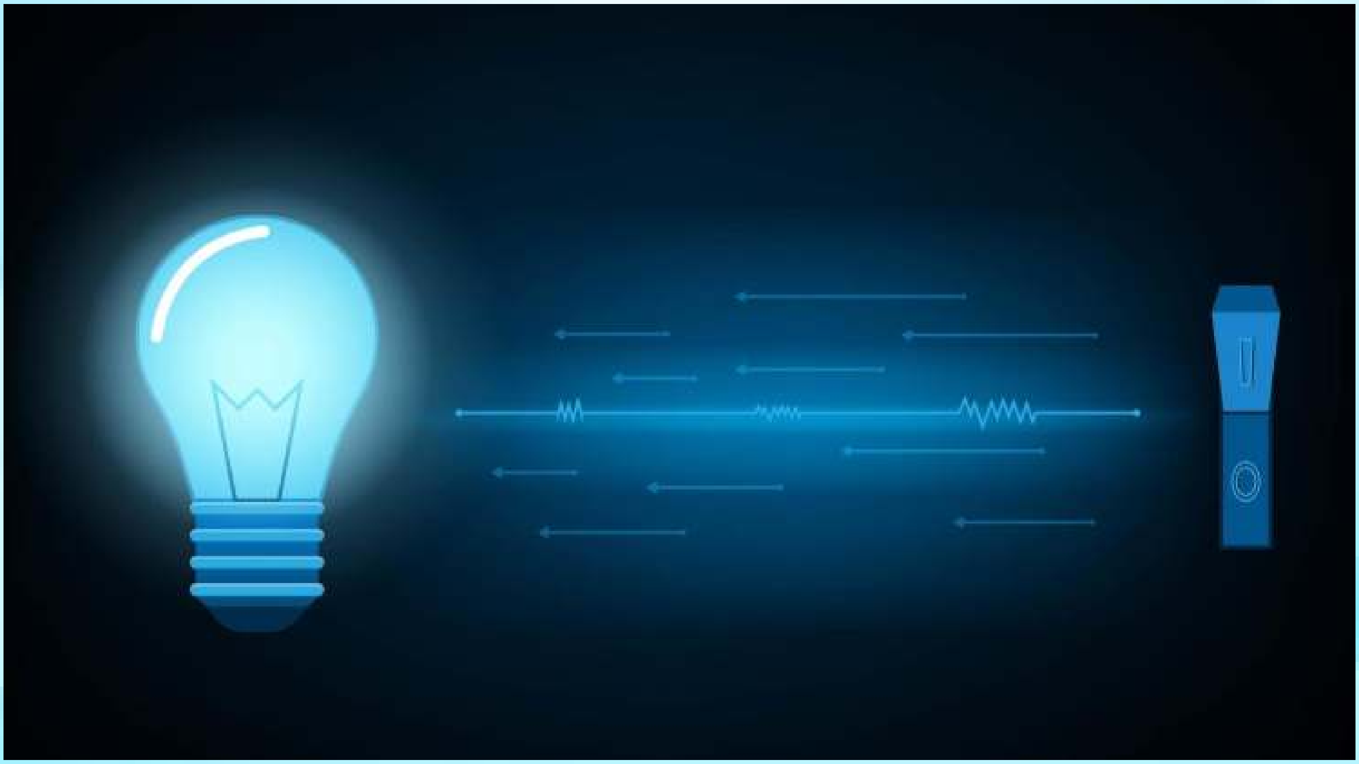
BASICS OF CONTROL PANEL DESIGN

ANANDA CHAITANYA TRAINING ACADEMY



PREFACE

Ananda Chaitanya Foundation, founded by Shri.Thillai Senthil Prabu, is committed to enhancing the well-being of individuals and communities through a range of transformative initiatives. These projects span education, skill development, spiritual growth, and healthcare, creating a holistic approach to societal upliftment.

"VAIYA THALAMAI KOL" - Ananda Chaitanya Training Academy (ACTA) is a Skill Development and Soft Skills Training initiative of Ananda Chaitanya Foundation that focuses on providing technical training and soft skills development.

Under the guidance of Shri. Thillai Senthil Prabu this book is compiled by Ananda Chaitanya Foundation's ACTA team members Shri. Devendra Kumar.M and Shri.Rajamurugan.K .

This handbook on Basics of Control Panel design is useful for the Students and working professionals to advance their careers and strengthen their foundational understanding of electrical design.

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CHAPTER - I
INTRODUCTION TO MCB

1. MCB (MINIATURE CIRCUIT BREAKER):

A Miniature Circuit Breaker (MCB) is an automatically operated electrical switch used to protect low voltage electrical circuits from damage caused by excess current from an overload or short circuit. MCBs are typically rated up to a current up to 125 A, do not have adjustable trip characteristics, and can be thermal or thermal-magnetic in operation.

FIGURE 1.1 MINIATURE CIRCUIT BREAKER

1.1 HOW DOES A MCB WORK?

MCBs are triggered by over current. Excess current causes the bimetallic strip within the MCB to heat, bend and trip. This releases a switch which moves the electrical contact points apart to confine the arc. The arc is divided and cooled by an insulated metal strip called the arc chute. The contacts close again once the fault has been fixed and the MCBs are reset.

An MCB is designed to protect against both overloading and short-circuiting. These are detected differently using separate processes. Overload protection is provided by the bimetallic strip using thermal operation, where as short-circuit protection is provided by the tripping coil via electromagnetic operation.

If the discharge is especially high, the MCB will trip very quickly within one-tenth of a second. When the over current is closer to the safety limits, the component will be slower to respond.

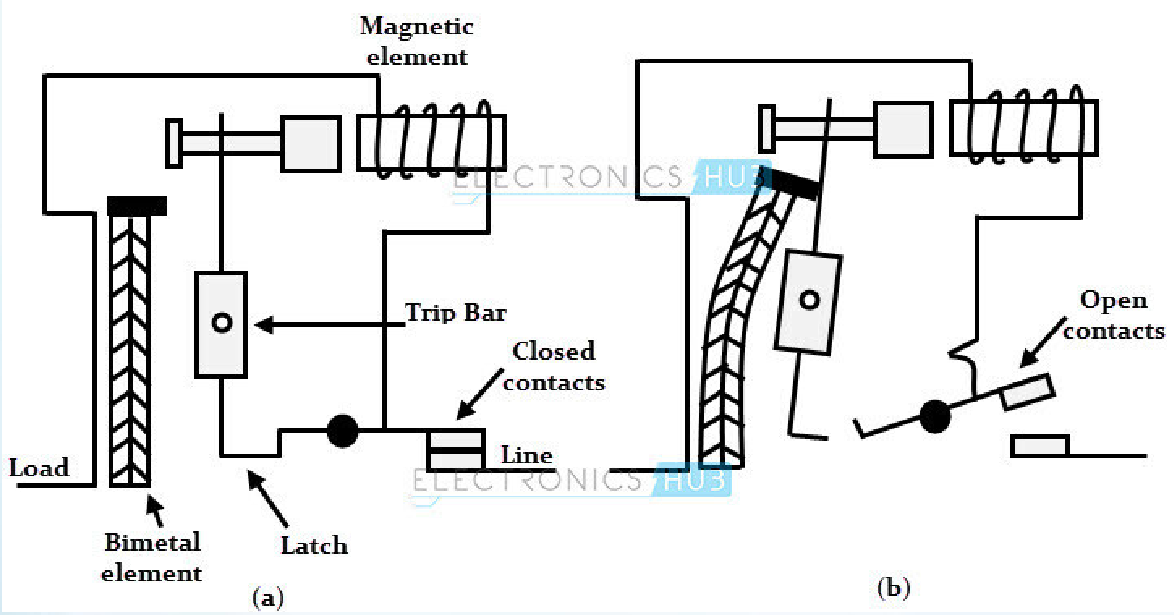


FIGURE 1.2 WORKING PRINCIPLE OF MCB

1.2 TYPES OF TRIPPING CURVES:

1. Z- Curve
2. B- Curve
3. C- Curve
4. K- Curve
5. D- Curve

1.3 CURRENT TRIPPING RANGES

Z Curve

– $2 \times I_n < I_{Tripp} < 3 \times I_n$ (AC)

