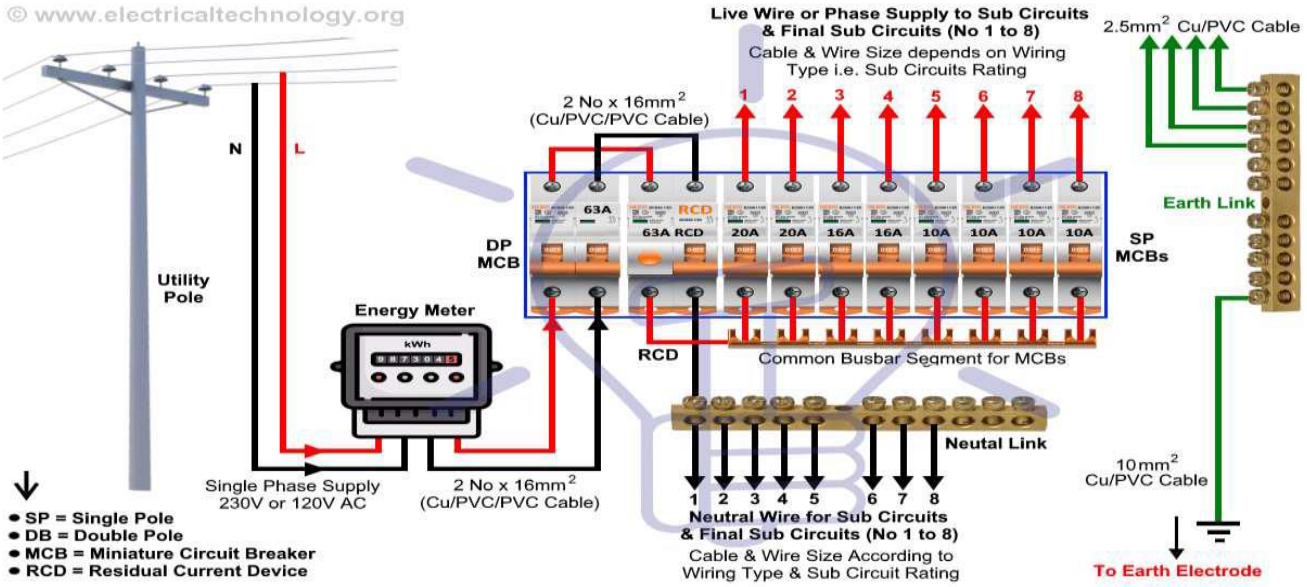
Domestic Wiring (Single Phase) Diagram



Wiring of the Distribution Board with RCD (Single Phase Supply)
(From Utility Pole & Energy Meter to the Consumer Unit)

Types of Wiring: Two-way and three-way control of load

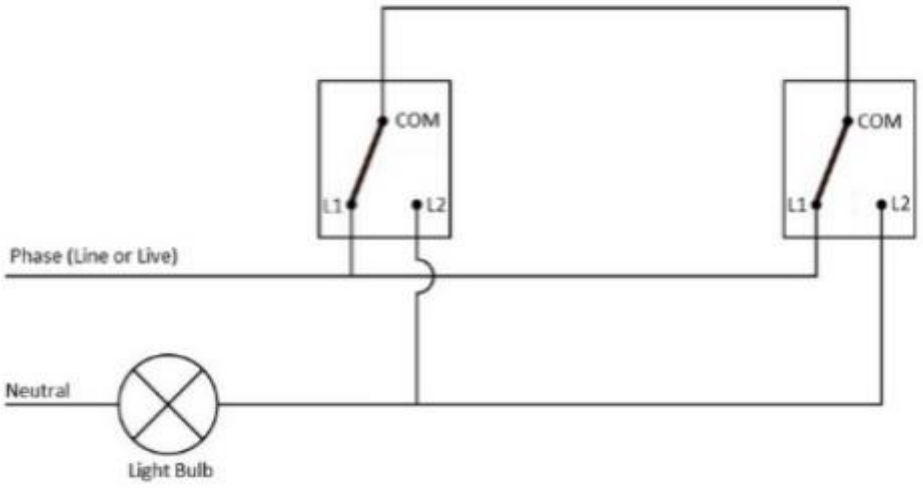
<u>Two-way control of load:</u>

What is a Two-way Switch?

