AUTOMOBILE MECHATRONICS

Basics of Electrical and Electronics Engg.

UNIT-4

Personal protective equipment (PPE):

Personal protective equipment (PPE) is specialized clothing and equipment used to reduce the risk of exposure to blood, body fluids, or other contaminants. PPE can create a barrier to prevent contact with infectious materials contaminating your eyes, nose, skin, mouth and clothing, but it must be used correctly to be effective.

Healthcare workers are exposed to many infectious hazards and face the risk of acquiring and spreading infection. You must be responsible for your own safety, help maintain a safe working environment, and follow procedures that reduce the risk associated with potential hazards. Standard precautions are the minimum requirements for protecting you and others from infection.

PPE used as a standard precaution include:

- gloves – to protect your hands
- gowns/aprons – to protect skin and clothing
- masks – for mouth and nose
- goggles – to protect the eyes
- face shields – to protect your face, mouth, eyes and nose
- footwear – protection for feet.

Personal protective equipment (PPE), also known as personal protection wear, is any type of clothing or equipment worn by a person to protect them from some specific hazard. Typically this is protection from any physical, radiological, electrical, chemical, biological, mechanical, or other threat in the workplace.

Types of Personal Protective Equipment

Workplaces are responsible for providing their employees with the proper types of personal protective equipment based on the specific hazards that exist in the facility. There are many types of PPE available to keep people safe. The following are some categories of personal protective equipment and the options within them.

Breathing Protection | Respirators

Respirators are a type of personal protective equipment designed specifically to protect the lungs of the people wearing them. They can help filter out dust, debris, chemicals, and many other potential dangers. There are many types of respirators used for PPE, including:

- **Basic Facemask** - A facemask can minimize the risk of exposure to simple biological contaminants, dust, debris, and other harmful impurities in the air. In a pinch, even a simple handkerchief could serve as a facemask (though not recommended for regular use).

- **Filtered Respirator** - If there are known impurities that can cause serious damage or illness, having a filter on the respirator is important. There are many types of filtered respirators available depending on how many impurities need to be removed.

- **Self-Contained Breathing Apparatus** - In situations where the air is extremely toxic, a self-contained breathing apparatus allows the employee to bring a supply of fresh air with them. This is also used when there is no oxygen to breath, such as under water

Skin & Body Protection Equipment

Many chemicals and other materials can cause serious injuries or illnesses when they come in contact with the skin. When working with these hazards, having proper personal protective equipment is extremely important.

- **Protective Clothing** - The most common type of skin protection equipment is general protective clothing. Something as simple as a lab coat helps reduce the risk of getting splashed with potentially hazardous solutions. While it isn't a high level of protection, it is sufficient for many situations.

- **Plastic Gloves** - Plastic (or latex) gloves are among the most common types of skin protection equipment. They can keep a wide range of hazards away, including biological and chemical solutions.

- **Cut-Resistant Gloves** - Employees who work with sharp objects should wear cut-resistant gloves. These gloves are made of special materials that prevent blades from slicing through them.

- **Heat-Resistant Clothing** - When working with fire or other high temperature hazards, employees should wear heat-resistant clothing. This could be heat-resistant gloves or it could be an entire suit, depending on the situation.

- **Electricity-Resistant Clothing** - When working with or around high voltage areas, having PPE that can reduce the risk of electrical shock is essential. This could be rubber boots, gloves, or an entire body suit.

- **Face Shields** - Face shields reduce the risk of having something splash up into the face, causing damage. Whether working with hot items, corrosive materials, or biological materials, face shields can protect one of the most vulnerable parts of the body.

- **Hard Hats** - Hard hats are a great way to keep someone's head safe when working in an area where something could fall on it.

Eye Protection

Protecting the eyes is extremely important because even a minor accident can cause long-term eye damage or even blindness. Here are several of the most common types of eye protection equipment:

- **Goggles** - Simple safety goggles provide a strong layer of protection to the eyes. This is good for preventing objects from flying into the eyes such as sawdust, stones, and shards of glass.

- **Welding Masks** - While welding masks sometimes cover the entire face, their main function is to protect the eyes from the extremely bright light of a torch. These masks are darkened significantly to prevent the light from reaching and damaging the eyes.

- **Sunglasses** - This is a simple type of PPE that most people never give a second thought. If you're regularly working in the sun or around bright lights, wearing sunglasses can help prevent many eye conditions down the road.

Hearing Protection

Protecting the hearing of employees is very important, but can be difficult. Many people don't notice when they are working around the constant noise of a factory or other workplace. While it may not be something people realize is happening, this can cause significant damage to the hearing over time. Wearing personal protective equipment for the ears is critical.

- **Ear Plugs** - Ear plugs are easy to use and provide a fair amount of protection by preventing loud noises from entering the ear at all.

- **Ear Muffs** - Ear muffs go over the entire ear, and when worn properly, can provide a significant amount of noise reduction.

- **Electronic Ear Muffs** - These advanced hearing protection devices work like ear muffs to stop the noise from coming in, but also have an electronic microphone that picks up voices and other noises and then plays them into the ear so people can still hear. The sounds are played at a low level so they do not cause damage.

There are different types of personal protective equipment for just about every situation. Figuring out what type is needed in a facility is a matter of evaluating the risks and determining what PPE can offer the needed protection.

Safety Precautions:

Actual safety requires whole hearted cooperation, from all levels of workers involved in the work. It is need not to say, that all the people engaged in the electrical work should well aware of all safety rules and regulations related to the work they are executing. The workers executing the work should be extremely disciplined. Electrical work should not be done by wearing loose dresses. Before starting the work, the working place should be made neat and clean. The place should also be sufficiently illuminated before work. All levels of voltage should be considered equally dangerous. Even the voltage levels which cannot produce electrical shock should also not be ignored. We shall first confirm the circuit is dead before touching it for repairing maintenance and any others works.

- We have to switch off, isolate and properly earth the circuit before doing any work with the circuit.
- We shall only execute the work after getting properly issued work permit from the concerned operating personal.
- The work permit can only be issued after making the circuit completely dead, isolated and earthed.
- We must display **Danger Board** at the place of work.
- We should not allow any unauthorized person to enter in the working place.
- We should not put any new equipment into the service without necessary testing by authority.
- All electrical equipments, bays, circuits, should be identified by properly viewable labels to avoid any mistake.

Personal Protective Equipments

- We should not work on electrical circuit during heavy lightning storm.
- We should wear shoes having sewn soles, preferably insulated rubber soles.
- We should not wear suspenders, arm bands, with metal buckets or other metal parts. We also do not wear metal key chain or metal keepers for key rings or watch rings outside the clothing during work. We should always, take extra precaution while work in extra damp area.
- When there is a hurry to do the work, the tired and exhausted workers should be avoided to do so.
- We should not toss the tools or working materials to other person. It is better to deliver the tools and materials hand to hand.
- We should not keep any tools at the edge of equipment cabinet or structure from where these may fall off.

- We should not do anything which may startle the person working in hazardous condition.