– $2 \times I_n < I_{Tripp} < 4.5 \times I_n$ (DC)

B Curve

– $3 \times I_n < I_{Tripp} < 5 \times I_n$ (AC)

– $4 \times I_n < I_{Tripp} < 7 \times I_n$ (DC)

C Curve

– $5 \times I_n < I_{Tripp} < 10 \times I_n$ (AC)

– $7 \times I_n < I_{Tripp} < 15 \times I_n$ (DC)

D Curve

– $10 \times I_n < I_{Tripp} < 20 \times I_n$ (AC)

– $10 \times I_n < I_{Tripp} < 21 \times I_n$ (DC)

K Curve

– $10 \times I_n < I_{Tripp} < 14 \times I_n$ (AC)

– $10 \times I_n < I_{Tripp} < 22.4 \times I_n$ (DC)

FIGURE 1.3 CURRENT TRIPPING RANGES

1.4 Graph for Tripping Curve

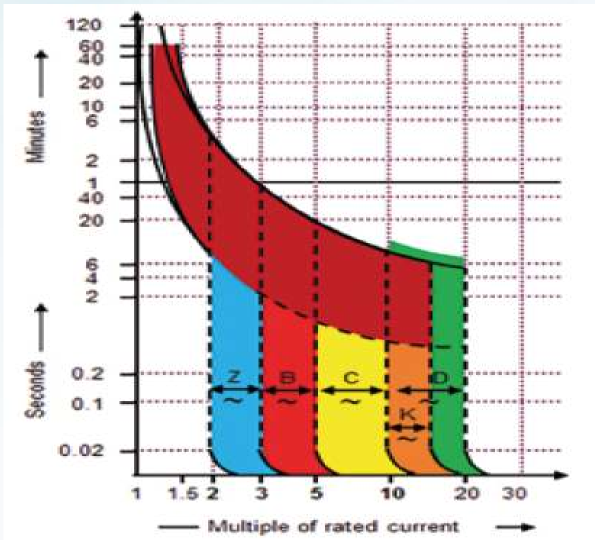


FIGURE 1.4 GRAPH FOR TRIPPING RANGE

1.5 Graph for Tripping Curve for Various load Current:

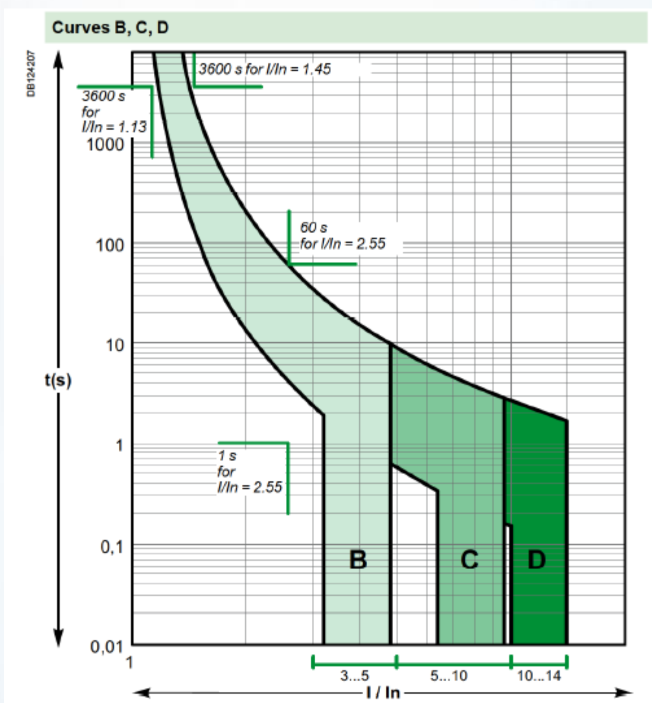


FIGURE 1.5 GRAPH FOR TRIPPING CURVE FOR VARIOUS LOAD CURRENT

1.6 APPLICATION:

Z Curve:

Designed to protect circuits that need a very low short circuit trip setting

Example: Semiconductors

B Curve:

Designed for cable protection

Example: Control Circuits, Lighting

C Curve:

Designed for medium magnetic startups

Example: Lightning Panels, Control Panels

D and K Curves:

Designed to allow for high inrush loads

Example: Motor or Transformer Circuits

CHAPTER - II
MOULDED CASE CIRCUIT BREAKER

2. MCCB (MOULDED CASE CIRCUIT BREAKER):

FIGURE 2.1 MOLDED CASE CIRCUIT BREAKER

A MCCB is type of electrical protection device that is used to protect the electrical circuit from excessive current, which can cause overload or short circuit. With a current rating of up to 2500A, MCCBs can be used for a wide range of voltages and frequencies with adjustable trip settings. These breakers are used instead of miniature circuit breakers in large scale PV systems for system isolation and protection purposes.

2.1 HOW THE MCCB OPERATES?

The MCCB uses a temperature sensitive device with current sensitive electromagnetic device to provide the trip mechanism for protection and isolation purposes. This enables the MCCB to provide:

- Overload protection
- Electrical fault protection against short circuit currents and
- Electrical switch for disconnection.

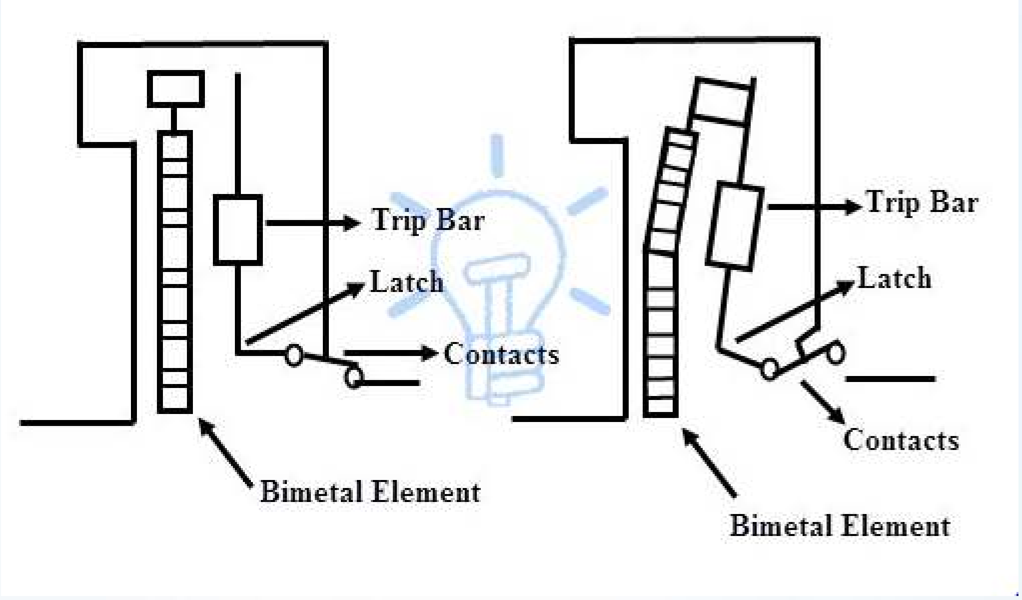


FIGURE 2.2 WORKING PRINCIPLE OF MCCB

2.2 OVERLOAD PROTECTION:

Overload protection is provided by the MCCB via the temperature sensitive component. This component is essentially a bimetallic contact: a contact which consists of two metals that expand at different rates when exposed to high temperature. During the normal operating conditions, the bimetallic contact will allow the electric current to flow through the MCCB. When the current exceeds the trip value, the bimetallic contact will start to heat and bend away due to the different thermal rate of heat expansion within the contact. Eventually, the contact will bend to the point of physically pushing the trip bar and unlatching the contacts, causing the circuit to be interrupted.

