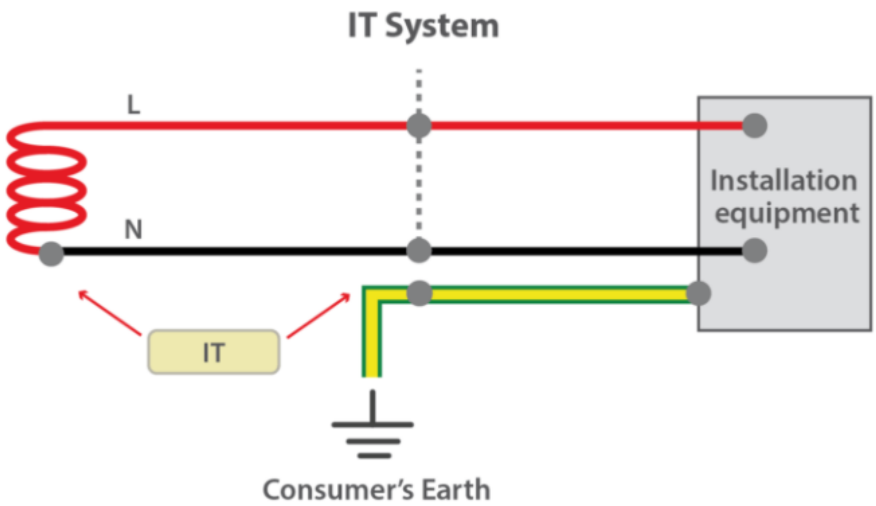


Figure: IT system

Main characteristics

- Solution offering the best continuity of service during operation
- Indication of the first insulation fault, followed by mandatory location and clearing, ensures systematic prevention of supply outages
- Generally used in installations supplied by a private MV/LV or LV/LV transformer
- Requires maintenance personnel for monitoring and operation
- Requires a high level of insulation in the network (implies breaking up the network if it is very large and the use of circuit-separation transformers to supply loads with high leakage currents)
- The check on effective tripping for two simultaneous faults must be carried out by calculations during the design stage, followed by mandatory measurements during commissioning on each group of interconnected exposed conductive parts
- Protection of the neutral conductor must be ensured as indicated in Protection of the neutral conductor inside chapter Sizing and protection of conductors

Comparison of system earthing arrangements

	TT	IT	TN-S	TN-C	TN-C-S
Earth fault loop impedance	High	Highest	Low	Low	Low
RCD preferred?	Yes	N/A	Optional	No	Optional
Need earth electrode at site?	Yes	Yes	No	No	Optional
PE conductor cost	Low	Low	Highest	Least	High
Risk of broken neutral	No	No	High	Highest	High
Safety	Safe	Less Safe	Safest	Least Safe	Safe
Electromagnetic interference	Least	Least	Low	High	Low
Safety risks	High loop impedance (step voltages)	Double fault, overvoltage	Broken neutral	Broken neutral	Broken neutral
Advantages	Safe and reliable	Continuity of operation, cost	Safest	Cost	Safety and cost

LO.3.6: connect surge arrestor based on protection area/ zone surge current

- **Content /topic1: Installing protection**

  ✓ **Surge arrestor**

Surge arresters are devices that help prevent damage to apparatus due to over voltages. The arrester provides a low-impedance path to ground for the current from a lightning strike or transient voltage and then restores to a normal operating conditions.

.The terms *surge protection device* (*SPD*) and *transient voltage surge suppressor* (*TVSS*) are used to describe electrical devices typically installed in power distribution panels, process control systems, communications systems, and other heavy-duty industrial systems, for the purpose of protecting against electrical surges and spikes, including those caused by lightning. Scaled-down versions of these devices are sometimes installed in residential service entrance electrical panels, to protect equipment in a household from similar hazards.

- **Content /topic2: Connection techniques of surge arrestor**

✓ **Connection in plastic enclosure**

Figure J39 below shows how to connect a SPD in plastic enclosure.

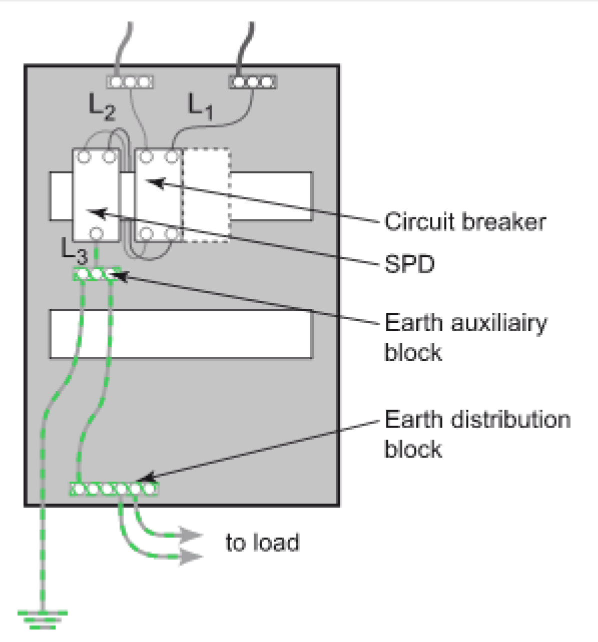


Fig. J39 – Example of connection in plastic enclosure

✓ **Connection in metallic enclosure**

In the case of a switchgear assembly in a metallic enclosure, it may be wise to connect the SPD directly to the metallic enclosure, with the enclosure being used as a protective conductor (see **Fig. J40**).

This arrangement complies with standard IEC 61439-2 and the Assembly manufacturer must make sure that the characteristics of the enclosure make this use possible.

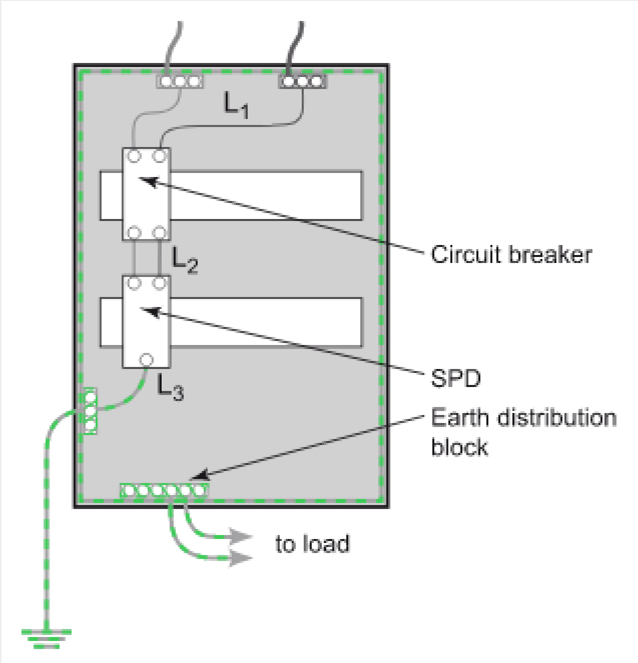


Fig. J40 – Example of connection in metallic enclosure

✓ **Conductor cross section**

The recommended minimum conductor cross section takes into account:

- The normal service to be provided: Flow of the lightning current wave under a maximum voltage drop (50 cm rule).

  Note: Unlike applications at 50 Hz, the phenomenon of lightning being high-frequency, the increase in the conductor cross section does not greatly reduce its high-frequency impedance.