Introduction to Relay

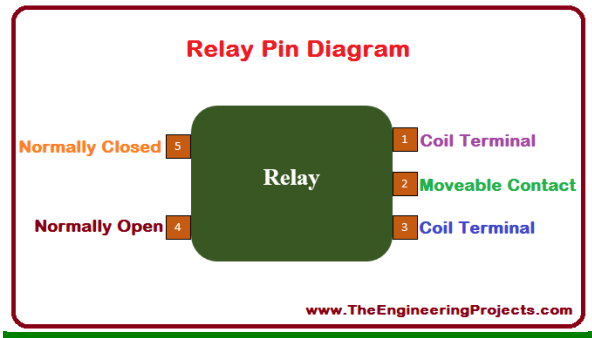
Relay is a switch, which opens and closes the circuit electronically. It uses electromagnetism from small voltage to provide higher voltages. It has two basic contacts i.e. NO (Normally Open) and NC (Normally Closed). When input voltage is applied across its coil, NC changes to NO and NO changes to NC. When input voltage is supplied, we say that the relay is energized. It has several features e.g. it can be used for switching smaller voltage to higher. But it cannot be used in power consuming devices. It has a wide range of applications. It can be used in home appliances, electronic circuits where there is a need of protection, robotics for controlling its motors from the proper motion and many more. A basic relay is given in the figure shown below.

1. Relay Pins

- Relay has total five (5) pins with different individual functions.
- Three pins are at one side of the structure.
- The other two pins are on the opposite side of the structure.
- All of these pins are provided in the table given in the figure shown below.

Relay Pins	
Pin. No	**Pin Name**
1	COIL
2	COM
3	COIL
4	NO
5	NC

- I have also made a relay pin configuration diagram.
- Pin configuration diagram is shown in the figure given below.



2. Relay Pins Description

- Each pin has different functions to perform.
- So, we must know about each of the function before using it, for the better use of it.
- All these pin descriptions are listed in the table shown in the figure below.

Relay Pins Description	
Pin Name	**Pin Name**
COIL	Coil terminal
COM	Common/Moveable contact
COIL	Coil terminal
NO	Normally open
NC	Normally closed

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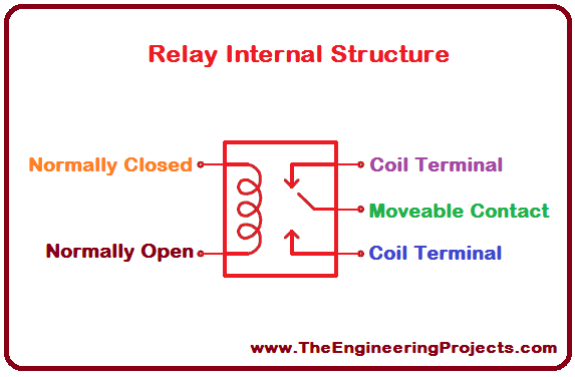
3. Relay Internal Structure

- Internal structure of any electronic device leads to the better understanding about its working principle.
- I have made a completely labeled internal structure of relay along with its pin configurations.
- Relay internal structure is shown in the figure given below.

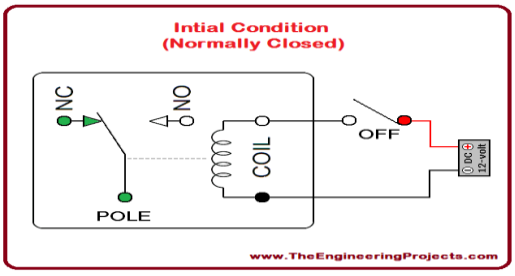


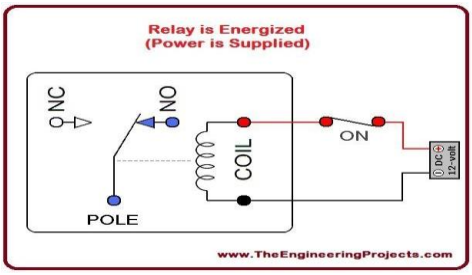
4. Relay Pinout

- If you want to know about the pin configuration of any electronic device you must have a look at its pinout diagram.
- Pinout diagram helps us to understand the pin configurations in a better way.
- I have made a pinout diagram which contains relay animation, internal structure and the real image.
- Relay pinout diagram is given in the figure shown below.

5. Relay Working Principle

- Relay works on a pretty simple principle.
- Initially when the power is not supplied and relay is in normally open condition, its contact will be opened.
- When relay is in normally closed condition, its contact will be closed.
- When power is supplied to its coil, it gets energized and its normally open condition is changed to normally closed and normally closed condition is changed to normally open.
- If we want to control the device via relay through a software then we have to attach this device to its normally open terminal.
- When the relay gets energized, that device will be turned on for the appropriate operation.
- Working principle of array can be understand from the visuals given in the figure shown below.
- Initially, when the power is not supplied and you can see the relay has normally closed contact as shown in the figure give below.





- As I have told earlier, when we supply power the normally closed contact will changed its state to normally open contact and vice versa.

- The explanation of the above step is given in the figure shown below.
- From the above figure, you can see contact has been changed to normally open contact.

6. Relay Functions

- Relay has the three basic functions to perform.
- All of these three functions are provided in the table given in the figure shown below.

Relay Functions	
Pin. No	**Pin Name**
1	On/Off control
2	Limit control
3	Logic operations

- **Air conditioning control** (to limit & control a very high power load) are the examples of **on/off control** of the relay.
- **Limit control** includes **motor speed control** (to disconnect it if it is moving with slow or faster than the desired speed).
- **Test equipment** is an example of **logic operation**, which connects the device with no. of test points.

Contactor – Construction, Operation, Application and Selection:

An **electrical contactor** is a switching device, widely used for the switching of motors, capacitors (for power factor correction) and lights. As the name indicates contactor are used to make or break contacts as like an ordinary on-off switch. The only difference is that the contactors have an electromagnet that holds the contacts when energized whereas switches do not have it.

The basic operation of a contactor is similar to that of a relay but contactor contacts can carry much more current than relays. Relays cannot be directly used in circuits where current exceeds 20 amperes. In such conditions contactors can be used. Contactors are available in a wide range of ratings and forms. Contactors are available up to the ampere rating of 12500A. Contactors cannot provide short circuit protection but can only make or break contacts when excited.

Features of Contactors

- A contactor is a relay that is used for switching power.
- They usually handle very heavy loads like an electric motor, lighting and heating equipments and so on.
- Though their output is used for switching very high loads, they are controlled by a circuit with very less power.
- According to the loads they handle, they vary in sizes from a small device to as huge as a yard.

- Though they are used for switching purposes, they do not interrupt a short-circuit current like a circuit breaker.
- They have ratings ranging from a breaking current of a few amperes and 24 DC volts to thousands of amperes with many kilo volts.

Constructional features of Contactor:

A contactor consists of an electromagnet, contacts and spring enclosed inside an enclosure. In some contactors, economizers are provided to reduce power consumption. Certain arrangements for arc extinction is also made inside for making and breaking operation of contactors.

Electromagnet is the key component in **contactors** without which it cannot function. It requires an additional supply for excitation. It drains negligible current from the supply during excitation. These electromagnets will be hollow cylindrical in shape. A rod (armature) with spring return arrangement will be placed in the hollow cylindrical electromagnet. In some contactors this electromagnet is split into two halves. One of the halves is fixed and the other is movable. Movable power contacts are fixed to the movable electromagnet. Under normal condition, these two halves of electromagnets are held apart using a spring in between.

In contactor with AC coil, the electromagnetic core is made up of laminated soft iron to reduce eddy current losses and in contactor with DC coil, the electromagnetic core is made up of solid steel/ soft ironic core since there is no risk of eddy current loss in DC.

Contacts:

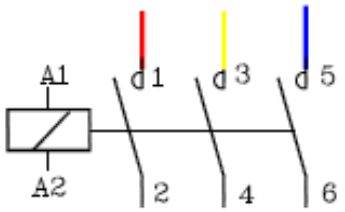
In a contactor there are two sets of contacts , of which one is stationary and the other is moveable. Silver tin oxide (AgSnO2), silver nickel (AgNi) and silver cadmium oxide (AgCdO)are the normally used contact materials. There materials have high welding resistance and stable arc resistance. Silver cadmium oxide and silver nickel are used in contactors of less ampere rating whereas Silver tin oxide is used in contactors of high ampere rating and in DC contactors.