The two way (double-pole) switch is used to ON and OFF the light from two different locations and the switch is mostly used in the case of stairs, in rooms that have two entries. This type of switch is generally used in some home wiring systems and industrial applications.

Two Way Switch Wiring

The COM, L_1, and L_2 are the three terminals of the two-way switch. The L1 terminals of both the switches are connected to phase, and L2 terminals of both the switches connected to one end of the bulb terminal and the other end of the bulb terminal are connected to neutral of the AC supply. The three-wire two-way switch wiring diagram is shown in the below figure.



The light is OFF when COM terminals of both the switches are connected with L_1 or L2 terminals. The light is ON when the first switch COM terminal is connected with the L_1 terminal and the second switch COM terminal is connected with the L_2 terminal. Similarly, the light is ON when the first switch COM terminal is connected with the L_2 terminal and the

second switch COM terminal is connected with the L_1 terminal. This is the function of two way switch wiring.

Three-way control of load: Self-assessment to the students

Electricity bill

The power rating of an electric appliance is **the electrical energy consumed per second by the appliance when connected across the voltage of the mains**.

One Unit of Electrical Energy: The power consumption of electrical appliances is measured in term of Units. A unit (as mentioned on the electricity bills) is represented in **kWH or Kilowatt Hour**. This is the actual electricity or energy used. If we use 1000 Watts or 1 Kilowatt of power for 1 hour then you consume 1 unit or 1 Kilowatt-Hour (kWh) of electricity. Therefore, **1 Unit = 1 kWh**

For example: A 1000 watt electric iron running for one hour will consume (1000 watt X 1 hour) 1000 watt hour or 1 kilowatt hour (kWh) of electricity. Similarly to calculate the monthly power consumption multiply the daily power consumption by 30 days and for annual power consumption multiply the daily power consumption by 365 days.

Example 1: Power consumed by a 100-Watt LED TV running for 24 hours in a day for the entire month.

Power rating of TV – 100 Watt

Operational Hours – 24 X 30 – 720 hours in a month

Energy consumed by the TV = 100-Watt X 720 Hours =72000 Watthours
(1 kilowatt hour (kWh) = 1000 watt hour)

Example 2 : A 1000 watt water heater running for 1 hours daily for the entire month. Power rating – 1000 Watt

Operational Hours – 1 X 30 – 30 hours in a month

Power consumed by water heater = 1000 Watt X 30 Hours
Power consumed by water heater = 30,000 Watt Hours = 30 kWh

Wattage & Power Consumption of Typical Household Appliances:

APPLIANCES	WATTAGE (MIN)	WATTAGE (MAX)	MINUNITS CONSUMED IN AN HOUR	MAX UNITS CONSUMED IN AN HOUR
1 Ton Air Conditioner	800W	1000W	0.8 kWh	1 kWh
1.5 Ton Air Conditioner	1000W	1500W	1 kWh	1.5 kWh
50 Inch LCD TV	140W	170W	0.14 kWh	0.17 kWh
50 Inch LED TV	90W	110W	0.09 kWh	0.11 kWh
Bread Toaster (2 Slice)	700W	1000W	0.7 kWh	1 kWh
Bread Toaster (4 Slice)	1200W	2500W	1.2 kWh	2.5 kWh
Ceiling Fan (48 Inch)	60W	80W	0.06 kWh	0.08 kWh
Desktop Computer	100W	450W	0.10 kWh	0.45 kWh
Dishwasher	1200W	1500W	1.2 kWh	1.5 kWh
Domestic Water Pump	200W	1500W	0.20 kWh	1.5 kWh