The thermal protection of the MCCB will typically have a time delay to allow a short duration of over current which is commonly seen in some device operations, such as inrush currents seen when starting motors. This time delay allows the circuit to continue to operate in these circumstances without tripping the MCCB.

2.3 EARTH FAULT PROTECTION:

MCCBs provides an instantaneous response to a short circuit fault, based on the principle of electromagnetism. The MCCB contains a solenoid coil which generates a small electromagnetic field when current passes through the MCCB. During normal operation, the electromagnetic field generated by the solenoid coil is negligible. However, when a short circuit fault occurs in the circuit, a large begins to flow through the solenoid and, as a result, a strong electromagnetic field is established which attracts the trip bar and opens the contacts.

2.4 ELECTRICAL SWITCH FOR DISCONNECTION:

In addition to tripping mechanisms, MCCBs can also be used as manual disconnection switches in case emergency or maintenance operations. An arc can be created when the contact opens. To combat this, MCCBs have internal arc dissipation mechanisms to quench the arc.

2.5 MCCB TRIPPING MECHANISM:

MCCBs have following various Operating Mechanisms.

- Thermal Trip
- Magnetic Trip
- Thermal- Magnetic Trip
- Electronic Trip
- Microprocessor Trip

2.6 THERMAL TRIP MECHANISM (Inverse-time):

- The thermal trip mechanism of MCCB works as a delay fuse.
- It will protect a circuit against a small overload that continues for a long time.
- In Thermal trip MCCB a bimetal strip is connected in series with the circuit load.
- When normal current pass through bimetallic strip and rise temperature of bimetallic strip and it increase length of bimetallic strip but this expansion rate is not enough for bending movement of strip and the contacts will remain closed.
- As current of MCCB increase beyond over load current. It heats enough bimetal and thus bimetallic Strip bend as per current level and Close contact will be open
- The amount of current needed to trip the MCCB depends on the size of bimetallic Strip.
- The time the bi-metal needs to bend and trip the circuit varies inversely with the current
- It has Inverse time characteristics, they allow a long-time delay on light overloads and they have a fast response on heavier overloads
- MCCB must carry 100% of rated current continuously at 40 deg C.

At 200% rated current, maximum trip times are

Amp Rating	Max Time @ 200%
0-30	2 min
31-50	4 min
51-100	6 min
101-150	8 min
151-225	10 min
1601-2000	28 min

2.7 Magnetic Trip Mechanism (Instantaneous-trip)

- In magnetic trip MCCB an electromagnet (an iron core with a wire coil around it, forming an electromagnet) is in series with the circuit load.
- If the current suddenly or rapidly increases enough, the magnetic element will attract the trip bar, release the latch, and the circuit breaker will trip.
- Thermal Trip gives inverse time characteristic and Magnetic Circuit Breaker (instantaneous-trip circuit breakers) gives instantaneous-tripping.

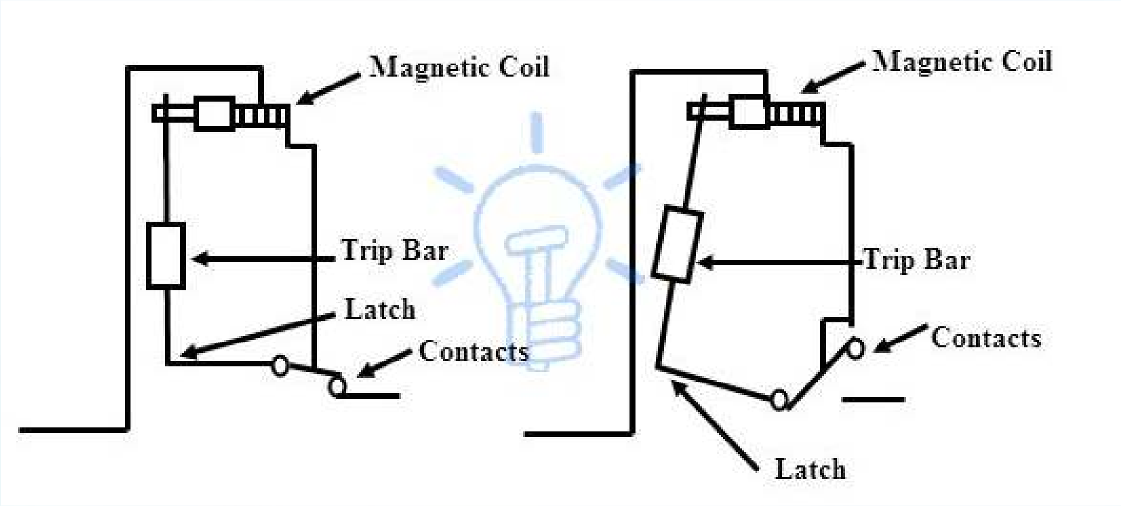


FIGURE 2.3 MAGNETIC TRIP MECHANISM

2.8 Thermal-Magnetic Trip mechanism (inverse-time & instantaneous-trip)

- Thermal-magnetic circuit breaker (TMD) is most common use for over current and short circuit protection.
- It is a combination of Thermal Circuit breaker and Magnetic Circuit Breaker.
- It contain two different switching mechanisms, a bi-metal switch and an electromagnet.
- The thermal Property (Bi-metal Strip gets elongated when heating) is used to sense the overload and Magnetic Property (Magnetic Flux / induction) is used to sense the short circuit.