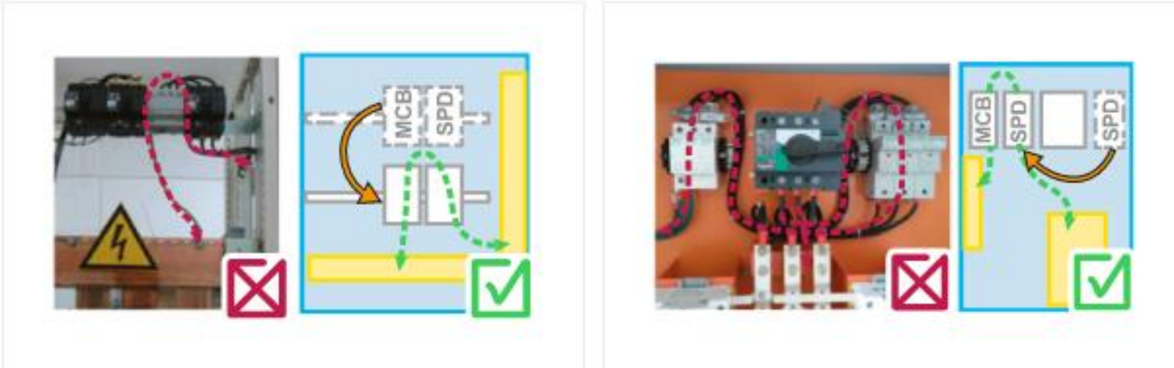
- The conductors' withstand to short-circuit currents: The conductor must resist a short-circuit current during the maximum protection system cutoff time.

  IEC 60364 recommends at the installation incoming end a minimum cross section of:

  - 4 mm^2 (Cu) for connection of Type 2 SPD;
  - 16 mm^2 (Cu) for connection of Type 1 SPD (presence of lightning protection system).

Examples of good and bad SPD installations

Fig. J41 – Examples of good and bad SPD installations



Example 1: Equipment installation design should be done in accordance to installation rules: cables length shall be less than 50 cm.

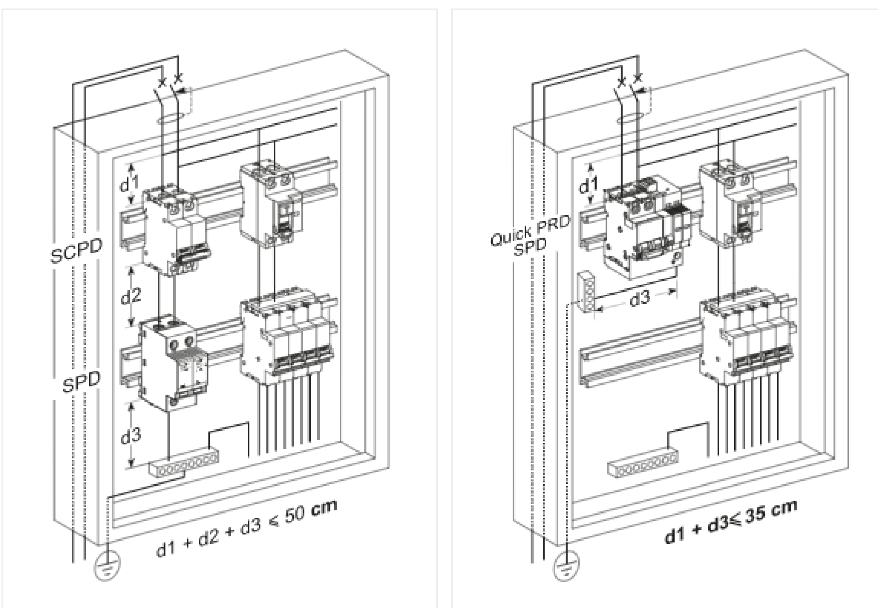
Exemple 2 : Positioning of devices should be linked to installation rules: reduce length of cables < 50 cm and keep the loop area rule of reducing impact of magnetic fields created by lightning current.

✓ Cabling rules of Surge Protection Device

The first rule to comply with is that the length of the SPD connections between the network (via the external SCPD) and the earthing terminal block should not exceed 50 cm.

Figure J42 shows the two possibilities for connection of a SPD.

Fig. J42 – SPD with separate or integrated external SCPD



Rule 2

The conductors of protected outgoing feeders:

- should be connected to the terminals of the external SCPD or the SPD;
- Should be separated physically from the polluted incoming conductors.

They are located to the right of the terminals of the SPD and the SCPD (see **Figure J43**).

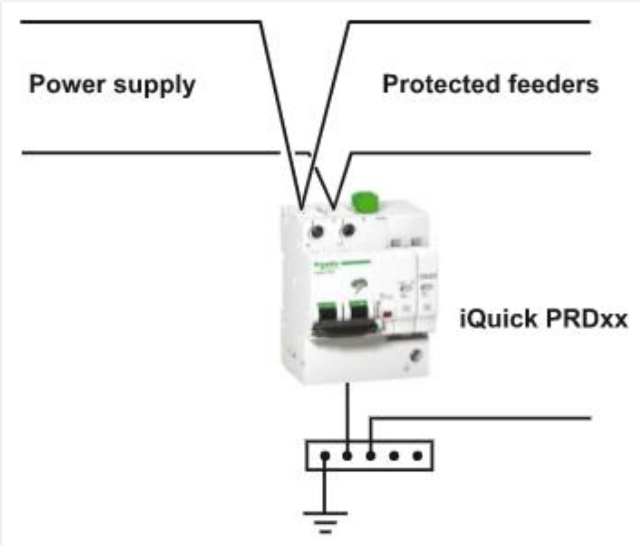


Fig. J43 – The connections of protected outgoing feeders are to the right of the SPD terminals

Rule 3

The incoming feeder phase, neutral and protection (PE) conductors should run one beside another in order to reduce the loop surface (see **Fig. J44**).

Rule 4

The incoming conductors of the SPD should be remote from the protected outgoing conductors to avoid polluting them by coupling (see **Fig. J44**).

Rule 5

The cables should be pinned against the metallic parts of the enclosure (if any) in order to minimize the surface of the frame loop and hence benefit from a shielding effect against EM disturbances.

In all cases, it must be checked that the frames of switchboards and enclosures are earthed via very short connections.

Finally, if shielded cables are used, big lengths should be avoided, because they reduce the efficiency of shielding (see **Fig. J44**).

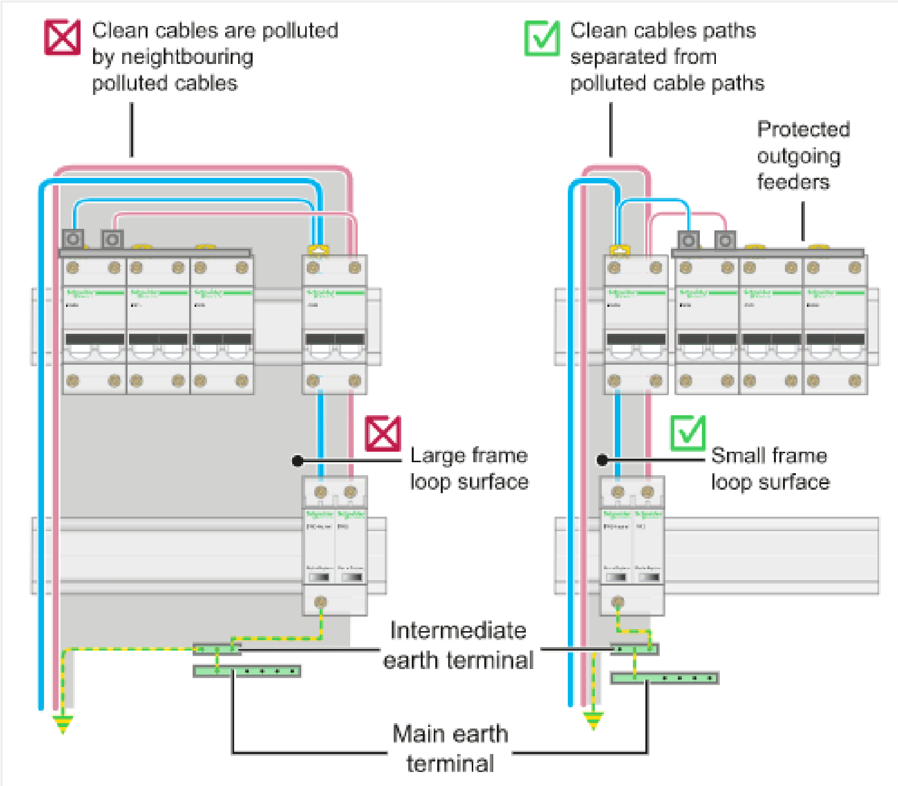


Fig. J44 – Example of improvement of EMC by a reduction in the loop surfaces and common impedance in an electric enclosure