Electric Kettle	1200W	3000W	1.2 kWh	3 kWh
Exhaust Fan	12W	12W	0.012 kWh	0.012 kWh
Fridge / Freezer	150W	400W	0.15 kWh	0.4 kWh
Front Load Washing Machine	500W	2200W	0.5 kWh	2.2 kWh
LED Light Bulb	7W	10W	0.007 kWh	0.01 kWh
Oven	1000W	2150W	1 kWh	2.15 kWh
Power Shower	7500W	10500W	7.5 kWh	10.5 kWh
Projector	220W	270W	0.22 kWh	0.27 kWh
Refrigerator	100W	200W	0.1 kWh	0.2 kWh
Top Load Washing Machine	500W	2500W	0.5 kWh	2.5 kWh
Tube Light	22W	22W	0.022 kWh	0.022 kWh
Vacuum Cleaner	450W	900W	0.45 kWh	0.9 kWh
Wall Mounted Fan	45W	60W	0.045 kWh	0.06 kWh
Washing Machine	500W	500W	0.5 kWh	0.5 kWh

Water Filter and Cooler	70W	100W	0.07 kWh	0.1 kWh
Zero Bulb	1W	1W	0.001 kWh	0.001 kWh

Note: The above list are approximate values and the exact power consumption will differ from brand to brand.

Definition of Tariff

It is the rate at which the electric energy is supplied to the consumer. It depends upon the magnitude of electric energy & load conditions. It will be different for different customers such as domestic, agricultural, commercial & industrial consumers.

Two-part tariff - It has fixed charges and running charges. The fixed charges depends upon the maximum demand of the consumer and running charges on the amount of kwh consumed.

Total charges=Rs(axkw+bxkwh)

a - Charges per kW of maximum demand

b - Charges per kWh of energy consumed

The consumer has to pay fixed charges irrespective of the consumer uses his load or not.

Advantages of Two-part Tariff:

- It is easily understood by the consumer. •
- It recovers fixed charges which depend upon the maximum demand of the consumer independent of the units consumed.

Disadvantages of Two-part Tariff:

- Consumer has to pay the fixed charges irrespective of the fact whether he has consumed or not the electrical energy.
- There is always error in assessing the maximum demand of the consumer.

Example1: A certain electric supply undertaking having a maximum demand of 110 MW generates 400x 106 kWh per year. The company supplies power to consumers having an aggregate demand of 170 MW. The annual expenses including capital charges are as follows:
a. Fuel: Rs. 5x106
b. Fixed expenses connected with generation : Rs. 7x106
c. Transmission and distribution expenses : Rs. 8 x106
Assume 90% of the fuel cost as variable charges and transmission and distribution losses as 15% of energy generated. Determine a two part tariff for the consumers on the basis of actual cost.

Soln (i) Fixed charges per annum :-

F.C for generation = Rs. 7×10^6

T & D expenses = Rs. 8×10^6

10% of fuel cost = Rs. 0.5×10^6 (10% of 5×10^6)

= Rs. 15.5×10^6

This cost has to be spread over the aggregate maximum demand of all consumers ie 170 MW

Cost per KW of max. demand = Rs. $15.5 \times 10^6 / 170 \times 10^3$ = Rs. 91.2/-

(ii) Running charges per annum :-

90% of fuel cost = Rs. 4.5×10^6 (90% of 5×10^6)

These charges have to be spread over the no. of kWh actually delivered. ie No. of units delivered = $0.85 \times 400 \times 10^6$

= 340×10^6

Running cost / kWh = Rs. $4.5 \times 10^6 / (340 \times 10^6)$ = 1.32 p/ kWh

Hence the two part tariff for the consumer would be Rs. 91.2 per kW of max. demand & 1.32 p per kWh consumed.