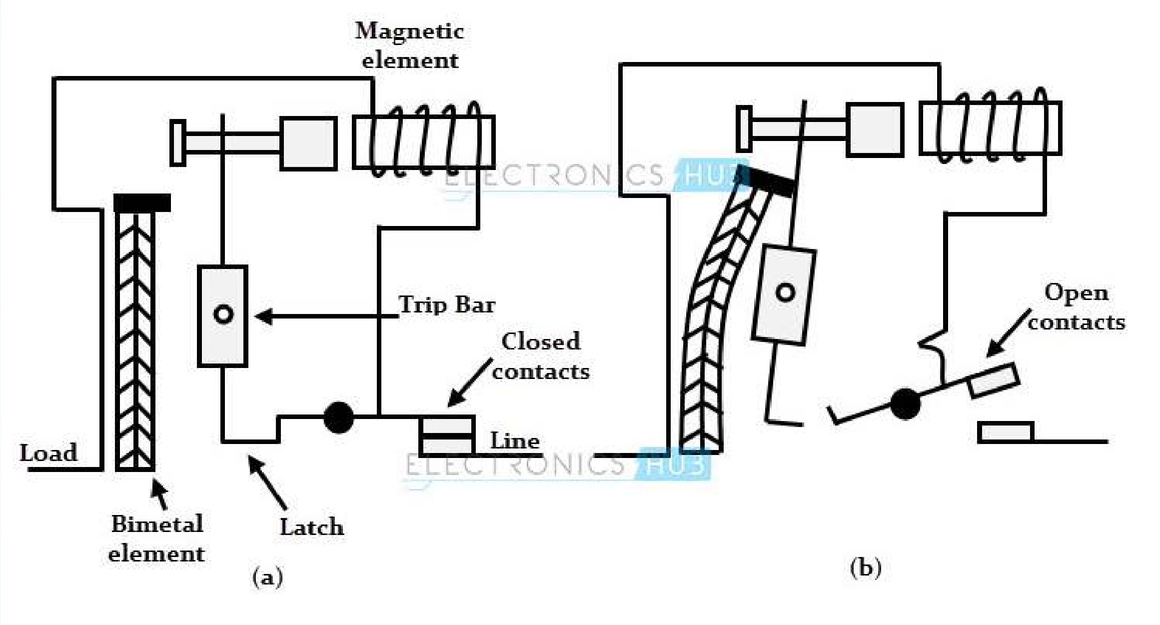
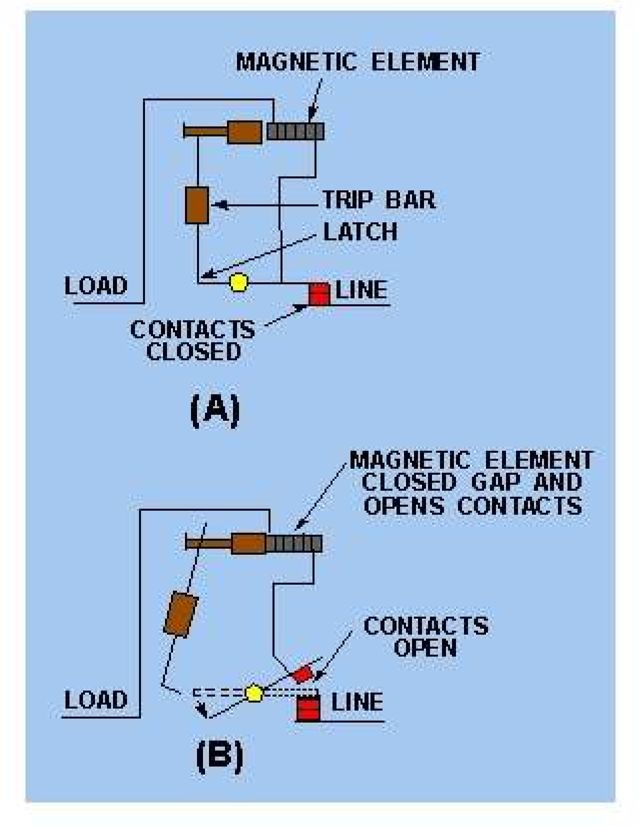


FIGURE 2.4 THERMAL - MAGNETIC TRIP MECHANISM



- In Thermal-Magnetic Circuit Breaker both Thermal element (Bimetallic Strip) and Magnetic element (Electromagnet) are connected in series with load.
- In normal Load a bimetallic element is heated by the normal load current, the bimetallic element does not bend, and the magnetic element does not attract the trip bar.
- If the temperature or current increases over a sustained period of time, the bimetallic element will bend, push the trip bar and release the latch. The circuit breaker will trip.
- If the current suddenly or rapidly increases enough, the magnetic element will attract the trip bar, release the latch, and the circuit breaker will trip.
- Thermal Trip gives inverse time characteristic and Magnetic Circuit Breaker (instantaneous-trip circuit breakers) gives instantaneous-tripping.

2.9 ELECTRONIC (STATIC) TRIP MECHANISM:

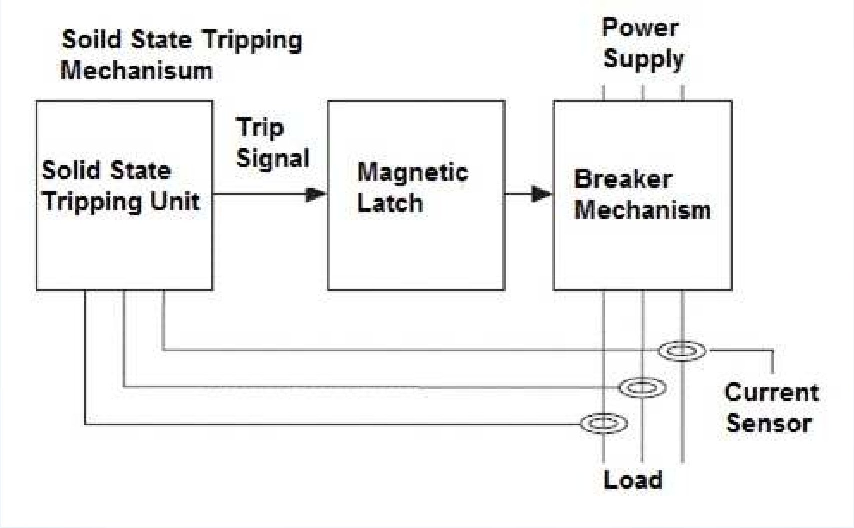


FIGURE 2.5 ELECTRONIC TRIP MECHANISM

- A coil, placed on each conductor, continuously measures the current in each of them.
- This information is processed by an electronic module which controls the tripping of the circuit breaker when the values of the settings are exceeded.
- Both the overload trip action and the short-circuit trip action of breakers with electronic trip units are achieved by the use of current transformers and solid-state circuitry that monitors the current and initiates tripping through a flux shunt trip when an overload or a short circuit is present.

2.10 MICROPROCESSOR TRIP MECHANISM

- In Microprocessor type tripping mechanism release, sensing and tripping executed by Microprocessor by use of CT or current sensing resistor
- It gives the very faster response than TMD Release.

2.11 Types of MCCB Used depends upon the Application

- TMD
- TMA
- TMG
- ELECTRONIC
- MICROPROCCESSOR

2.12 TMD (Thermal & Magnetic threshold for Distribution)

1. Standard MCCB Rating available: 10A - 1600A
2. Operating Time: 4 milli Second
3. Thermal Threshold Trip current : 0.7....1 x In
4. Magnetic Threshold Trip current : 10 x In

2.13 TMA(Thermal & Magnetic threshold for Intermediate between TMD & TMG)

1. Standard MCCB Rating available: 10A - 1600A
2. Operating Time: 4 milli Second
3. Thermal Threshold Trip current : 0.7....1 x In
4. Magnetic Threshold Trip current : 5....10 x In

2.14 TMG (Thermal & Magnetic threshold for Generator)

1. Standard MCCB Rating available: 10A - 1600A
2. Operating Time: 4 milli Second
3. Thermal Threshold Trip current : 0.7....1 x In
4. Magnetic Threshold Trip current : 2.5....10 x In

2.15 ELECTRONIC (Thermal & Magnetic threshold for Higher load)

1. Standard MCCB Rating available: 20A - 2500A
2. Operating Time: 4 milli Second
3. Thermal Threshold Trip current : 0.6....1 x In
4. Magnetic Threshold Trip current : 2....10 x In

2.16 MICROPROCCESSOR (Thermal & Magnetic threshold for Higher load)

1. Standard MCCB Rating available: 20A - 2500A
2. Operating Time: 4 milli Second
3. Thermal Threshold Trip current : 0.6....1 x In
4. Magnetic Threshold Trip current : 2....10 x In

CHAPTER - III
AIR CIRCUIT BREAKER

3. ACB (AIR CIRCUIT BREAKER):

Air circuit breaker is also known as Air blast circuit breaker. It is an automatically operated electrical switch that uses air to protect an electric circuit from damage caused by excess current from an overload or short circuit. Its primary function is to interrupt current flow after a fault is detected. When this happens, an arc will appear between the contacts that have broken the circuit. Air circuit breakers use compressed air to blow out the arc, or alternatively, the contacts are rapidly swung into a small sealed chamber, the escaping of the displaced air, thus blowing out the arc.