L. O 3.7: use color code based on wire standard requirements

- **Identification of conductors**
  - ✓ **IEE and RSB regulations**
  - ✓ **Color identification of cores of flexible cables and bare conductors for fixed wiring**

Changes to cable core colour identification

Table 7B – Cable to BS 6004 (flat cable with bare cpc)

Cable type	Old core colours	New core colours
Single-core + bare cpc	Red or black	Brown or blue
Two-core + bare cpc	Red, black	Brown, blue
Alt. Two-core + bare cpc	Red, red	Brown, brown
Three-core + bare cpc	Red, yellow, blue	Brown, black, grey

Table 7C – Standard 600/1000V armoured cable

BS 6346, BS 5467 or BS 6724

Cable type	Old core colours	New core colours
Single-core	Red or black	Brown or blue
Two-core	Red, black	Brown, blue
Three-core	Red, yellow, blue	Brown, black, grey
Four-core	Red, yellow, blue, black	Brown, black, grey, blue
Five-core	Red, yellow, blue, black, green-and-yellow	Brown, black, grey, blue, green-and-yellow

Table 7D – Flexible cable to BS 6500

Cable type	Old core colours	New core colours
Two-core	Brown, blue	No change
Three-core	Brown, blue, green-and-yellow	No change
Four-core	Black, blue, brown, green-and-yellow	Brown, black, grey, green-and-yellow
Five-core	Black,blue, brown, black, green-and-yellow	Brown, black, grey, blue, green-and-yellow

Addition or alteration to a d.c. installation

Where an addition or alteration is made to a d.c. installation wired in the old core colours with cable to the new core colours, unambiguous identification is required at the interface. Cores should be marked as follows:

Neutral and midpoint conductors	
Old and new conductors:	M
Line conductors	
Old and new conductors:	Brown or grey, or
Old and new conductors:	L, L+ or L-

Table 7E – Example of conductor marking at the interface for additions and alterations to a d.c. installation identified with the old cable colours

Function	Old conductor		New conductor	
	Colour	Marking	Marking	Colour
Two-wire unearthed d.c. power circuit				
Positive of two-wire circuit	Red	L+	L+	Brown
Negative of two-wire circuit	Black	L-	L-	Grey
Two-wire earthed d.c. power circuit				
Positive (of negative earthed) circuit	Red	L+	L+	Brown
Negative (of negative earthed) circuit	Black	M	M	Blue
Positive (of positive earthed) circuit	Black	M	M	Blue
Negative (of positive earthed) circuit	Blue	L-	L-	Grey
Three-wired d.c. power circuit				
Outer positive of two-wire circuit derived from three-wire system	Red	L+	L+	Brown
Outer negative of two-wire circuit derived from three-wire system	Red	L-	L-	Grey
Positive of three-wire circuit	Red	L+	L+	Brown
Mid-wire of three-wire circuit	Black	M	M	Blue
Negative of three-wire circuit	Blue	L-	L-	Grey

Learning unit 4: install lightning arrestors system

L.O4.1: Implement hazard control and safety measures related to the installation of lightening arrestor system.

- **Content /topic 1: Controlling electrical hazards**

To effectively control and prevent hazards, employers should:

f) Involve workers, who often have the best understanding of the conditions that create hazards and insights into how they can be controlled.
g) Identify and evaluate options for controlling hazards, using a "hierarchy of controls."
h) Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.
i) Develop plans with measures to protect workers during emergencies and non-routine activities.
j) Evaluate the effectiveness of existing controls to determine whether they continue to provide protection, or whether different controls may be more effective. Review new technologies for their potential to be more protective, more reliable, or less costly.

Most dangerous consequences of using electricity are electric shock and electric fire. They are usually caused by damaged insulation, overheating of cables or damp conditions.

- ✓ **Damaged insulation**

- ➢ Rubber is used as insulation for the current-carrying conductors of most electrical appliances.

- Rubber insulation is prone to damage due to regular bending and twisting. (Common appliances that bend/twist during usage: Hair dryer and Iron) The rubber insulation might break apart and expose the wire.
- This damaged insulation would result in

3. Electric shock →→ resulting in serious injury or even death to users.
4. Short circuit in the current path by connecting exposed current-carrying conductors together →→ resulting in the wires heating up →→ fire hazard.

✓ **Damaged tools and equipment**

Electrical tools can be extremely hazardous if they become damaged enough to cause the user to contact exposed live wires.

Check the plug carefully, too. If the plug is the three-prong type and a prong is missing or loose, take the tool out of service until it can be repaired by an electrician.

Before using the tool, check the area carefully for objects with sharp edges and other areas where the cord could be pinched, scraped or cut. Avoid these areas whenever possible. If you can't avoid them, take precautions to protect the cord, such as chaffing gear.

Store electric power tools in a waterproof toolbox when they are not in use. Remember that the cords and other parts of tools become weather beaten if not stored properly and insulation can rot away exposing the wire.

Inspect each tool carefully before you use it. If there are cracks, cuts or abrasions on the cord take the tool out of service until an electrician can replace the cord. Don't try to fix it yourself unless qualified to do so.

✓ **Wet conditions**

- Effective body resistance drop drastically from 100 kΩ to 100 Ω under damp condition (wet environment condition). Activities like sweating, bathing and etc lower the effective resistance of our body.
- This damp condition, coupled with unsafe usage of electrical appliances, would result in large currents flowing through our body causing electrical shock and leading to serious injury or even death.

- **Content /topic2: Accident prevention:**

  - ✓ Use Personal protective equipment (PPE)

i. Overcoat: designed for the **purpose** of keeping the wearer clearly in view, they make abundant **use** of colors that can always be seen and glow in the dark.

j. Overall: **Overalls** are a type of **safety** clothing made of tough cotton, denim or linen and usually used as protective clothing while working

k. Gloves: a covering for the hand worn for protection against cold or dirt and typically having separate parts for each finger and the thumb.

l. Safety shoes: a **shoe** with a reinforced toe cap to minimize foot injuries caused by dropped articles. With a sole of material incapable of sparking for work near combustibles or explosives.

m. Helmet: are one of the most frequently used forms of PPE. **Safety Helmets** will protect the user's head against: impact from objects falling from above, by resisting and deflecting blows to the head

n. Earmuff: are objects designed to cover a person's **ears** for **hearing protection** or for warmth. They consist of a thermoplastic or metal head-band, that fits over the top or back of the head, and a cushion or cup at each end, to cover the external **ears**.

o. Goggles: are forms of *protective* eyewear that usually enclose or protect the area surrounding the *eye* in order to prevent particulates, water or chemicals from striking the eyes.

p. Nose protection mask: are loose-fitting **masks** that cover the **nose** and mouth, And have ear loops or ties or bands at the back of the head.

✓ Inspect tools and equipment

The inspection of tools and equipment is a must in order to work safely, that is why a worker, company or organization have to make sure if there is:

✓ Adequate supply of tools and equipment for inspection

✓ Appropriate PPE for inspection according to each job specification.

✓ Inspect tools and equipment

The inspection of tools and equipment is a must in order to work safely, that is why a worker, company or organization have to make sure if there is:

✓ Adequate supply of tools and equipment for inspection

✓ Appropriate PPE for inspection according to each job specification.

Overheating of cables.

- Especially thin wire conductors, when very large currents are made to flow through these conductors, these wire conductors will heat up and produce very high temperatures. Short-circuit or overloading of cables are conditions that lead to such large currents.
- This overheating of cables would result in melting of the insulation and catching fire.

LEARNING OUTCOME 4.2: SELECT MATERIALS, TOOLS AND EQUIPMENT IN ACCORDANCE WITH THE INSTALLATION TO BE DONE

- **Content / topic 1: Equipment:**

✓ Multimeter

A digital multimeter is the best choice for your first multimeter, even the cheapest will be suitable for testing simple projects and I recommend this one from Rapid Electronics: Digital Multimeter (basic) This has all the ranges required for testing simple projects: DC voltage, DC current (including a useful 10A range), resistance, diode test and AC voltage.