The movable set of contacts is attached to the armature or movable electromagnet. Contact material must withstand mechanical stresses, arcs, erosion and must have very low resistance.

Electromagnet and contacts are packed inside an enclosure made of plastic, ceramic or Bakelite, which protects it from dust and external environment and ensures safe opening and closing of contacts.

Arc extinction is a major part of contactor operation. AC arcs can be easily extinguished since it passes through zero twice for every cycle. DC contactors used magnetic blowouts or specially designed arc chutes for arc extinction.

Operating principle of Contactors:

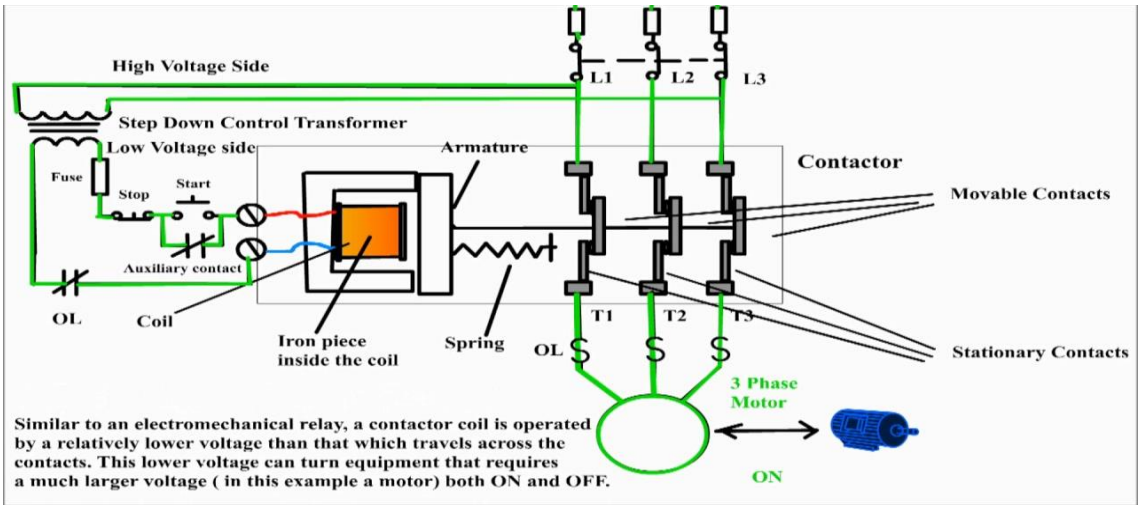


Symbol of contactor

The operating principle of a contactor is very simple. Whenever the electromagnetic coil is energized, an electromagnetic field is produced. This electromagnetic field attracts the metallic rod (armature) towards the gap in the hollow cylindrical magnet. In contactors with split electromagnets, the movable half of the electromagnet is attracted towards the fixed electromagnet. This action closes the contacts. The contacts remains closed as long as the electromagnet remains excited. When the coil is de energized, moving contact is pushed back to its normal position by the spring. Contactors are designed to open and close contacts rapidly. Moving contacts may bounce as it rapidly makes contacts with the fixed contacts. Bifurcated contacts are used in some contactors to avoid bouncing.
The input to the contactor coil may be AC or DC (available in various voltage ranges starting from 12Vac/ 12Vdc to 690Vac). A small amount of power is drained by the contactor coil during its operation. Economiser circuits are used to reduce the power consumed by the contactor during its operation.

Contactors with AC coils have shading coils. Otherwise, the contactor may chatter every time the alternating current crosses zero. Shading coils delay demagnetization of the magnetic core and avoids chattering. Shading is not required in DC coils as the flux produced is constant.

Arc occurs between the contacts every time when contacts are closed or opened under load. Arc formed during the breaking of a load is more destructive and may damage the contacts, hence reducing the life of the contactor. In addition to that high temperature of arc degrades the gases surrounding the contacts and forms harmful gases such as carbon mono-oxide, ozone etc. This may affect the mechanical durability of the contactors. Several methods are adopted for control and extinction of arcs.

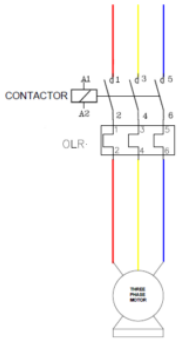


As mentioned earlier, DC arcs are more severe compared to AC arcs. In DC contactors magnetic blowouts are used to propagate the arcs towards specially designed arc chutes and extinguishing it by splitting it. Contactors used in low voltage AC applications (690Volt or less), atmospheric air surrounding the contacts extinguishes the arc. For medium voltage and high voltage applications vacuum contactors are used to avoid the risk of arc.

Application of contactors:

Motor Starters:

Contactors are used in motor starter either Direct-on-line or Star Delta along with thermal overload relays or motor protection circuit breakers. Even in our homes, one can find it inside the pump starters.



Switching of capacitor Banks

In capacitor banks, **capacitor** contactors are used for switching of capacitors based on the correction requirements. Capacitor switching contactors are specially designed to control high transient currents during switching of contactors.

Lighting control

Contactors are used in the switching of street, commercial and residential lights. Especially timer controlled lighting systems uses contactors for switching. Latch type contactors are also available. In these type of contactors, two coils are available, one for opening and the other for closing. Closing coil closes the contacts, when excited and cuts off the supply to the coil. Contact is then held closed mechanically. Second coil is used for opening the contacts.

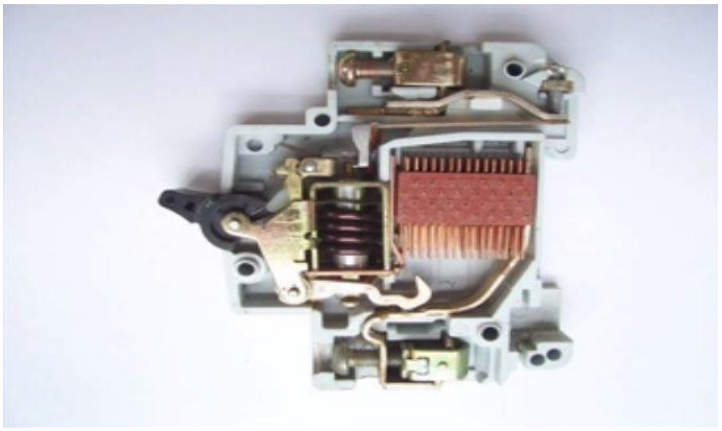
Comparison of Relay and Contactors:

RELAYS	CONTACTOR
Relatively smaller in size and use in single phase.	Larger when compared to Relays and used in three phase circuits.
Used in circuits with lower ampacity. (Max 20A)	Used in circuits with low and higher ampacity up to 12500A
Mainly used in control and automation circuits, protection circuits and for switching small electronic circuits.	Used in the switching of motors, capacitors, lights etc.
Consists of at least two NO/NC contacts	Consists of a minimum one set of three phase power contacts and in some additional auxiliary contacts are also provided.

MCB(miniature circuit breaker):

A miniature circuit breaker (MCB) automatically switches off electrical circuit during an abnormal condition of the network means in overload condition as well as faulty condition. Nowdays we use an MCB in low voltage electrical network instead of a fuse. The fuse may not sense it but the miniature circuit breaker does it in a more reliable way. MCB is much more sensitive to overcurrent than fuse.