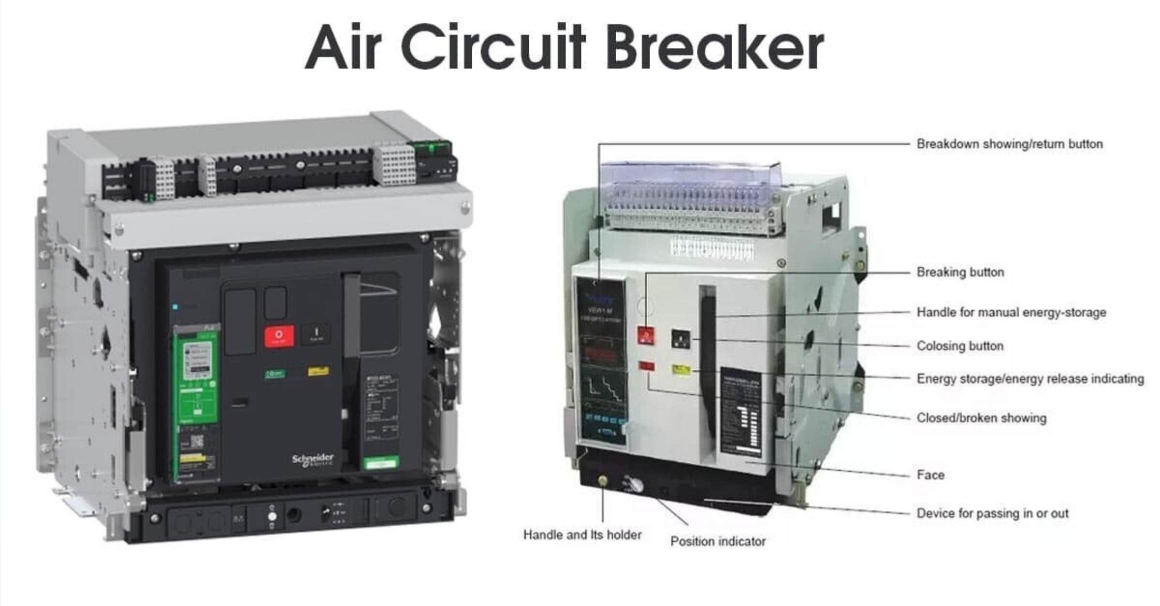


FIGURE 3.1 AIR CIRCUIT BREAKER

3.1 WORKING PRINCIPLE OF AIR CIRCUIT BREAKER:

The working principle of this breaker is rather different from those in any other types of circuit breakers. The main aim of all kind of circuit breaker is to prevent the reestablishment of arcing after current zero by creating a situation where in the contact gap will withstand the system recovery voltage.

The air circuit breaker does the same but in different manner. For interrupting arc it creates an arc voltage in excess of the supply voltage. Arc voltage is defined as the minimum voltage required maintaining the arc. This circuit breaker increases the arc voltage by mainly three different ways,

- It may increase the arc voltage by cooling the arc plasma. As the temperature of the arc plasma is decreased, the mobility of the particle in arc plasma is reduced, hence more voltage gradient is required to maintain the arc.
- It may increase the arc voltage by lengthening the arc path. As the length of arc path is increased, the resistance of the path is increased, and hence to maintain the same arc current more voltage is required to be applied across the arc path. That means arc voltage is increased.
- Splitting up the arc into a number of series arcs also increases the arc voltage.

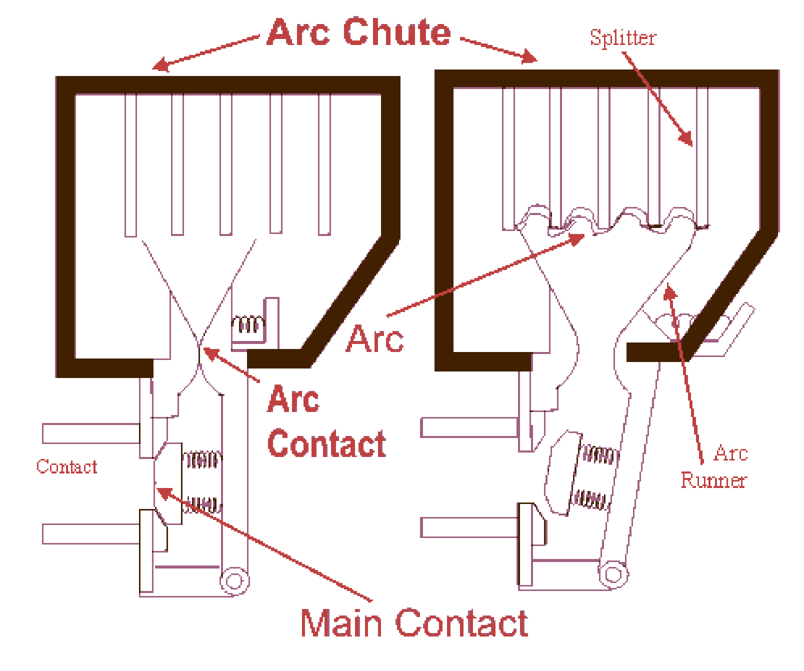


FIGURE 3.2 WORKING PRINCIPLE OF AIR CIRCUIT BREAKER

CHAPTER - IV
MOTOR PROTECTION CIRCUIT BREAKER

4. MPCB (MOTOR PROTECTION CIRCUIT BREAKER):

FIGURE 4.1 MOTOR PROTECTION CIRCUIT BREAKER

MPCB contains thermal overload protection, short circuit fault protection, unbalanced load and phase loss fault protection. MPCB is a widely used circuit breaker for both static and dynamic equipment. The reliability of the MPCB greater than MCCB or fuse.

4.1 FUNCTIONS OF MPCB:

- Protection against electrical faults such as short circuits, line-to-ground faults and line-to-line faults. The MPCB can interrupt any electrical fault that is below its breaking capacity.
- Motor overload protection, when a motor draws electric current above its nameplate value for an extended period of time. Overload protection is normally adjustable in MPCBs.
- Protection against phase unbalances and phase loss. Both conditions can severely damage a three-phase motor, so the MPCB will disconnect the motor in either case as soon as the fault is detected.
- Thermal delay to prevent the motor from being turned back on immediately after an overload, giving the motor time to cool down. An overheated motor can be permanently damaged if it is turned back on.
- Motor Circuit Switching – MPCBs are normally equipped with buons or dials for this purpose.
- Fault Signaling – Most models of motor protection circuit breakers have a LED display that is turned on whenever the MPCB has tripped. This is a visual indication for nearby personnel that a fault has occurred and the electric motor must not be connected again until the fault is addressed.
- Automatic Re connection – Some MPCB models allow a cool down time to be input in case there is an overload, after which the motor will restart automatically.