Calculation of electricity bill for domestic consumers.

Electricity consumption is recorded in terms of kWh (Kilowatt Hour) or Units by the electricity meter installed in the premise.

A person from the utility (or DISCOM or distribution company) visits the premise at a selected frequency (in most states it is monthly, but in some states it is bimonthly or even quarterly based on choice) and records the reading on the meter. This meter reading is subtracted from your previous meter reading to come up with the units consumed (or kWh consumed) for the period. The units consumed are then applied to a slab-based tariff structure to come up with energy or electricity charges. In all states the tariff structures for residential consumers are designed in such a way that per unit charge is less if the consumption is less and more if the consumption is more. In fact it increases significantly as we increase the electricity consumption.

For Example: Mumbai Reliance energy has following tariff:

First 100 units: Rs 2.96/unit & Next 200 units (from 101 to 300): Rs 5.56/unit

Next 200 units (from 301 to 500): Rs 9.16/unit Any units after that (above 500): Rs 10.61/unit.

So taking the above case, if the consumption is less than 100 units, we just pay Rs 2.96 per unit. But if the consumption increases beyond 500 units, every unit above 500 is charged at Rs 10.61 per unit. So if we have consumed 540 units in a month, the bill will be calculated as:

First 100 units @ Rs 2.96 = Rs 296

Next 200 units @ Rs 5.56 = Rs 1112

Next 200 units @ Rs 9.16 = Rs 1832

Final 40 units @ Rs 10.61= Rs 424.4

So we pay higher amounts per unit as our consumption increases. The motive behind such structure is to motivate people to consume less electricity.

What is Electrical Fuse?

A fuse is a part of the circuit which consists of a conductor which melts easily and breaks the connection when current exceeds the predetermined value. The **materials used for fuse wires** are mainly tin, lead, zinc, silver, antimony, copper, aluminum etc.

Advantages of fuse

1)It is simplest and cheapest protecting device.

2)It requires no maintenance.

3)The Operation of fuse is automatic

4)The minimum operating time during abnormal condition.

5)With the help of fuse heavy currents can be interrupted without noise, smoke, gas and flame.

Disadvantages of fuse

1)Fuse is required to be replaced or rewired after its operation.

2)The replacement or rewiring of fuse takes a lot of time.

3)It is not possible to provide secondary protection to fuses.

PROPER FUSE RATING TO WIRE SIZE

Wire Gauge (copper)	Fuse Rating	Comment
22 gauge (ga.)	--	24 volt thermostat, 10-16 volt doorbell
18 ga.	--	Lamp cord, Low voltage equipment
16 ga.	--	Lamp cord, low volt sound system wiring (to speakers, etc.)
14 ga.	15 Ampere (amp)	Common old house wiring (knob and tube)
12 ga.	20 amp	Common residential circuit wiring
10 ga.	30 amp	Electric dryer (under 20 feet length)