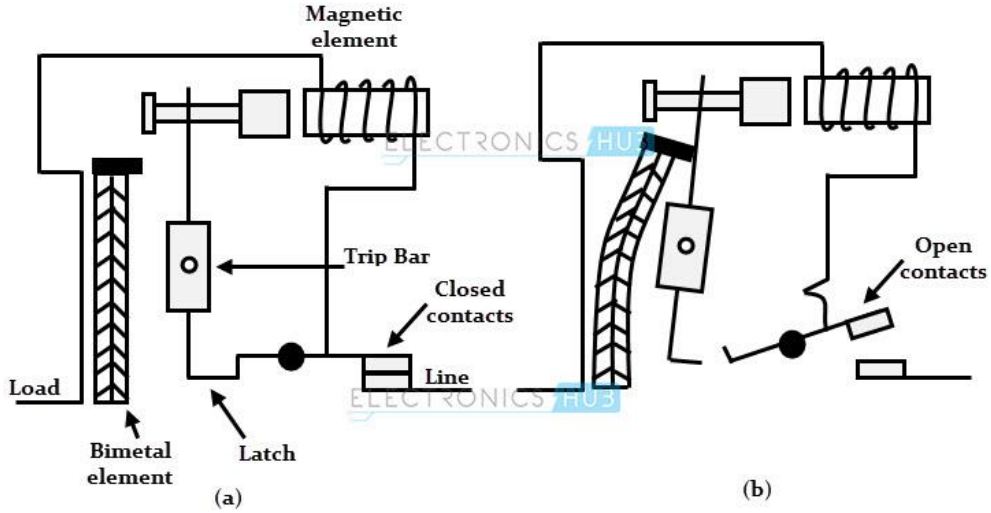
Handling a MCB is electrically safer than a fuse. Let's look at the working of the miniature circuit breaker.



Inside an MCB

The working principle of MCB:

Whenever continuous overcurrent flows through MCB, the bimetallic strip is heated and deflects by bending. This deflection of bimetallic strip releases a mechanical latch. As this mechanical latch is attached with the operating mechanism, it causes to open the miniature circuit breaker contacts, and the MCB turns off thereby stopping the current to flow in the circuit. To restart the flow of current the MCB must be manually turned ON. This mechanism protects from the faults arising due to overcurrent or overload.



An MCB is very simple, easy to use and is not generally repaired. It is just easier to replace. The trip unit is the main part, responsible for its proper working. There are two main types of trip mechanism. A bi-metal provides protection against overload current and an electromagnet provides protection against short-circuit current.

MCB operation: If the circuit is overloaded for a long time, the bi-metallic strip becomes overheated and deformed. This deformation of Bi-metallic strip causes, displacement of latch point. The moving contact of the MCB is arranged by means of spring pressure, with this latch point, that a little displacement of latch causes, release of spring and makes the moving contact to move for opening the MCB.

The current coil or trip coil is placed so that during short circuit fault the magneto-motive force (mmf) of the coil causes its plunger to hit the same latch point and make the latch to be displaced. Again, when operating lever of the miniature circuit breaker is operated by hand, that means when MCB goes off position manually, the same latch point is displaced as a result moving contact separated from fixed contact in the same manner.

It may be due to deformation of a bi-metallic strip, or increased mmf of a trip coil or maybe a manual operation, the same latch point is displaced and same deformed spring is released, which ultimately responsible for movement of the moving contact. When the moving contact separated from fixed contact, there may be a high chance of arc. This arc then goes up through the arc runner and enters arc splitters and is finally quenched. When we switch it on, we reset the displaced operating latch to its previous on position and the MCB is ready for another switch off or trip operation.

Earth Leakage Circuit Breaker(ELCB) :

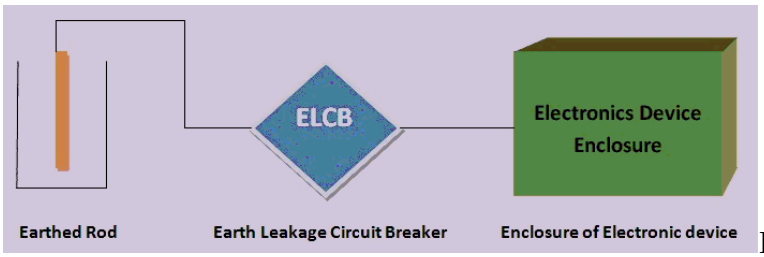
Early earth leakage circuit breakers are voltage detecting devices, which are now switched by current sensing devices (RCD/RCCB). Generally, the current sensing devices termed as RCCB and voltage detecting devices named as Earth Leakage Circuit Breaker (ELCB).
An ECLB is one kind of safety device used for installing an electrical device with high earth impedance to avoid shock. These devices identify small stray voltages of the electrical device on the metal enclosures and intrude the circuit if a dangerous voltage is identified. The main purpose of Earth leakage circuit breaker (ECLB) is to stop damage to humans & animals due to electric shock.

An ELCB is a specific type of latching relay that has a structure's incoming mains power associated through its switching contacts so that the circuit breaker detaches the power in an unsafe condition. The ELCB notices fault currents of human or animal to the earth wire in the connection it guards. If sample voltage seems across the ELCB's sense coil, it will turn off the power, and remain off until manually rearrange. A voltage sensing ELCB doesn't detect fault currents from human or animal to the earth.

Earth Leakage Circuit Breaker

How to Connect Earth Leakage Circuit Breaker

The earth circuit is adapted when an ELCB is used; the connection to the earth rod is accepted through the earth leakage circuit breaker by linking to its two earth terminals. One goes to the fitting earth circuit protective conductor (CPC), and the other to the earth rod or another kind of earth connection. Thus the earth circuit permits through the ELCB's sense coil.



Earth Leakage Circuit Breaker

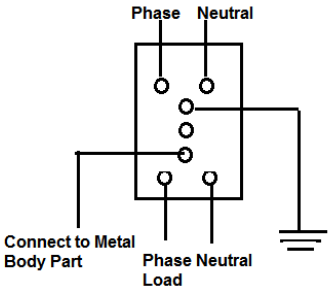
Types of Earth Leakage Circuit Breaker (ELCB)

There are two types of Earth Leakage Circuit Breaker (ELCB)

- Voltage Operated ELCB
- Current Operated ELCB

1. Voltage Operated ELCB:

Voltage-operated ELCB device is used to detect a voltage to choose the Earth leakage. A single-phase voltage ELCB includes 6-terminals namely line in, line out, neutral in, neutral out, Earth and fault. The metal body of the load is associated with the fault terminal of the Earth Leakage Circuit Breaker (ELCB) & Earth terminal is associated with the ground. For usual working, the voltage across the trip coil is '0', as the Load's body is isolated from the supply line. When an Earth fault happens on the load due to the interaction of line wire to the metal body, a current will run through fault to the ground. The flow of current will set up a voltage across the trip coil, which is associated between E & F. The energized trip coil will tour the circuit to guard the load device & the user.



Voltage Operated ELCB

A voltage-operated ELCB detects a growth in potential between the threatened consistent metalwork and a distant isolated Earth reference electrode. They work as a sensed potential of around 50V to open the main breaker & separate the supply from the threatened premises.A voltage-operated ELCB includes a second terminal for linking to the remote reference Earth connection.

The Earth circuit is improved when an ELCB is utilized; the link to the Earth rod is delivered through the ELCB by linking to its two Earth terminals. One terminal energy to the installation Earth circuit protective conductor, aka Earth wire (CPC), and the other to the Earth rod or some type of earth connection.