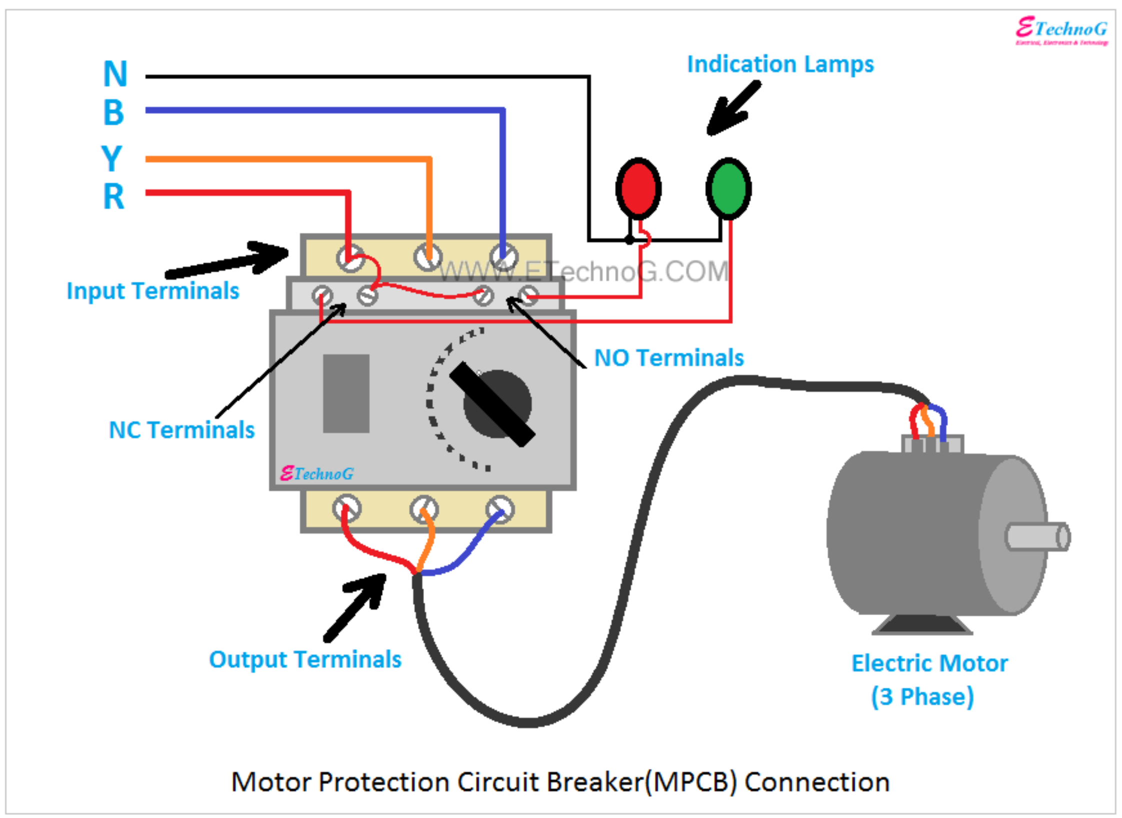


FIGURE 4.2 MOTOR PROTECTION CIRCUIT BREAKER WORKING

CHAPTER - V
RESIDUAL CURRENT TRANSFORMER

5. RCCB (RESIDUAL CURRENT CIRCUIT BREAKER):

RCCB is also known as ground fault circuit interrupter. It is an electrical safety device that quickly breaks an electrical circuit with leakage current to ground. RCCB is used to protect the equipment and to reduce the risk of serious harm from an ongoing electrical shock.

FIGURE 5.1 RESIDUAL CURRENT CIRCUIT BREAKER

5.1 WORKING PRINCIPLE OF RCCB:

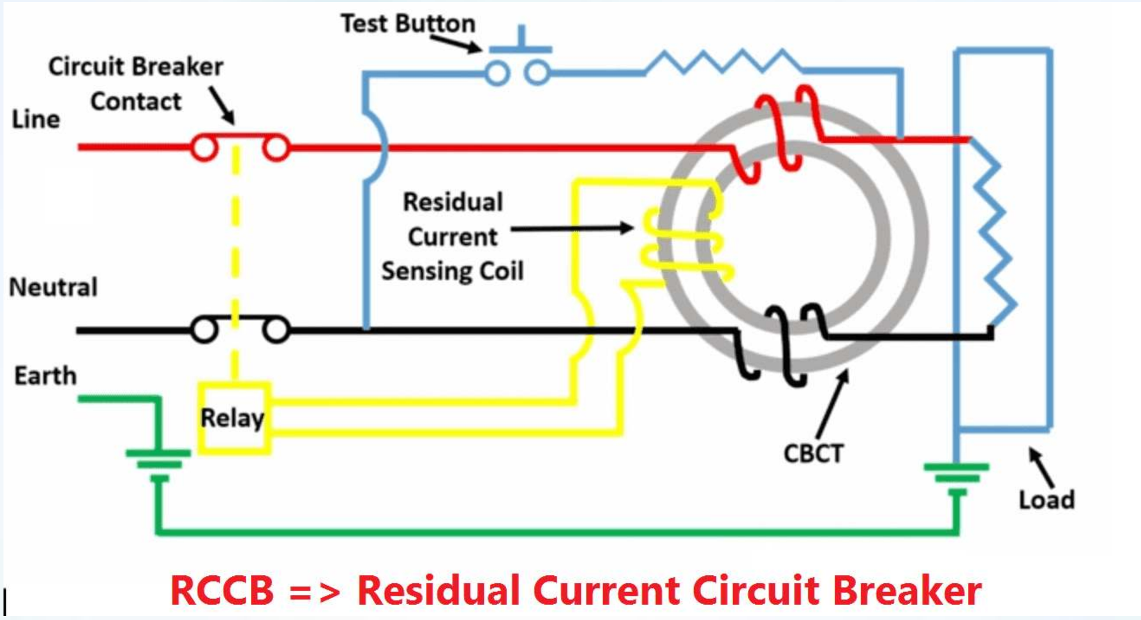


FIGURE 5.2 WORKING PRINCIPLE OF RCCB

RCCB works on the principle of Kirchhoff's law, which states that the incoming current must be equal to the outgoing current in a circuit. RCCB thus compares the difference in current values between live and neutral wires. Ideally, the current flowing to the circuit from the live wire should be the same as that flowing through the neutral wire. In case of a fault, the current from the neutral wire is reduced, the differential between the two known as Residual Current. On spotting a Residual current, the RCCB is triggered to trip off the circuit.

5.2 BENEFITS OF RCCB:

- Provides protection against earth fault as well as any leakage current.
- Automatically disconnects the circuit when the rated sensitivity is exceeded.
- Offers possibility of dual termination both for cable and busbar connections.
- Offers protection against voltage fluctuation as it includes a filtering device that guards against transient voltage levels.

CHAPTER - VI
CONTACTOR

6. CONTACTOR:

When a relay is used to switch a large amount of electrical power through its contacts, it is designated by a special name:contactor. Contactors typically have multiple contacts, and those contacts are usually (but not always) normally-open,so that power to the load is shut off when the coil is de-energized.