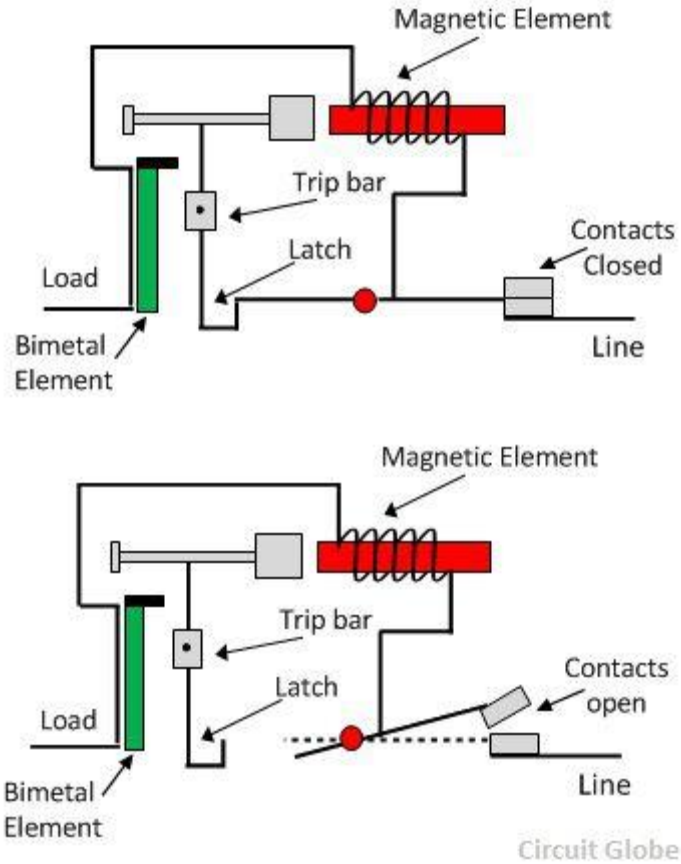
8 ga.	30 to 45 amp	Electric dryer (over 20 feet length)
6 ga.	50 to 60 amp	Electric range, power feed to subpanel, heat pump unit
4 ga.	70 to 85 amp	Service entrance wire on old 60 amp main service panel
2 ga.	95 to 115 amp	Service entrance wire for 100 amp main service panel
1 ga.	110 to 130 amp	Service entrance wire for 125 amp main service panel
2/0 ga.	145 to 170 amp	Service entrance wire for 150 amp main service panel
3/0 ga.	165 to 200 amp	Service entrance wire for 200 amp main service panel

What is Miniature Circuit Breaker (MCB)?

An **MCB or miniature circuit breaker** is an electromagnetic device that represents complete enclosure in a molded insulating material. The main function of an MCB is to switch the circuit, i.e., to open the circuit (which has been connected to it) automatically when the current passing through it (MCB) exceeds the value for which it is set. It can be manually switched ON and OFF as similar to normal switch if necessary.

Working & Operation of MCB

Figure shows the general line diagram of MCB.



Under normal working conditions, MCB operates as a switch (manual one) to make the circuit ON or OFF. Under overload or short circuit condition, it automatically operates or trips so that current interruption takes place in the load circuit. The visual indication of this trip can be observed by automatic movement of the operating knob to OFF position. This automatic operation MCB can be obtained in two ways as we have seen in MCB construction; those are magnetic tripping and thermal tripping.

Under overload condition, the current through the bimetal causes to raise the temperature of it. The heat generated within the bimetal itself enough to cause deflection due to thermal expansion of

metals. This deflection further releases the trip latch and hence contacts get separated. In some MCBs, magnetic field generated by the coil causes develop pull on bimetal such that it deflection activates the tripping mechanism.
Under short circuit or heavy overload conditions, magnetic tripping arrangement comes into the picture. Under normal working condition, the slug is held in a position by light spring because magnetic field generated by the coil is not sufficient to attract the latch. When a fault current flows, the magnetic field generated by the coil is sufficient to overcome the spring force holding slug in position. And hence slug moves and then actuate the tripping mechanism.
A combination of both magnetic and thermal tripping mechanisms are implemented in most of MCBs. In both magnetic and thermal tripping operations, an arc is formed when the contacts start separating. This arc is then forced into arc splitter plates via arc runner. These arc splitter plates are also called arc chutes where arc is formed into a series of arcs and at the same time energy extracted and cools it. Hence this arrangement achieves the arc extinction.

Advantages of MCBs:

- MCBs have more sensitive to current then fuse.
- It has quick work against short circuits.
- It works quickly on overloading and under voltage.
- It is very simple to resume the supply.
- It can be easily used circuit control switch when needed.
- Handling MCB is electricity safer than handling fuse.

Disadvantages of MCBs:

- The cost of the MCB is greater than the fuse.
- The cost of the MCB distribution board is greater than the rewireable fuse board.