Advantages of Voltage Operated ELCB

- ELCBs are less sensitive to fault conditions and have few nuisance trips.
- While current and voltage on the ground line generally fault current from a live wire, this is not continuously the case, therefore there are conditions in which an ELCB can annoyance trip.
- When an installation of the electrical instrument has two contacts to earth, a near high current lightning attack will root a voltage gradient in the earth, offering the ELCB sense coil with sufficient voltage to source it to a trip.
- If either of the soil wires become detached from the ELCB, it will no longer install will frequently no longer be correctly earthed.
- These ELCBs are the necessity for a second connection and the opportunity that any extra connection to ground on the threatened system can inactivate the detector.

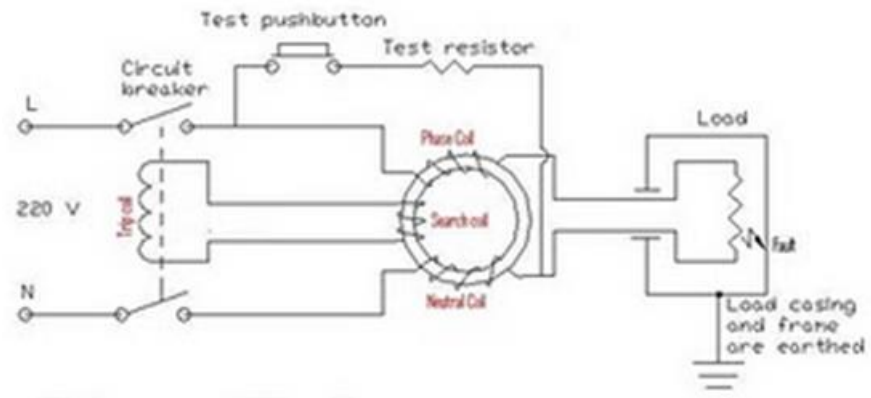
Disadvantages of Voltage Operated ELCB

- They do not sense errors that don’t permit current through the CPC to the ground rod.
- They do not permit an only building system to be simply divided into many sections with independent error protection because earthing systems are typically used mutual earth, Rod.
- They may be skipped by outside voltages from something associated with the earthing system like as metal pipes, a TN-C-S or a TN-S earth mutual neutral and earth.
- As electrical leaky utilizations like washing machines, some water heaters and cookers might source the ELCB to trip.
- ELCBs present an extra resistance & an extra point of failure in the earthing system.

Current Operated ELCB:

RCCB is the generally used ELCB and it comprises of a three winding transformer, that has two primary windings and also one secondary winding. Neutral & line wires work as the two main windings. A wire wound coil is the minor winding. The flow of current through the minor winding is "0" in the stable condition. In this condition, the flux owed to the current over the phase wire will be deactivated by the current through the neutral wire, meanwhile the current, that flows from the phase will be refunded to the neutral.

When an error occurs, a slight current will run into the ground also. This creates a confuse between line and neutral current and that makes an unstable magnetic field. This encourages a current flow through the minor winding, which is associated with the sensing circuit. This will detect the outflow and direct signal to tripping system.



Current Operated ELCB

Difference between RCCB and ELCB

S.No	RCCB	ELCB
1.	RCCB refers to ear stands for Residual Current Circuit Breaker.	ELCB stands for Electric Leakage Circuit Breaker.
2.	It is a new name and refers to current operated devices.	ELCB refers to voltage operated earth leakage device.
3	It ensures 100% detection of leakage current& is available to sense the AC as well as DC leakage current.	It is not preferable as it can only detect current that flow back through the main earth wire.

4	RCCB has no connection with the earth wire and that's why it can trip when both currents (phase and neutral) are different and it withstands up to both the currents are same.	ELCB is working based on Earth leakage current. These devices measured the voltage on the earth conductor; if this voltage was not zero this indicated a current leakage to earth.

Different Types of Fuses and Its Applications

In the field of electronics or electrical, a fuse is an essential device used in various electrical circuits which gives the protection from the overcurrent. It comprises a strip or a metal wire that dissolves when the heavy flow of current supplies through it. Once this device has functioned in an open circuit, it ought to rewire or changed based on the type of fuse. A fuse is an automatic disconnection of supply which is frequently shortened to ADS. The alternative of the fuse is a stabilizer or circuit breaker, but they have many different characteristics.

Why do we require Fuse?

These are used to prevent the home appliances from the high current or overload damage. If we use a fuse in the homes, the electrical faults cannot happen in the wiring and it doesn't damage the appliances from the fire of wire burning. When the fuse gets break or damage, then an abrupt sparkle happens which may direct to damage your home appliances. That is the reason we require different types of fuses to guard our home-appliances against damage.

Working Principle of Fuse

The working principle of the fuse is "heating consequence of the current". It is fabricated with a lean strip or thread of metallic wire. The connection of the Fuse in an electrical circuit is always in series.When the too much current is produced due to the heavy flow of current in the electrical circuit, the fuse gets soften and it opens the circuit. The extreme flow of current may direct to the collapse of the wire and prevents the supply.

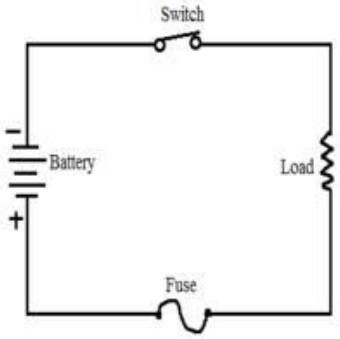


Image Source

The fuse can be changed by the new fuse with an appropriate rating. It can be designed with the elements like Cu (copper), Zn (zinc), Al (aluminum) and Ag (silver). They also perform like a circuit breaker for breaking the circuit while the abrupt fault happens in the circuit. This works like a safety measure or protector for humans from risks. Like this, the fuse works.

Fuse rating = (power (watts)/voltage (volts)) x 1.25

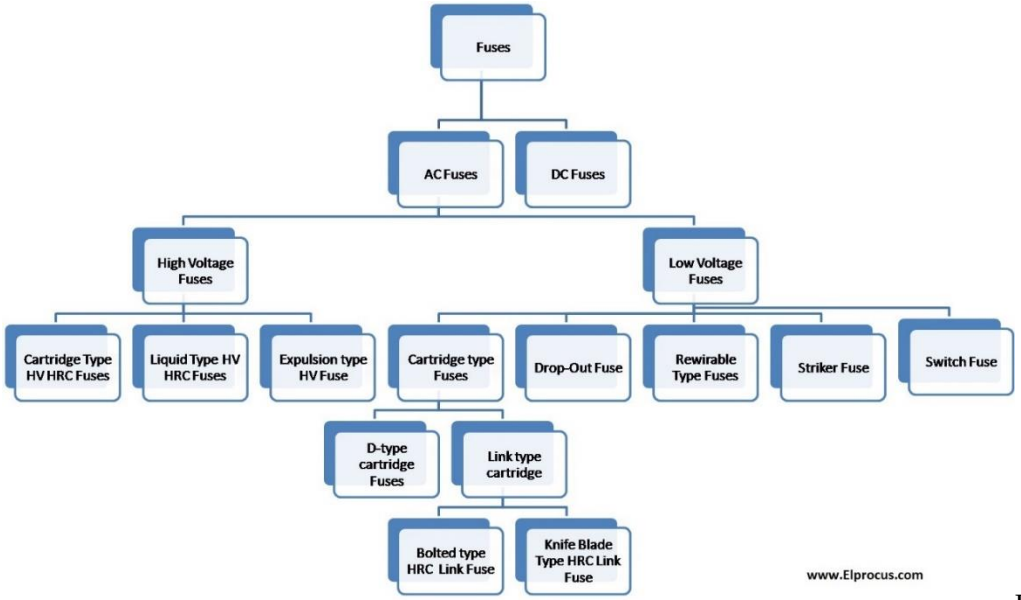
The selection of a fuse can be done by calculating the fuse rating by using the above formula.