- **Lamp tester :**is a piece of electronic testing equipment that is used to carry out essential lighting equipment tests.it is a simple and cost-effective way of safety establishing the presence of voltage in lamps and testing filament continuity.
- **Phase sequence tester**

Phase sequence meter is used for detecting the sequence of the supply in three-phase electric circuits. Since the direction of rotation of three phase electric motors can be changed by changing the phase sequence of supply. And also the correct operation of measuring instruments like 3 phase energy meterand automatic control of devices also depend on the phase sequence.

✓ **megohmmeter**

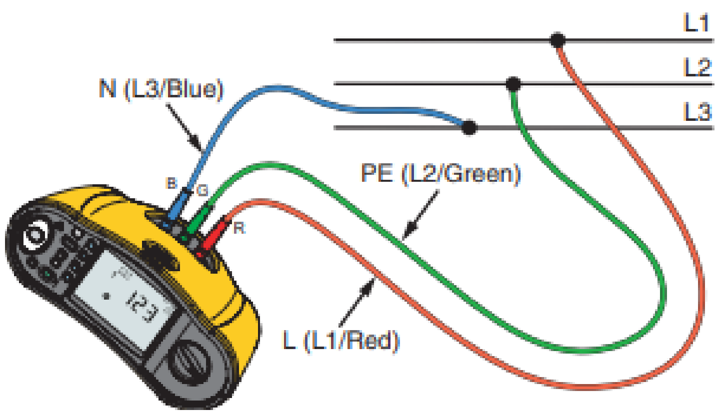
A megohmmeter is a high resistance meter dedicated to measure an ohmic value under a direct voltage of great stability
To measure a high value resistance, techniques for measuring a low value current are used. A constant voltage source (DC Voltage) is applied to the resistance to be measured and the resulting current is read on a highly sensitive ammeter circuit that can display the resistance value (in MΩ, GΩ, TΩ)
A Megohmmeter is also called a high resistance tester, a teraohmmeter , a megger, a high insulation tester

✓ **Polarity checker plug**

Ensuring that your electronics are connected to the AC line with the correct polarity is essential if you want to realize the full potential of your system. What follows is a simplified explanation of the phenomenon, and a description of a simple method of determining the proper connection of the power cord for any piece of equipment in your system.

- ✓ **Multi-function tester**

  Multi-function tester Is an electronic device used by electricians to test electrical circuit that used the low voltages.

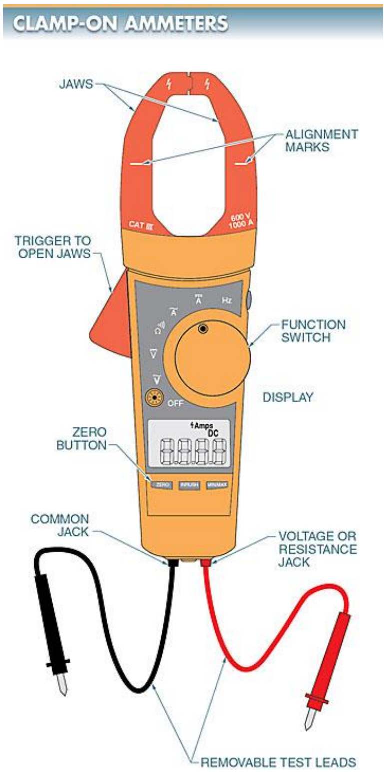


- ✓ **Clap-on ammeter**

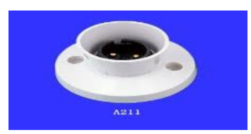
A clamp-on ammeter is a meter that measures the current in a circuit by measuring the strength of the magnetic field around a single conductor. Clamp-on ammeters measure currents from 0.01 A or less to 1000 A or more.

A clamp-on ammeter is normally used to measure current in a circuit with over 1 A of current and in applications in which current can be measured by easily placing the jaws of the ammeter around one of the conductors.

Most clamp-on ammeters can also measure voltage and resistance. To measure voltage and resistance, the clamp-on ammeter must include test leads and voltage and resistance modes.



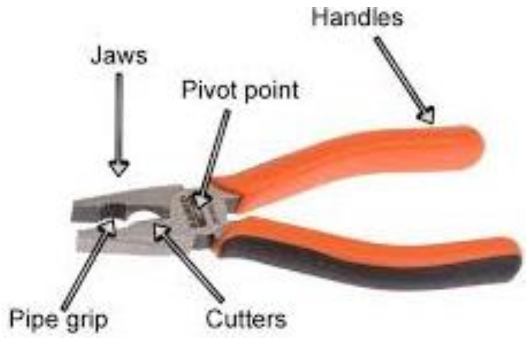
- **Content / topic 2 :.Materials :**

Wires  Used to conduct current	**Lamps**  Used for lighting purpose	**Lamp holder**  Accommodate lamps and permit connection between lamp and wires.	**Conduit**  Used to provide mechanical protection of wires and cables
Cable 	**Switches** 	**Outlet socket** 	Junction box 

Used to conduct electrical power	Used to switch the follow of current in electrical installation	Used to power the electrical appliance	Provide cover where wire are connected together
Trunking  Used to provide mechanical protection of wires and cables	**Wire clips**  Used to hold wires on wall or on wood in surface installation	**Wooden screws**  Used to fix different accessories like junction box, switches, circuit breakers and so on securely	**Insulation tape**  Used to insulate the wires after their connection to avoid short circuit between live and neutral and electrocution
Circuit breakers  Used for electrical installation protection	Fuse  Used for electrical installation protection		

- **Content / topic 3.Hand tools:**
  - ✓ **Pliers**

Figure: Parts of pliers



- ✓ **Wire strippers**

- Stripping insulation from conductors
- Cutting small conductors
- Crimping wire lugs

- ✓ **Side cutter pliers** (Lineman's pliers)

- Cutting large conductors
- Forming loops on large conductors
- Pulling and holding large conductors

- ✓ **Diagonal pliers** (dykes)

- Cutting small conductors
- Cutting conductors in limited spaces

- ✓ **Needle-nose pliers**

- Forming loops on small conductors
- Cutting and stripping small conductors

- ✓ **Combination pliers:**

- Cutting and gripping wires

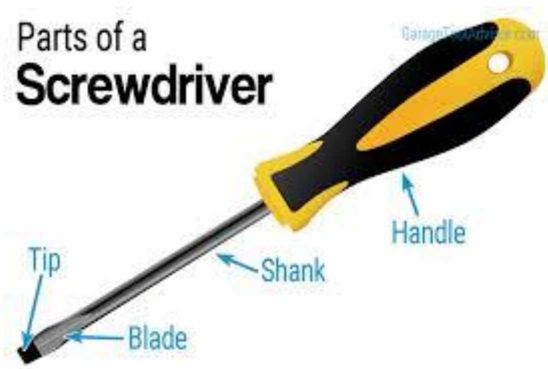
- ✓ **Screwdrivers**

Screwdrivers and nut drivers

Electricians need several screwdrivers and nut drivers to work with various types of fasteners and applications.

Categories of screw drivers

Figure: Parts of screw driver



a) Flat-blade screwdriver

Installing and removing slot-head screws

b) Phillips screwdriver

Installing and removing phillips-head screws

c) Rotating speed screwdrivers

Used for trim work, installing switch and receptacles

d) **Star screwdrivers:**

Installing and removing special screws with special heads

L.O 4.3: select lightening arrestor system based on the area to be protected

The primary objective in arrester application is to select the lowest rated surge arrester that will provide adequate protection of the equipment insulation and be rated such that it will have a satisfactory service life when connected to the power system.

Various types of surge arresters. Photo: Wikimedia Commons.

✓ **Surge Arrester Selection and Application Process**

A comprehensive surge arrester selection and application process should include a review of:

1. All system stresses (continuous operating voltage, temporary overvoltages, and switching surges)
2. Service conditions expected
3. System-grounding configuration (grounded or effectively ungrounded) at the arrester installation location.

Knowing the system configuration (wye/delta, grounded or ungrounded) is a key factor in selecting an arrester rating. Arrester nominal ratings for various utilization system voltages (line-to-line) are based on the system's grounding configuration.