Electrical Shock: A sudden agitation of the nervous system of a body, due to the passage of an electric current is called an electric shock or A sudden discharge of electricity through a part of the body

The factors affecting the severity of the shock are,

1. Magnitude of current passed through the body.
2. Path of the current passed through the body.
3. Time for which the current is passed through the body.
4. Frequency of the current.
5. Physical and psychological condition of the affected person.

Effects of Electrical Shock

- loss of consciousness
- Muscle spasms, numbness or tingling
- Breathing problems, irregular heartbeat.

Elementary first Aid against Shock

The first aid can save the life and reduce severity of the accidents. The first aid against an electric shock involves following steps,

1. Do not panic.
2. Carry the affected person and lay him in a comfortable position and call the doctor immediately.
3. Look for stoppage of breathing.
4. Start giving him artificial respiration if breathing is stopped.
5. Never give anything to the person to drink when the person is unconscious.
6. The artificial respiration should be continued for longer time.
7. The burns caused due to electric flashes should be covered with sterile dressing and then bandaged.
8. Do not make crowd round and let patient get the fresh air.

Earthing

- **Definition:** The process of transferring the **immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire** is known as the electrical earthing. The electrical earthing is done by connecting the non-current carrying part of the equipment or neutral of supply system to the ground.
- Mostly, the galvanised iron is used for the earthing. The **earthing provides the simple path to the leakage current**. The short circuit current of the equipment passes to the earth which has zero potential. Thus, protects the system and equipment from damage.

Types of Electrical Earthing

Neutral Earthing

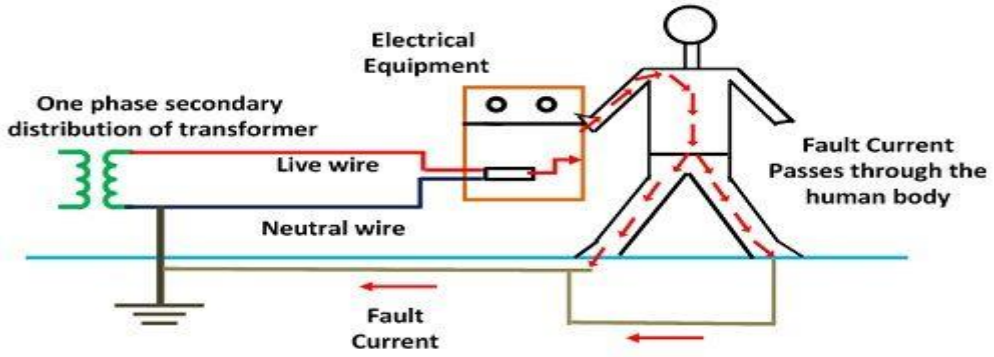
- In neutral earthing, the neutral of the system is directly connected to earth by the help of the GI wire. The neutral earthing is also called the system earthing. Such type of earthing is mostly provided to the system which has star winding. For example, the neutral earthing is provided in the generator, transformer, motor etc.

Equipment Earthing

- Such type of earthing is provided to the electrical equipment. The non-current carrying part of the equipment like their metallic frame is connected to the earth by the help of the conducting wire. If any fault occurs in the apparatus, the short-circuit current passes to the earth by the help of wire. Thus, protect the system from damage.