- Choose the fuse.
- Write down the voltage (volts) and power (watts) of the appliance.
- Calculate the fuse rating.

After the result, use the maximum fuse rating. For instance, if the calculated fuse rating is the maximum fuse rating. For example, if the calculated fuse rating is 7.689 amps, you can use an 8 amp fuse.

Different Types of Fuses:

The fuses are classified into several types based on the application namely **AC type fuse** and **DC type fuse**. Again these fuses are classified into several types. The following diagram illustrates the electrical fuse types chart based on the AC fuse and DC fuse.



DC Fuses

DC fuses are available superior in size, and DC supply has a stable value over 0 volts. So it is tough to remove and deactivate the circuit. There will be a chance of generation of an electric Arc between dissolved wires. To conquer this, electrodes located at better distances. For this reason, the size of DC fuse gets amplified.

Image Source

AC Fuses

The AC fuse is slighter in size and oscillated 50 to 60 times in each and every sec from least to highest. As a result, there is no scope for Arc generation between the dissolved wires. For this reason, they can be crammed in small size. Further, AC fuses are classified into two parts namely HV fuses and LV fuses. Here LV& HV indicates the low voltage and high voltage.

LV Fuses

The low voltage fuses are divided into five types such as rewireable, cartridge, drop out, striker and switch fuses.

Image Source

Rewirable Fuses

Rewirable fuses are LV fuses, which are almost used in small applications like wiring in the house, small-scale industries, and other tiny current applications. These types of fuses include two essential parts such as a fuse base, which has two terminals like in and out. In general, this element is fabricated with Porcelain. Another part of this fuse is a fuse carrier, which grips the fuse element. This element is fabricated with aluminum, tinned copper and lead. The main advantage of a fuse carrier is, we can simply plug and remove from the base of the fuse without the risk of shock. As the fuse is damaged due to heavy current, then we can simply eliminate the Fuse Carrier as well as put back the fuse wire.

Image Source

Cartridge type Fuses

The cartridge type of fuses has entirely closed containers and the metal contact as well. The applications of this fuse mainly include low voltage (LV), high voltage (HV), and small fuses. Again, these types of fuses are classified into two types, they are D-type and Link-type fuses.

Image Source

D-type Cartridge Fuse

This type of fuse is composed with the cartridge, base of the fuse, adapter ring, and cap. The base of the fuse includes a fuse cap, which is packed with the fuse ingredient by cartridge using an adapter ring.

It is composed of the cartridge, fuse base, cap & adapter ring. The fuse base has the fuse cap, which is fitted with the fuse element with a cartridge through the adapter ring. The connection of the circuit is finished when the tilt of the cartridge builds contact through the conductor.

Image Source

Link Type Fuse

The link type fuse is also known as high rupturing capacity (HRC) or BS type fuse. In this sort of fuse, the current flow with fuse element is specified under standard condition.

In this BS type fuse, the flow of current by fuse element is given under normal condition. The arc which is generated by the fuse blown is controlled is fabricated with porcelain, ceramic, and silver. The container of the fuse element is packed with silica sand. This type of fuse is again categorized into two parts includes a blade type and bolted type.

Image Source

Blade and Bolted type Fuses

The knife type fuse or plug-in type of fuses is designed with plastic. This type of fuse can be simply changeable in the electric circuit exclusive of any load.

In bolted type fuse, plates of this fuse are conducting are set to the base of the fuse.


Image Source

Striker type Fuse

The striker type of fuse is employed for tripping and closing the electrical circuit. These fuses are having plenty of force as well as displacement.

Switch type Fuse

Basically, the switch type fuse is enclosed with a metal switch and also a fuse. These fuses are mainly used in low and intermediate voltage levels.

HV (High Voltage) Fuses

Generally, HV fuses are used to protect the transformers like instrument transformers, small power transformer and also used in power systems. These fuses are normally charged for voltages over 1500V to 138000V.

Image Source

The fuse part in HV fuses are fabricated with either copper, silver or in some cases Tin is used, in order to offer consistent and steady performance. These fuses are classified into three types which include the following.

Cartridge Type HRC Fuse

The fuse component of the HRC is cut in the helix form which evades the effect of corona at the upper voltages. It includes two fused elements namely low resistance and high resistance, and that are located parallel by each other. The low-resistance wires take the usual current which is blown-out as well as decreases the short-circuit current throughout the fault state.

Cartridge Type HRC Fuse

Liquid Type HRC Fuse

This type of fuse is packed with carbon tetrachloride also preserved at both the tops of the caps. Once the error occurs when the flowing current surpasses away from the allowable limit, and the element of the fuse is blown-out. The fluid of the fuse performs as an arc extinguishing standard for the HRC fuse types. They may be used to protect the transformer as well as the support protection to the breaker circuit.

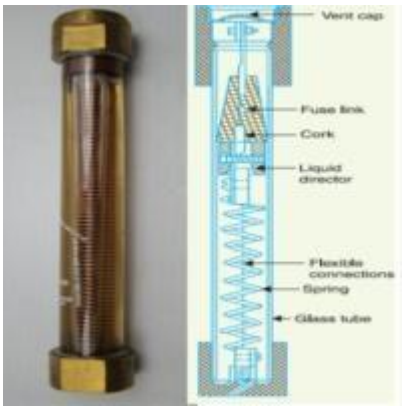


Image Source

Expulsion Type HV Fuse

These types of fuses are extensively used to protect the feeders as well as transformer due to they're low-priced. It is designed for 11kV; also their cracking capability is up to 250 MVA. This type of fuse includes an unfilled open finished cylinder designed with synthetic resin-bonded paper.

Image Source

The elements of the fuse are positioned in the cylinder, and the tubes tops are linked to appropriate equipment at every finish. The arc generating is blown off in the inside covering of the cylinder, and the gases thus shaped destroys the arc.

Applications of Different Types of Fuses

The different types of fuses and their uses have discussed are essential components in all the electrical circuits. Some of the main **applications of fuses in Electrical and Electronics field** include the following.

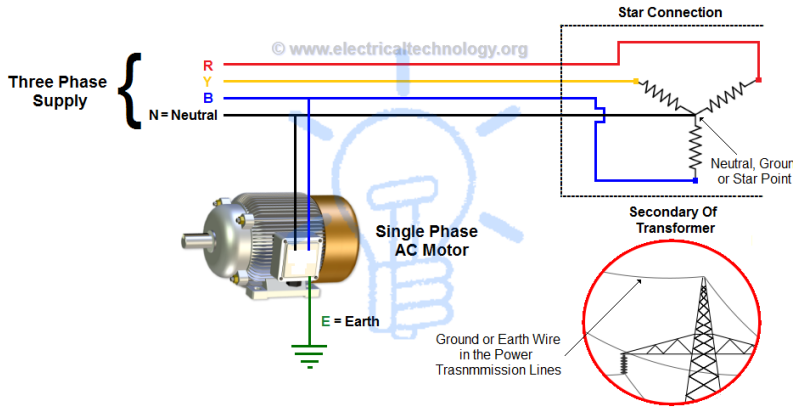
- Power Transformers
- Electrical Appliances, like ACs (Air Conditioners), TV, Washing Machines, Music Systems, and
- many more.
- Electrical Cabling in Home
- Mobile Phones
- Motor starters
- Laptops
- Power Chargers
- Cameras, Scanners, Printers, and Photocopiers
- Automobiles, electronic devices and Gaming's