Choosing the correct arrester rating is critical to prevent an application where the arrester can potentially have a violent failure. Any system other than a solidly grounded configuration is considered to be effectively ungrounded and a higher arrester rating should be chosen.

MCOV Rating

Arresters are continually exposed to the power system operating voltage during normal operation. For each arrester rating, there is a recommended limit to the magnitude of voltage that may be applied continuously. This is called the Maximum Continuous Operating Voltage (MCOV).

The arrester rating is selected so that the maximum continuous power system voltage applied to the arrester is less than, or equal to, the arrester's MCOV rating. Both the circuit configuration (wye or delta) and arrester connection (Line-to-Ground or Line-to-Line) are taken into consideration.

- In most cases the arresters are connected line-to-ground.
- If arresters are connected line-to-line, then phase-to-phase voltage must be considered.

Special attention should be given to the grounding configuration of the system, either solidly grounded or effectively ungrounded (impedance/resistance grounded, ungrounded, or temporarily ungrounded). This is a key factor in the selection and application of an arrester.

- LO4.3.1 **Lightning Arrestor's selection according to their component**

✓ **Rods or 'air terminals'**

A lightning rod is a tall metallic tip, or pointed needle, placed at the top of a building. One or more conductors, often copper strips, are used to earth the rod. Rods are designed to act as the 'terminal' for a lightning discharge.

✓ **Conductor cables**

Numerous heavy cables placed around the building in a symmetrical arrangement. This is sometimes referred to as a 'Faraday cage'. These cables are run along the tops and around the edges of roofs, and down one or more corners of the building to the ground rod(s) which carry the current to the ground. This type of LPS may be used for buildings which are highly exposed or house sensitive installations such as computer rooms.

✓ **Ground rods**

These are long, thick rods buried deep into the earth around a protected structure. They are normally made of copper or aluminium and are designed to emit positive streamers.

✓ **Characteristics of Surge Arresters**

The most common surge arresters are **non-linear metal oxide resistors** type in a **porcelain or silicone rubber housing,** and are fitted in **parallel** with the object protected and connected to the earth grid.

Other construction type is **silicon carbide** (SiC) **resistors** (valve-type arresters).

Main electrical characteristics of surge arresters are:

- **Resealing voltage** (voltage across the arrester at which the follow current is still definitely interrupted after sparkover).
- **Maximum continuous operating voltage** (highest power-frequency – **50 Hz or 60 Hz** – voltage that the arrester can withstand permanently).
- **Rated short-circuit current**
- **Nominal discharge current**, which common values are **5 kA, 10 kA and 20 kA**.

Surge arresters are connected **between the life conductors and the earth**. In installations with voltages above **52 kV** surge arresters may be provided with "**discharge operation counters**".

- ✓ **Parameters of lightning arrester**
    - ✓ **Highest system volt**
    - ✓ **Rated frequency**
    - ✓ **Nominal discharge**
    - ✓ **Maximum continuous operating voltage**
    - ✓ **Partial discharge**
    - ✓ **Lightning impulse protection level**
    - ✓ **High current impulse**

LEARNING OUTCOME 4.4: Install lightening arrestor system in accordance with the standards

- **Content /topic1: Conduct risk assessment Analysis**

In order to apply the appropriate set of lightning measures, a lightning risk assessment became imperative. The beginning of this study is the flash striking point. Depending on the striking point, the lightning current can cause different types of damage to a structure. Then, this damage can result in consequential loss in the structure, which translated in a relative value of probable annual loss, it calls risk, R. Finally, the risk value is compared with a tolerable value depending on the type of loss and either the overall risk value is higher or lower than the tolerable risk value, so protection measures should be implemented or not, respectively

LIGHTNING RISK ASSESSMENT

Performing a risk assessment to determine if the facility needs a lightning protection system requires the engineer to compare environmental factors (Nd) to the tolerable risk factors (Nc).

Comparison is conducted by a ratio between the environmental factors and the tolerable risk. If the calculated ratio is 1.0 or greater, then a lightning protection system, which includes SPDs, is required. If the calculated ratio is less than 1.0, then a lightning protection system is not required.

The environmental factors are calculated using the equation of Equation 1.

n this example, we need to determine if a new structure that we are designing should have a lightning protection system based on the following parameters:

$$N_d = N_g A_e C_1 (10^{-6})$$

The environmental factors consist of the collective area of the facility (Ae), its surrounding environment (C1) and the lightning flash density (Ng) of the area.

LIGHTNING RISK ASSESSMENT EXAMPLE

1. Structure size – 100 meters long, 60 meters wide, 15 meters tall

2. The structure is the tallest structure in the vicinity

3. The location of the facility is in St. Petersburg, FL

4. The structure is metal with a metallic roof

5. The structure contains and data center for a regional bank

6. The structure is normal occupied with more than 300 people

- **Content /topic2: Lightning protection design**

The destructive capacity of lightning makes it necessary to assess the **need for protection**, and possibly to **install a system** for effective protection Standards.

In the field of lightning protection, using either ESE lightning rods or classical Faradisation systems, the following principle standards are used:

- NFC 17-102 and similar ESE standards: "Protection of structures and open areas against lightning by lightning rods with early emission device". ESE product standard, which has been adapted in many countries under national designations in similar terms. For example: UNE 21186 in Spain. Coexists with IEC 62305.

- IEC 62305: “Protection against lightning”. European and international standard.

Design rules of the electrical installation protection system

To protect an electrical installation in a building, simple rules apply for the choice of

- SPD(s);
- its protection system.

For a power distribution system, the main characteristics used to define the lightning protection system and select a SPD to protect an electrical installation in a building are:

- SPD
  - quantity of SPD
  - type
  - level of exposure to define the SPD's maximum discharge current Imax.
- Short circuit protection device
  - maximum discharge current Imax;
  - short-circuit current Isc at the point of installation.

The logic diagram in the below illustrates this design rule.

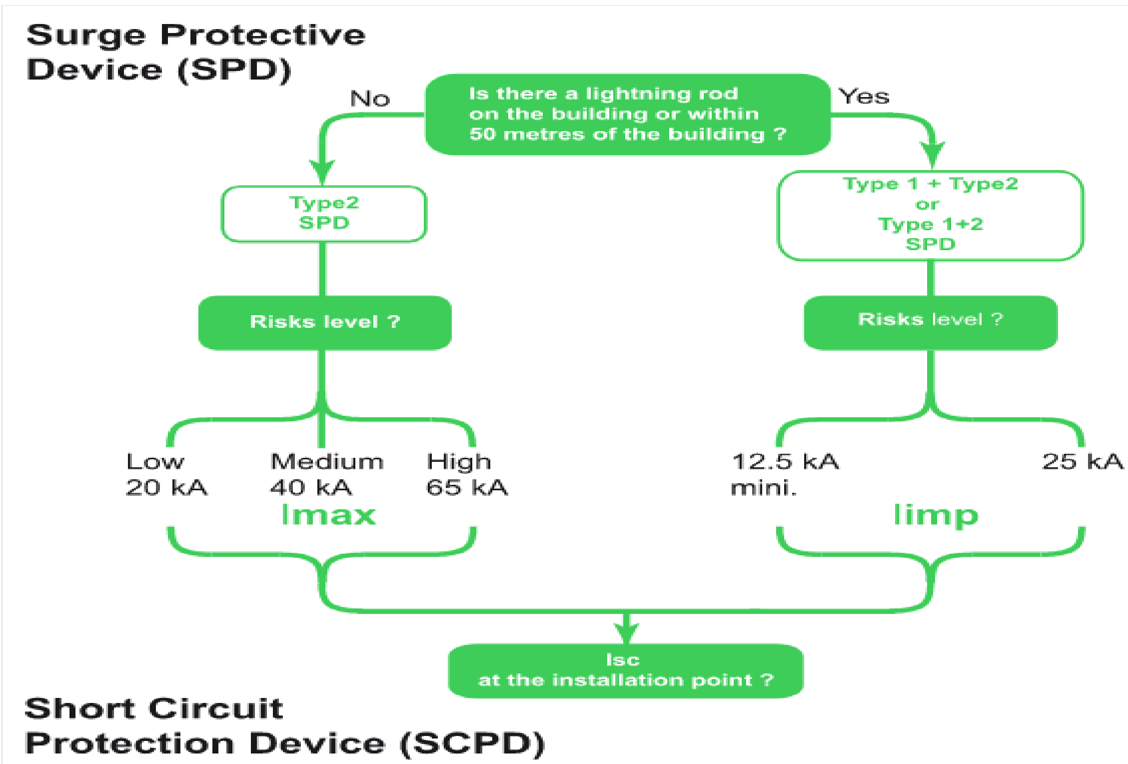


Fig. J20 – Logic diagram for selection of a protection system

The other characteristics for selection of a SPD are predefined for an electrical installation.