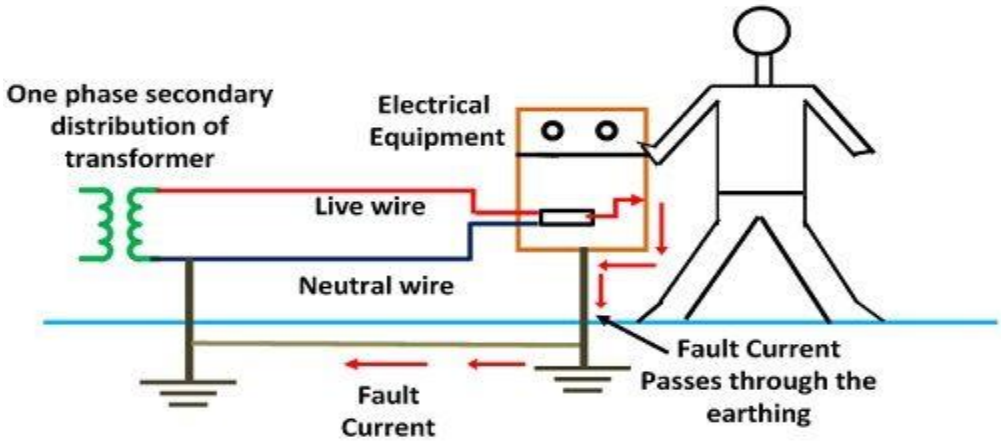
Importance of Earthing

Following figures show the importance of earthing. In case of electrical system without earthing, fault current flows through the human body whereas in case of system with earthing it is diverted to ground/earth.