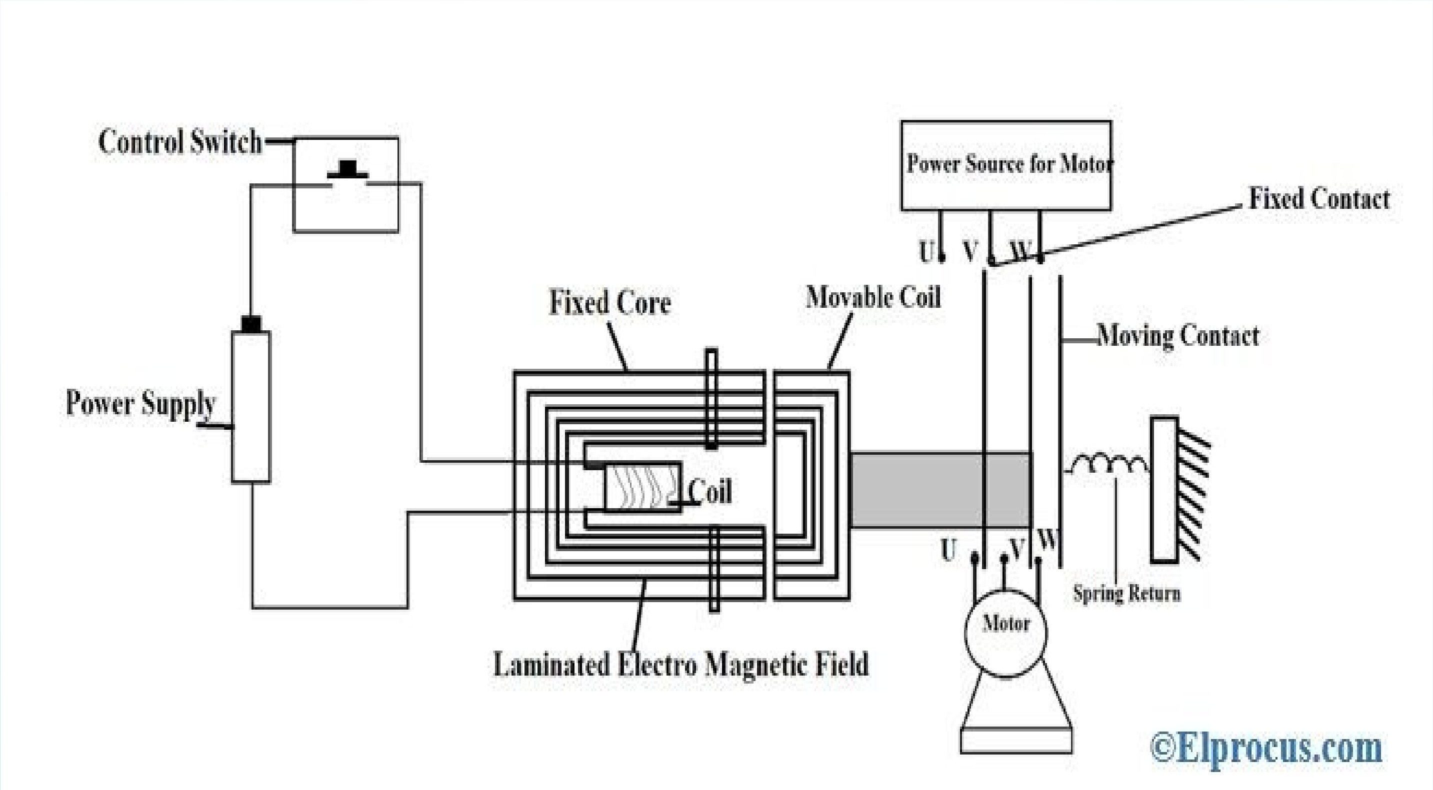
A contactor is one of the main electrical circuit parts, which can stand on its own power control device or part of a starter. They are used to connect and break power supply lines running through power lines or repeatedly establish and interrupt electrical power circuits.

FIGURE 6.1 CONTACTOR

6.1 WORKING PRINCIPLE OF CONTACTORS:

An electromagnetic field is generated whenever current flows where the moving coils attract each other. A large amount of current is drawn initially by an electromagnetic coil. The moving contact is pushed forward by moving core, as a result, the force created by the electromagnet holds the moving and fixed contacts together.

On de-energizing, the contactor coil gravity or spring moves back the electromagnetic coil to its initial position and there is no flow of current in the circuit.



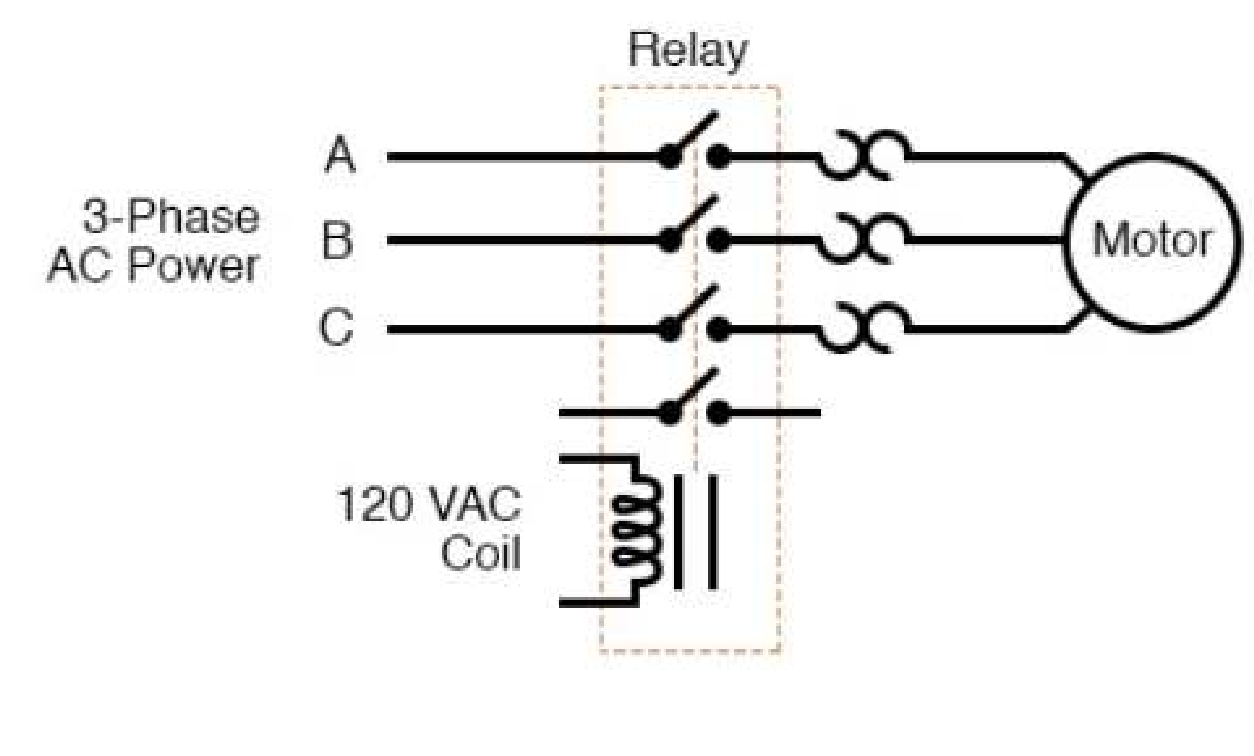


FIGURE 6.2 WORKING PRINCIPLE OF CONTACTOR

If contactors are energized with AC current, a small portion of the coil is the shaded coil, where the magnetic flux in the core is slightly delayed. This effect is too average as it prevents the core from buzzing at twice line frequency. There are internal tipping point processes to ensure rapid action so that contactors can open and closed very rapidly.

6.2 DIFFERENCE BETWEEN RELAY AND CONTACTORS:

RELAY	CONTACTORS
A relay is used for low voltage switching purpose.	It is used for high voltage switching purpose.
The relay contactor is similar to the auxiliary contactor.	There are two types of contactors auxiliary and power.
The size of the relay is small.	The size of the contactor is large.
Cannot be repaired.	Can be repaired.

CHAPTER - VII
FUSES

7. FUSES:

Fuse is an electric device which interrupts the flow of current in an electric circuit. It is installed in a circuit to stop the flow of excessive current. A fuse is usually a short piece of wire. The fuse is made up of a material which has high resistivity and low melting point, so that it melts down due to overheating of the wire during high current flow.

FIGURE 7.1 FUSES

The thickness of the fuse wire is determined based on the amount of current flow in the circuit. Normally an alloy of tin and lead is used as the fuse wire, as it has high resistivity and low melting point.

If a fault causes a flow of excess current, then a thin conductor is used to break the circuit by melting or separating it, the thin conductor used is known as an Electric Fuse. A fuse can be sacrificed if anything in the circuit goes wrong since they are weak points that are intentionally placed in a circuit.

7.1 WORKING PRINCIPLE OF FUSE:

- The electric fuse works on the basis of the heating effect of the electric current. It is composed of a non-flammable thin metallic wire with a low melting point.
- If a high amount of electricity is passed from the electric fuse, there is production of heat which causes the fuse to melt which leads to the opening of the circuit and the blockage of current.