Concept of Neutral and Earthing:

Neutral:

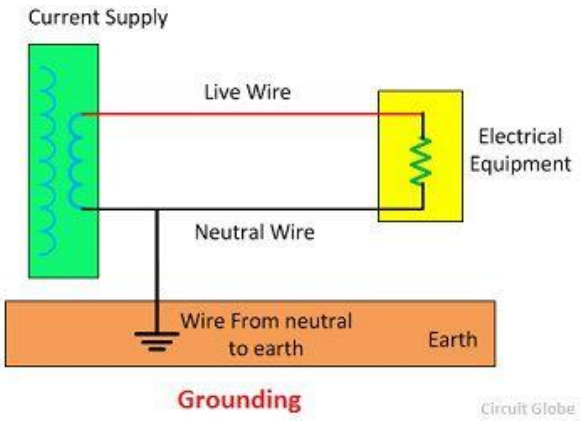
Neutral is return path for an AC circuit which is supposed to carry current in normal condition. This current may be because of many reasons, primarily because of phase current imbalance and some time because 3rd and 5th harmonics also.

There may be others reasons too but the magnitude of this current is in fraction of phase current and in few case it can be even double of phase current. So Neutral wire is always assumed to be charged (in active circuit). This neutral wire is given to ground (by grounding) to make the second terminal of neutral wire at zero potential.



Definition of Grounding

In grounding, the current carrying parts are directly connected to the ground. The grounding provides the return path for the leakage current and hence protect the power system equipment from damage.



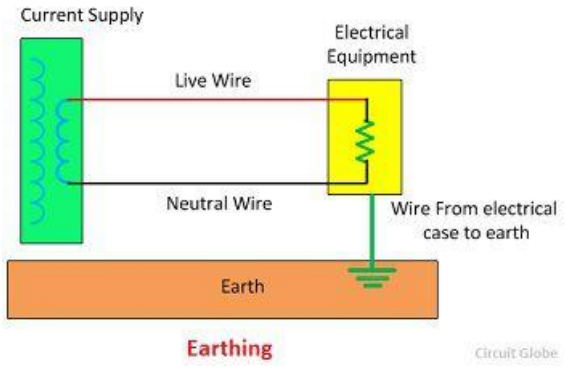
When the fault occurs in the equipment, the current in all the three phases of the equipment become unbalance.The grounding discharges the fault current to the ground and hence makes the system balance.

The grounding has several advantages like it eliminates the surge voltage and also discharge the over voltage to the ground. The grounding provides the great safety to the equipment and improves the service reliability.

Definition of Earthing

The ‘earthing’ means the connection of non-current carrying part of the equipment to the earth. When the fault occurs in the system, then the potential of the non-current part of the equipment

raises, and when any human or stray animal touch the body of the equipment, then they may get shocked.



The earthing discharges the leakage current to the earth and hence avoid the personnel from the electric shock. It also protects the equipment from lightning strokes and provides the discharge path for the surge arrester, gap and other devices.

The earthing is achieved by connecting the parts of the installation to the earth by using the earth conductor or earth electrode in intimate contact with the soil placed with some distance below the ground level.

Difference Between Neutral and Earthing

One of the major difference between the grounding and the earthing is that in grounding, the current carrying part is connected to the ground whereas in earthing the non-current carrying parts is connected to ground. The other differences between them are explained below in the form of the comparison chart.

Grounding(Neutral) V/S Earthing Comparison Chart

Basis For Comparison	Grounding	Earthing
Definition	The current carrying part is connected to ground.	The body of the equipment is connected to ground.
Location	Between the neutral of the equipment and ground	Between the equipment body and earth pit which is placed under the earth surface.

Basis For Comparison	Grounding	Earthing
Symbol		
Zero Potential	Does not have	Have
Protection	Protect the power system equipment.	Protect the human from electric shock.
Application	Provide the return path to the current.	It discharges the electrical energy to the earth.
Types	Three (Solid, Resistance and Reactance grounding)	Five (Pipe, Plate, Rod earthing, earthing through tap and strip earthing)
Color of wire	Black	Green
Use	For balancing the unbalance load.	For avoiding the electrical shock.
Examples	Neutral of generator and power transformer is connected to ground.	The enclosure of the transformer, generator, motor etc. are connected to the earth.

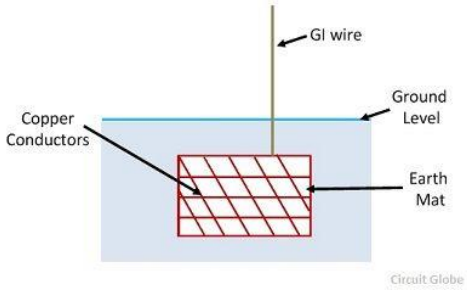
Methods of Earthing:

There are several methods of earthing like wire or strip earthing, rod earthing, pipe earthing, plate earthing or earthing through water mains. Most commonly used methods of earthing are pipe earthing and plate earthing. These methods are explained below in details.

Earthing Mat

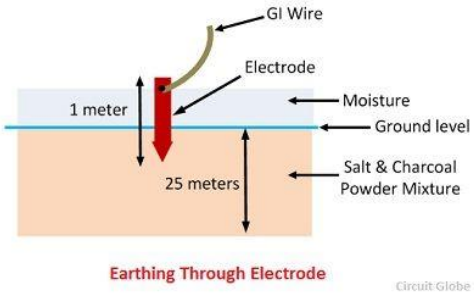
Earthing mat is made by joining the number of rods through copper conductors. It reduced the overall grounding resistance. Such type of system helps in limiting the ground potential. Earthing mat is mostly used in a placed where the large fault current is to be experienced. While designing an earth mat, the following step is taken into consideration.

- In a fault condition, the voltage between the ground and the ground surface should not be dangerous to a person who may touch the noncurrent-carrying conducting surface of the electrical system.
- The uninterrupted fault current that may flow into the earthing mat should be large enough to operate the protective relay. The resistance of the ground is low to allow the fault current to flow through it.The resistance of the mat should not be of such a magnitude as to permit the flow of fatal current in the live body.
- The design of grounding mat should be such that the step voltage should be less than the permissible value which would depend on the resistivity of the soil and fault required for isolating the faulty plant from the live system.



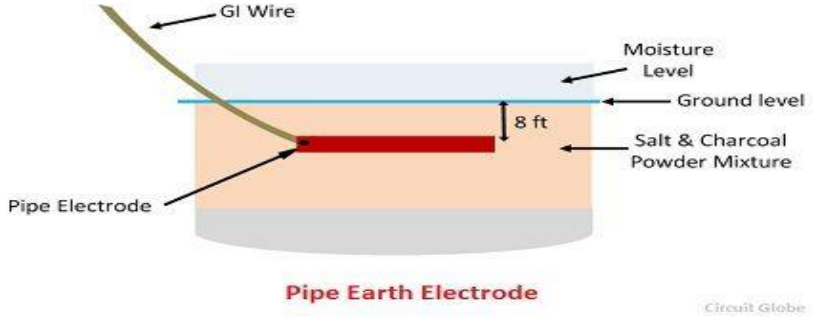
Earthing Electrode

In this type of earthing any wire, rod, pipe, plate or a bundle of conductors, inserted in the ground horizontally or vertically. In distributing systems, the earth electrode may consist of a rod, about 1 meter in length and driven vertically into the ground. In generating substations, grounding mat is used rather than individual rods.