Electrical System Without Earthing

Circuit Globe

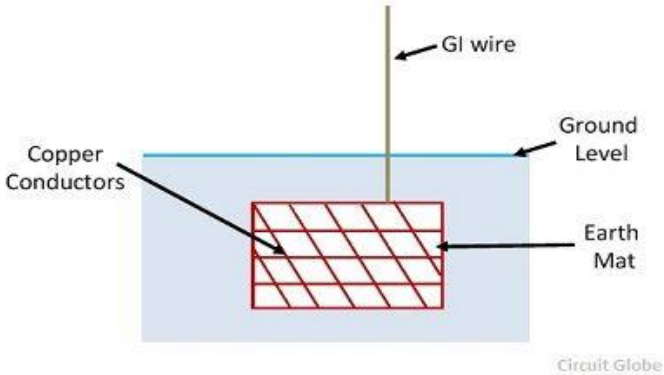


Electrical System With Earthing

Circuit Globe

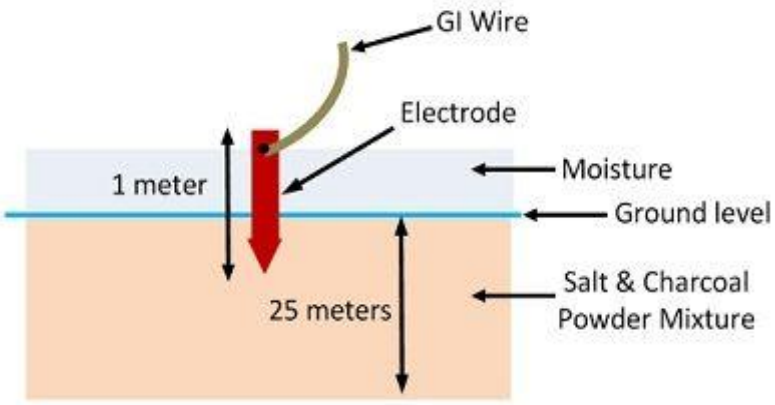
Methods of Earthing

- **Earthing Mat**



Circuit Globe

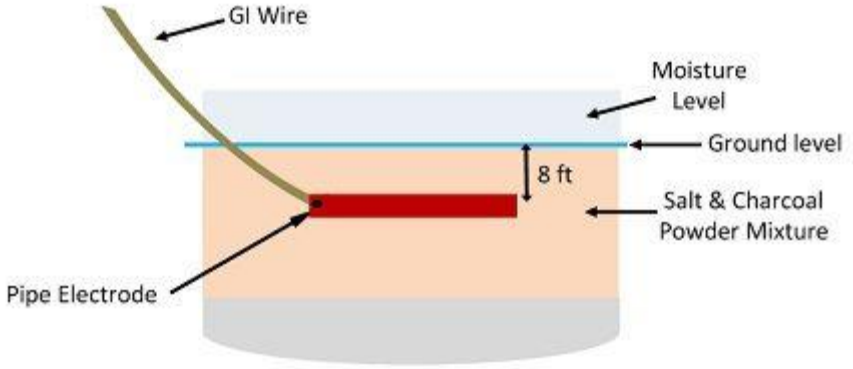
- **Earthing Electrode**



Earthing Through Electrode

Circuit Globe

- **Pipe Earthing**



Pipe Earth Electrode

Circuit Globe

- **Plate Earthing**

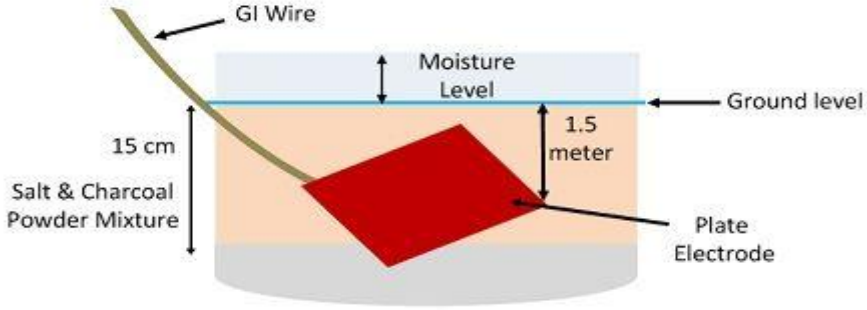


Plate Earth Electrode

Circuit Globe

Grounding

The grounding includes measures for protecting the part of the circuit, which provides the desired function or the working feature of that circuit.

Grounding can be performed directly or indirectly. Direct grounding is carried out by direct connection of the grounding system. Indirect grounding is performed by binding to the grounding system through impedance (active resistance, inductance, capacitance, or combinations thereof).

Difference between Earthing and Grounding

Characteristics	Earthing	Grounding
Condition	The circuit part that does not carries current under normal condition	The circuit part that does carries current under normal condition
Protection	Protection of people and animals from an electric shock if touching	Protections of power system equipment
Wire	Generally green wire	Generally black wire
Path	Providing a path to a large surface of zero volt potential	Providing a return path to the current in case of faulty/abnormal conditions.

ELECTRICAL HAZARDS

- **SHOCK**. Electric shock occurs when the human body becomes part of the path through which current flows.
- **BURNS.** Burns can result when a person touches electrical wiring or equipment that is energized.
- **ARC-BLAST**. Arc-blasts occur from high- amperage currents arcing through the air. This can be caused by accidental contact with energized components or equipment failure.
- **EXPLOSIONS**. Explosions occur when electricity provides a source of ignition for an explosive mixture in the atmosphere.
- **FIRES**. Electricity is one of the most common causes of fires both in the home and in the workplace. Defective or misused electrical equipment is a major cause.

Safety Precautions while working with Electricity

It is necessary to observe safety precautions while using the electric supply to avoid the serious problems like shocks and fire hazards. Some of the safety precautions are listed below:

1. Insulation of the conductors used must be proper and in good condition.
2. Periodically Megger tests should be conducted and insulation must be checked.
3. Earth connection should be always maintained in proper condition.
4. Make the mains supply switch off and remove the fuses before starting work with any electrical installations.
5. Fuses and circuit breakers must have correct ratings
6. Use dry rubber soled shoes while working.
7. Use rubber gloves while touching any terminals or removing insulation layer from a conductor
8. Use a line tester to check whether a live terminal carries any current still better method is to use a test lamp.
9. Always use insulated screw drivers, pliers, line testers etc.
10. Never touch two different terminals at the same time.
11. Never remove the plug by pulling the wires connected to it
12. The sockets should be fixed at a height beyond the reach of the children.
13. Never touch the switch, sockets and any other electrical appliance with wet hand.
14. For more sensitive equipment, use RCCB or ELCB