- number of poles in SPD;
- voltage protection level Up;
- operating voltage Uc.

Designing an LPS

Inclusion of an LPS should taken into consideration during the design stage. The design should ensure that even if lightning strikes the structure first, the large voltage currents will be drawn into the LPS before serious damage can be done.

An LPS can be designed so as to utilize parts of the building that can safely carry large current loads, and draw energy away from the parts of the building that are not able to.

An LPS should be designed and installed to prevent side flashes between objects. By maintaining the electrical continuity of objects to a bonding conductor, any differences in electric potential can be zeroed, allowing any voltage changes to occur simultaneously.

Failure to design proper grounding will render an LPS ineffective as safe dispersal of the energy from the strike will not be possible. Additional earthing from that provided by a utility supplier is often required.

- **Content /topic3:Construction of the lightning protection system**

The role of the building protection system is to protect it against direct lightning strokes.

The system consists of:

- the capture device: the lightning protection system;
- down-conductors designed to convey the lightning current to earth;
- "crow's foot" earth leads connected together;
- links between all metallic frames (equipotential bonding) and the earth leads.

When the lightning current flows in a conductor, if potential differences appear between it and the frames connected to earth that are located in the vicinity, the latter can cause destructive flashovers.

The 3 types of lightning protection system

Three types of building protection are used:

The lightning rod (simple rod or with triggering system)

The lightning rod is a metallic capture tip placed at the top of the building. It is earthed by one or more conductors (often copper strips) (see **Fig. J12**).

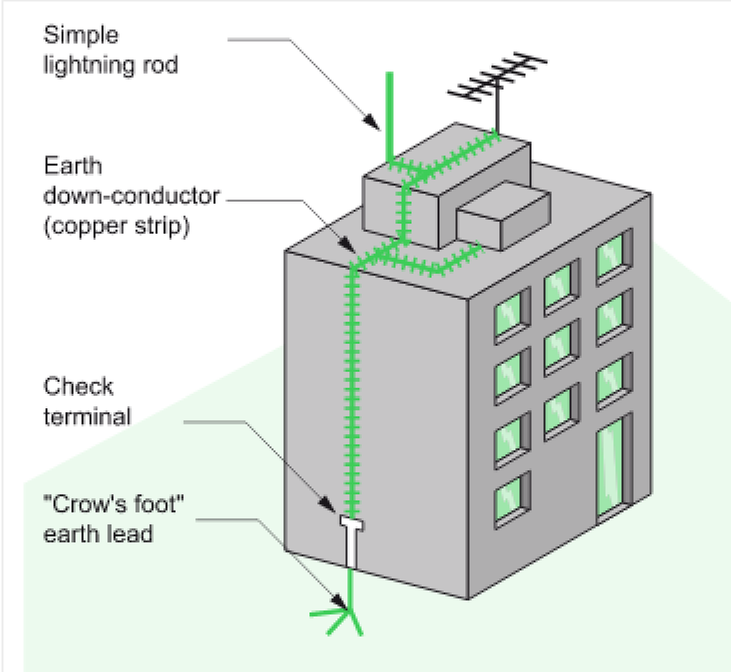


Fig. J12 – Lightning rod (simple rod or with triggering system)

The lightning rod with taut wires

These wires are stretched above the structure to be protected. They are used to protect special structures: rocket launching areas, military applications and protection of high-voltage overhead lines (see **Fig. J13**).

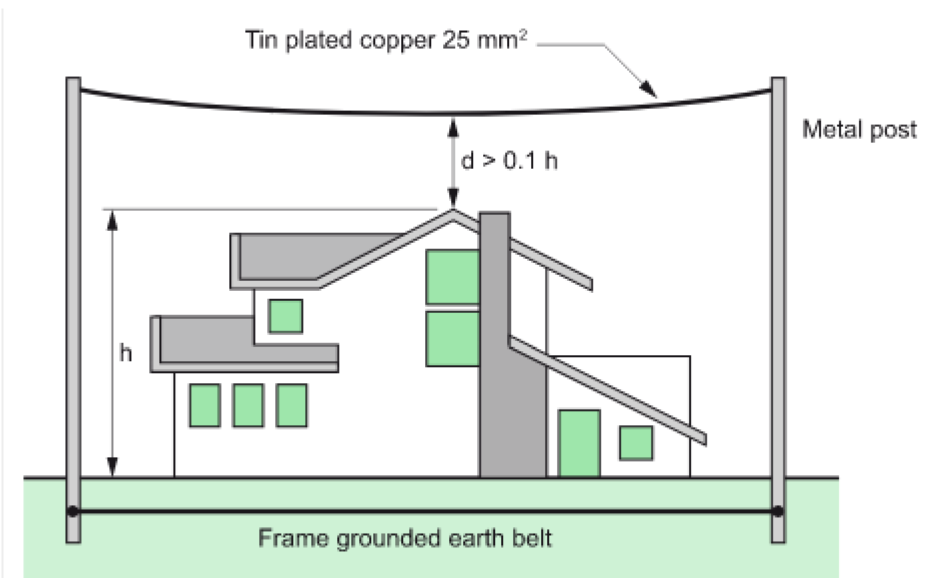


Fig. J13 – Taut wires

The lightning conductor with meshed cage (Faraday cage)

This protection involves placing numerous down conductors/tapes symmetrically all around the building. (see **Fig. J14**).

This type of lightning protection system is used for highly exposed buildings housing very sensitive installations such as computer rooms.

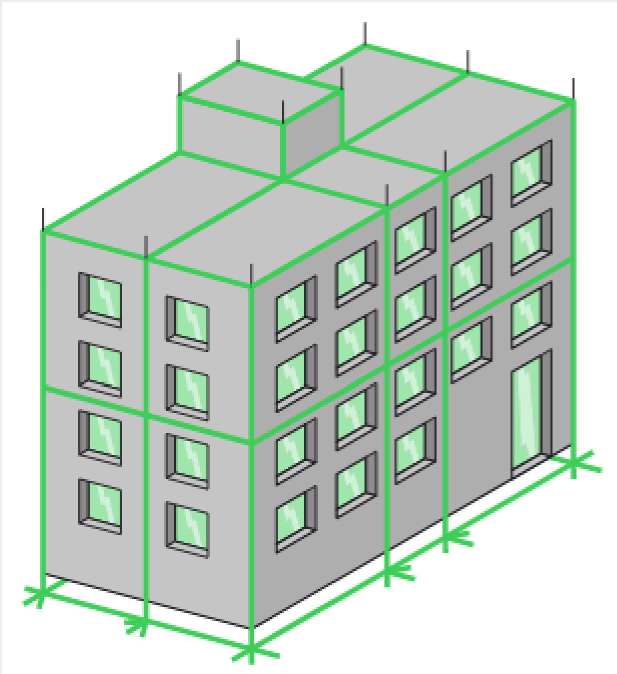


Fig. J14 – Meshed cage (Faraday cage)

Consequences of building protection for the electrical installation's equipment

---

50% of the lightning current discharged by the building protection system rises back into the earthing networks of the electrical installation (see **Fig. J15**): the potential rise of the frames very frequently exceeds the insulation withstand capability of the conductors in the various networks (LV, telecommunications, video cable, etc.).

Moreover, the flow of current through the down-conductors generates induced overvoltages in the electrical installation.

> As a consequence, the building protection system does not protect the electrical installation: it is therefore compulsory to provide for an electrical installation protection system.