Pipe Earthing

This is the most common and best system of earthing as compared to other systems suitable for the same earth and moisture conditions. In this method the galvanized steel and perforated pipe of approved length and diameter in place upright in a permanently wet soil, as shown below. The size of the pipe depends upon the current to be carried and type of soil.



Normally, the size of the pipe uses for earthing is of diameter 40 mm and 2.5 meters in length for ordinary soil or of greater length in case of dry and rocky soil. The depth at which the pipe must be buried depends on the moistures of the ground.

The pipe is placed at 3.75 meters. The bottom of the pipe is surrounded by small pieces of coke or charcoal at a distance of about 15 cm. Alternate layers of coke and salt are used to increase the effective area of the earth and to decrease the earth resistance respectively.

Another pipe of 19 mm diameter and minimum length 1.25 meters is connected at the top of GI pipe through reducing socket.

During summer the moisture in the soil decreases, which causes an increase in earth resistance. So a cement concrete work is done to keep the water arrangement accessible, and in summer to have an effective earth, 3 or 4 buckets of water are put through the funnel connected to 19 mm diameter pipe, which is further connected to GI pipe.

The earth wire either GI or a strip of GI wire of sufficient cross section to carry faulty current safely is carried in a GI pipe of diameter 12 mm at a depth of about 60cm from the ground.

Plate Earthing

In Plate Earthing an earthing plate either of copper of dimension 60cm×60cm×3m of galvanized iron of dimensions 60 cm× 60 cm×6 mm is buried into the ground with its face vertical at a depth of not less than 3 meters from ground level.

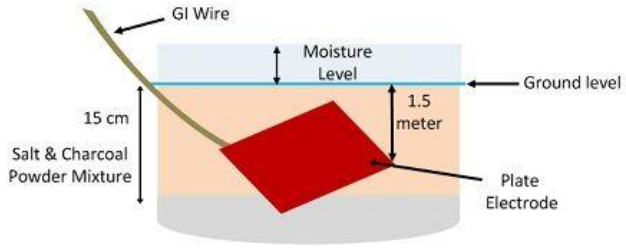
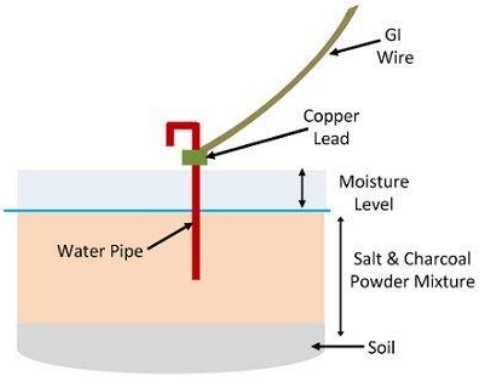


Plate Earth Electrode

The earth plate is inserted into auxiliary layers of coke and salt for a minimum thickness of 15 cm. The earth wire (GI or copper wire) is tightly bolted to an earth plate with the help of nut or bolt. The copper plate and copper wire are usually not employed for grounding purposes because of their higher cost.

Earthing Through Water Mains

In this type of earthing the GI or copper wire are connected to the water mains with the help of the steel binding wire which is fixed on copper lead as shown below.



Earthing Through Water Mains

The water pipe is made up of metal, and it is placed below the surface of the ground, i.e. directly connected to earth. The fault current flow through the GI or copper wire is directly get earthed through the water pipe.

Method Of Neutral Grounding

The methods commonly used for grounding the system neutral are

1. Solid grounding (or effective grounding)

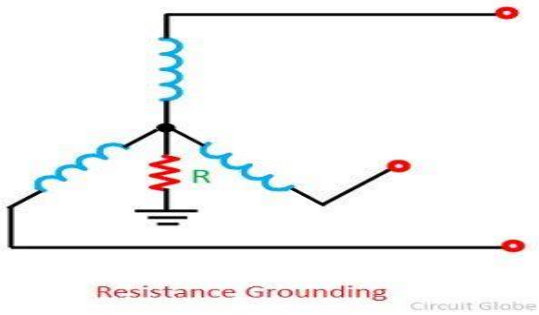
2. Resistance Grounding
3. Reactance Grounding

Resistance & Reactance Grounding

Resistance grounding

In this type of neutral grounding, the neutral of the system is connected to ground through one or more resistance. Resistance grounding limits the fault currents. It protects the system from transient overvoltages. Resistance grounding decreases the arcing grounding risk and permits ground-fault protection.

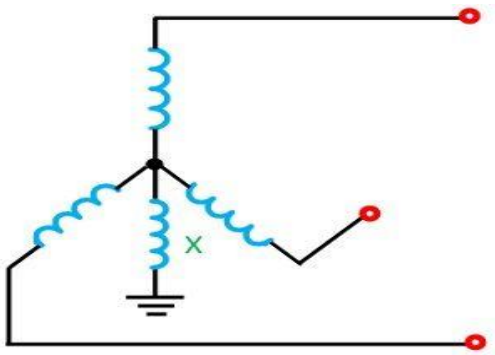
The value of resistance used in the neutral grounding system should neither be very high nor be very low shown in the figure below.



A very low resistance makes the system to the solidity grounded, whereas a very high resistance makes the system ungrounded. The value of resistance is chosen such that the ground-fault current is limited, but still sufficient ground current flows permit the operation of ground faults protections. In general, the ground fault may be limited up to 5% to 20% of that which occur with a three-phase line.

Reactance Grounding

In reactance grounded system, a reactance is inserted between the neutral and ground to limit the fault current as shown in the figure below.

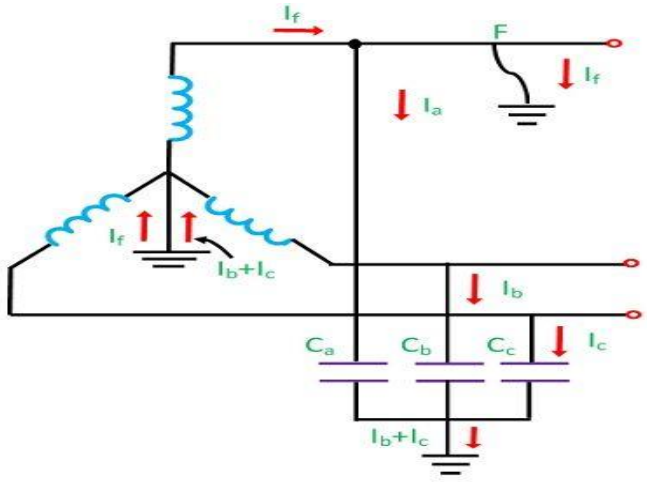


Reactance Grounding

To minimize transient overvoltages, the ground fault current in a reactance grounded system should not be less than 25% of the three phase fault current. This is considerably more than the minimum current desirable in resistance grounded systems.

Solid Grounding

A power system is said to be effectively grounded or solidly grounded when the neutral of a generator, power transformer or grounding transformer are directly connected to the ground through a conductor of negligible resistance and reactance. A part of a system or system is said to be solidly grounded when the positive-sequence impedance of the system is greater or equal to the zero sequence resistance, and positive sequence reactance is three times greater than or equal to the zero sequence reactance.



Solidly ground system

Consider a system having three phases a, b and c shown in the figure above. If the single-ground-fault occur in phase **a** the voltage of the phase becomes zero. However, the remaining two phases b and c will still have the same voltages as before shown in the figure below. When the fault occurs in the system, in addition to the charging current the power source also feeds the fault current.

For the solidly neutral grounded system, it is necessary that the ground fault current should not exceed 80% of the three-phase fault. It is usually used for keeping the fault current within safe limits.