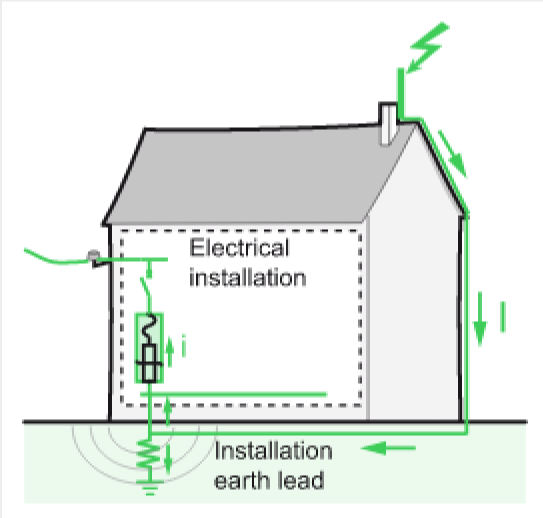


Fig. J15 – Direct lightning back current

Lightning protection - Electrical installation protection system

The main objective of the electrical installation protection system is to limit overvoltages to values that are acceptable for the equipment.

The electrical installation protection system consists of:

- one or more SPDs depending on the building configuration;
- the equipotential bonding: metallic mesh of exposed conductive parts.

Implementation

The procedure to protect the electrical and electronic systems of a building is as follows.

- Identify all sensitive loads and their location in the building.
- Identify the electrical and electronic systems and their respective points of entry into the building.
- Check whether a lightning protection system is present on the building or in the vicinity.
- Become acquainted with the regulations applicable to the building's location.
- Assess the risk of lightning strike according to the geographic location, type of power supply, lightning strike density, etc.

Solution implementation

- Install bonding conductors on frames by a mesh.
- Install a SPD in the LV incoming switchboard.

- Install an additional SPD in each subdistribution board located in the vicinity of sensitive equipment (see **Fig. J16**).

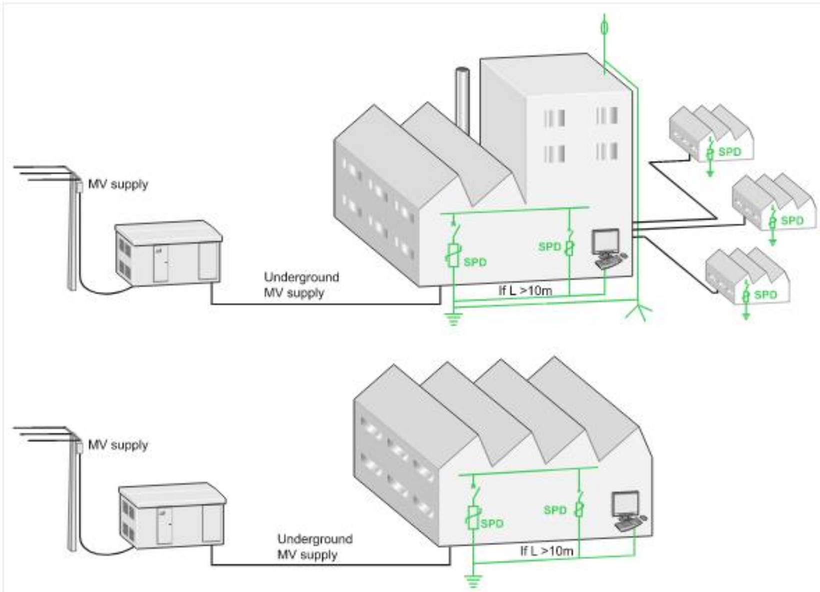
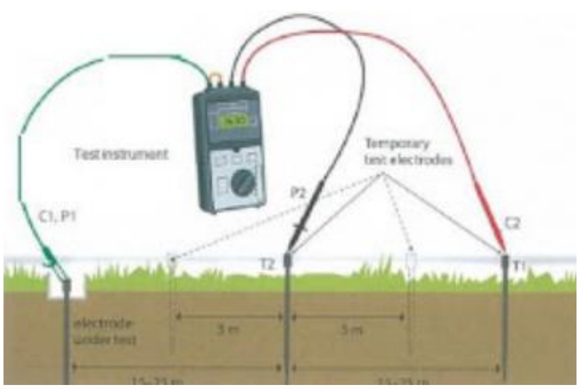


Fig. J16 – Example of protection of a large-scale electrical installation

L.O.4.5: Check lightening arrestor system in accordance with the standards

- **Content /topic1: Different checking method of lightining**

✓ **Electrode Testing**



How to determine the resistance of earth electrode?

Reason for earth electrode resistance testing

The purpose of this test is to establish that the resistance of the soil surrounding an earth electrode is suitable and that the electrode makes contact with the soil

Recognised types of earth electrode

The following types of earth electrode are recognised:

1. earth rods or pipes
2. earth tapes or wires
3. earth plates
4. underground structural metalwork, embedded in foundations
5. welded metal reinforcement of concrete, embedded in the earth
6. metal sheaths and coverings of cables (subject to Regulation 542.02 to 05 in BS 7671)
7. other suitable underground metalwork .

Example (Refer to the diagram above)

There are two temporary test electrodes/spikes (T1 and T2) which must be inserted into the ground. These are normally supplied with the test instrument.

- **C2 -** terminal on the meter is connected to T1 via a long lead, ideally 30-50 m away from the electrode under test.
- **P2 -** terminal on the meter is connected to T2 via a long lead, and is centrally positioned between T1 and the electrode under test Ideally, the distance between the earth electrode and test spike T1 should be ten times the length of the electrode under test, but this dimension is likely to be affected by the location of the electrode and any surrounding buildings, paths or driveways, for example.
- **C1 - e**arth electrode being tested (Ra)

Three readings are taken during this test, with test spike T2 moved for each reading. The distance T2 is moved for the second and third readings depends on the distance between the electrode and spikeT1 .

If the distance between them is 30 m then, typically, T2 will be moved 10% of that distance, which is 3 meter. So, the first test is taken with spike T2 in the central position, the second test with the spike moved 10% closer to the earth electrode and the third test with the spike moved 10% from the centre, away from the earth electrode.

Here we will consider example readings for an earth electrode in good soil or clay

(the earth electrode is 3 meter long, so the distance between the electrode and test spike T2 is 30 m):

- with T2 central = 72 ohms
- with T2 3 m closer to the electrode under test = 70.5 ohms
- with T2 3 m closer to T1 = 73.5 ohms

Evaluation of test results

Once the three results have been obtained, the average of the three is found. So, using the example values given above, the average reading is: **72 ohms**

The three readings obtained should fall within a tolerance of 5% of the average, so 5% of 72 is 3.6 ohms so a tolerance of **± 5%** gives **75.6 ohms** and **68.4 ohms.**

As the three readings all fall within this 5% tolerance, they are acceptable and the average value (72 ohms) would be recorded as the earth electrode resistance **(Ra = 72 ohms).**

Note: If the deviation exceeds 5%, further tests must be carried out with a larger separation between the earth electrode under test and spike T1.

Acceptable test values for an earth electrode

Earth electrode resistance values can differ greatly, dependent on the type of ground and environmental conditions, the material of the electrode used and area of contact with the general mass of earth.

It is recommended that the earth electrode resistance test is carried out when the ground conditions are least favorable, such as during dry weather.

Note: If the reading of the three values are **above 200 ohms**, the soil condition may not be stable, as soil conditions change due to factors such as soil drying and freezing.

- ✓ **Resistance test**

Insulation Resistance Test

This test is to measure the total resistance of a product's insulation by applying a voltage of 500 V – 1000 V for low voltage systems. The acceptable value of resistance for a product to pass an insulation resistance test is relative. They can be quite different for one motor or machine tested three days in a row, yet not mean bad insulation. What really matters is the trend in readings over a time period, showing lessening resistance and warning of coming problems.[5] The insulation resistance test is not a substitute for the high voltage test. Many standards and safety agencies have specified this is a universal test for all products. This test may also be carried out after every maintenance procedure or repair.

- ✓ **Continuity testing of earthing wire**

Earth Continuity Test

This test is performed by measuring the resistance between the third pin (ground) and outside metal body of the product under test. The maximum acceptable value is generally 0.5 ohms although certain standards may specify 0.1 ohms. This test is generally carried out at a slightly higher current (e.g. 25–60 A) so that the ground bond circuit maintains safe voltages on the chassis of the product, even at a high current, before the circuit breaker trips. This test is essential so that the product does not cause an electric shock resulting from insulation failure. In India current specified is 16 A so the test is done at double of the current i.e. 32 A.

- ✓ **Corrosion**

Inspections and testing should be carried out:

- During the construction of the structure, especially in order to check the embedded electrodes and associated clamps and bonds
- After installation of the Lightning Protection System
- Periodically at such intervals as determined with regard to the nature of the structure to be protected
- After alterations or repairs, or when it is known that the structure has been struck by lightning

It is particularly important to check the following during the periodic inspection:

- Deterioration and corrosion of air termination elements, conductors and connections
- Corrosion of earth electrodes
- Earthing resistance value for the earth termination system
- Condition of connections, equipotential bonding and fixings

L.O 4.6: Arrange tools, materials and equipment in working place

- **Content /topic1: Storage and maintenance of electrical tools**

Power tools and other machines are designed for long life, but each requires some **care** and **maintenance** to meet its life expectancy. Properly storing power tools, performing maintenance as needed, and replacing machine parts will extend a tool's life to its full **potential** and deliver more **value** to its owner. We offer some general tips and guidelines below for extending the life of any machine or power tool. **Proper Storage** Our **three guidelines** for tool storage are:

1. Store tools in an area protected from the elements (like moisture).

2. Store tools in a clean and organized space.

3. Store tools in a well-ventilated area.

Care and Maintenance before being stored, most power tools can use a little **cleaning** and a couple of quick **checks** for damage or other problems. Here's some **maintenance tips** for keeping those tools in good shape:

- Use a toothbrush and a soft **cloth** to wipe debris from power tool casings before storage.

- **Content /topic2: Storage and maintenance of electrical material**

Material Storage & Handling

On receipt of the Lightning Protection System materials at site necessary precautions shall be taken for unloading, shifting and storage, as follows:

- Material shall be stored in a covered / dry space at all the time to avoid being damaged.
- All materials received at site shall be inspected and ensured that the materials are as per approved material submittal.
- Any discrepancies, damage etc., found will be notified and reported for further action.
- Material found not suitable for site use will be removed from site immediately.

Cleaning & Preparation of Earthing Materials

The surfaces of all conductors etc. to be welded must be clean, dry & bright. Oil and grease may be burned out with a butane/acetylene torch or cleaned with a rapid-drying solvent such as Methylene Chloride. After cleaning use a cable brush or card cloth brush to remove any residue and brighten the surfaces.

Corroded cable must be cleaned. It is especially important that the ends of the individual strands are clean; this can best be achieved by making a fresh cut on the end of the cable.

Bent or out-of-round cable will hold the mould open and cause leeks; therefore, the cable must be straightened before clamping the mould into place. Remove any insulation before cutting to prevent insulating material becoming trapped in the strand-ends.

Use a file, emery cloth or card brush to remove oxides. On tubes, clean the inside surface as well as the outside end.

Remove rust and all scale with a rasp, coarse file or grinder (not resin-bonded). Galvanised surfaces may be cleaned with emery cloth to remove oxide film; it is not necessary to remove galvanising. For cast iron less than 12mm thick do not use larger than powder no. 65. Use only P2 powders for cast iron; do not use regular powders. Under some conditions of temperature and humidity, the surface to be welded will sweat, causing porous welds. This can be eliminated by warming the surface with a hand torch.

Ends that are threaded, 'mushroomed' from driving or drilled and tapped must be cut off. Undersized rods may be built up with copper shim. Use a grinder to remove all mill scale and rust front the rail surface, (wire-brushing is inadequate), and to remove any raised lettering on the rail web.

- **Content /topic 3 : Storage and maintenance of electrical equipment**

Test and Maintenance Equipment. All maintenance work r.eq' u'ires that use" of. Proper 'tools and equipment properly, perform the task to be done. In addition to their ordinary tools(each craftsman (such as carpenters, pipe fitters, and machinists) uses some special tools or equipment based on the nature of the Work to be performed, The electrician is no exception, , additional equipment not found in his toolbox should be readily avail. able: The size of the plant; nature of its operations; extent of its maintenance, repair, and test facilities; are all factors which de. termine the use-frequency of the equipment.

• **Routine Maintenance** – Activities that are conducted while equipment and systems are in service. These activities are predictable and can be scheduled, staffed, and budgeted. Generally, these are the activities scheduled on a time-based, run-time-meter-based, or a number of operations schedule. Some examples are visual inspections, infrared scans, cleaning, functional tests, measurement of operating quantities, lubrication, oil tests, governor, and excitation system alignments.

REFERENCE

LEANING UNITY 1. ANALYZE PROTECTION SYSTEM ACCORDING TO THE TYPES OF LOAD

1. https://ehsdailyadvisor.blr.com/2012/09/common-workplace-eye-hazards-and-what-to-do-about-them/
2. https://www.hsa.ie/eng/Topics/Hazards/
3. https://www.haspod.com/blog/construction/10-simple-construction-site-safety-rules

LEANING UNITY 2. INSTALL PROTECTIVE DEVICES

4. https://www.diydoctor.org.uk/projects/consumer_unit.htm
5. https://www.designingbuildings.co.uk/wiki/Switchgear
6. https://www.relectric.com/blog/2019/09/15/installing-circuit-breakers/amp/
7. https://www.c3controls.com/white-paper/replacing-fuses-with-circuit-breakers/
8. https://www.relectric.com/circuit-breaker-tips/how-to-test-a-circuit-breaker
9. https://www.dfliq.net/blog/circuit-breaker-box-labeling-why-and-how/

LEANING UNITY 3. INSTALL EARTHING SYSTEM

10. https://www.electricalinstallation.org/enwiki/Selection_criteria_for_the_TT,_TN_and_IT_systems#cite_note-J-12
11. https://www.lsp-international.com/power-supply-system/
12. https://blog.nvent.com/erico-what-is-soil-resistivity-and-how-does-it-affect-grounding/
13. https://electrical.theiet.org/wiring-matters/years/2017/65-may-2017/new-video-safe-isolation-procedure/
14. https://www.powerandcables.com/product/earth-tapes-rods-bars-copper/marconite/
15. https://www.powerandcables.com/product/earth-tapes-rods-bars-copper/earth-rods/
16. https://www.fairfaxva.gov/home/showdocument?id=492
17. https://www.electrical installation.org/enwiki/Cabling_rules_of_Surge_Protection_Device
18. https://testguy.net/content/286-Surge-Arresters-Selection-Application-and-Testing-Overview#arrester_construction

19. https://methodstatementhq.com/method-statement-installation-testing-lightening-protection-system.html
20. https://www.usbr.gov/power/data/fist/fist4_1B/4-1B%20Maintenance%20Scheduling%20for%20Electrical%20Equipment%20(November%202005).pdf

LEANING UNITY 4. INSTALL LIGHTENING ARRESTORS SYSTEM

21. https://www.ereplacementparts.com/repaircenter/article/880/Power_Tool_Care_and_Maintenance_101.html
22. https://lightningmaster.com/services/lightning-protection-system-lps-inspection-maintenance/
23. https://keyelectrical.com/lightning-protection/
24. https://www.pat-testing-course.com/blog/faqs/insulation-resistance-test/
25. https://professional-electrician.com/technical/earth-electrode-testing/
26. http://www.electricalaxis.com/2016/11/how-to-perform-earth-electrode.html?m=1
27. http://www.cirprotec.com/Support/Knowledge-area/Lightning-protection/Step-by-step/Step-by-step-protection
28. https://www.designingbuildings.co.uk/wiki/Lightning_protection_system
29. https://www.electrical-installation.org/enwiki/Design_rules_of_the_electrical_installation_protection_system
30. https://www.electricaltechnology.org/2018/07/types-characteristics-of-surge-arresters.html/amp
31. https://www.electricaltechnology.org/2015/05/earthing-and-electrical-grounding-types-of-earthing.html