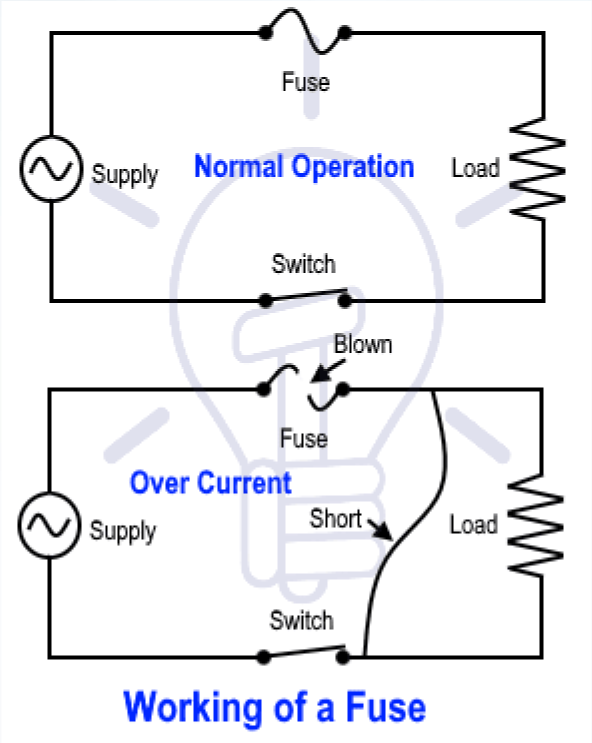


FIGURE 7.2 WORKING PRINCIPLE OF FUSE

- Once a fuse melts, it can be changed or replaced with a new fuse.
- A fuse is normally made up of elements like zinc, copper, aluminium and silver.
- A fuse acts as a circuit breaker and breaks the circuit in case any fault occurs in the circuit. It acts as a protector of electric appliances and also as a safety measure for humans.

CHAPTER - VIII
RELAYS

8. RELAYS:

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

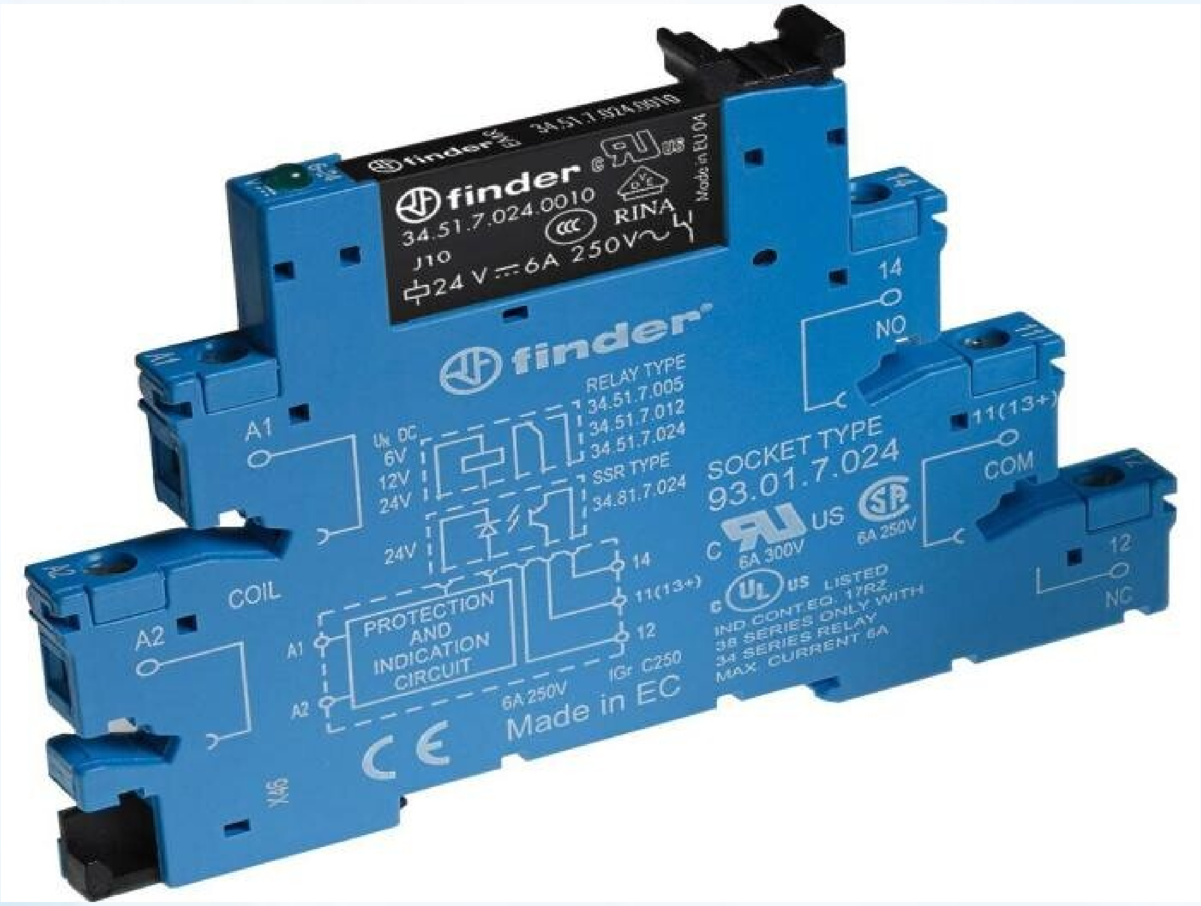


FIGURE 8.1 RELAY

8.1 WORKING PRINCIPLE OF A RELAY:

- Relay works on the principle of electromagnetic induction.
- When the electromagnet is applied with some current, it induces a magnetic field around
- A switch is used to apply DC current to the load.
- In the relay, Copper coil and the iron core acts as electromagnet.
- When the coil is applied with DC current it starts attracting the contact. This is called energizing of relay.
- When the supply is removed it retrieves back to the original position. This is called De-energizing of relay.
- There are also such relays, whose contacts are initially closed and opened when there is supply.
- Solid state relays will have sensing element to sense the input voltage and switches the output using opto-coupling.

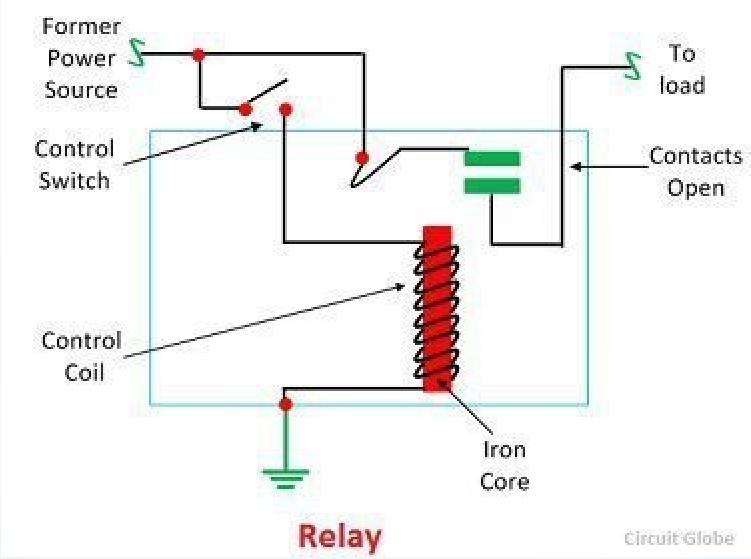


FIGURE 8.2 WORKING PRINCIPLE OF RELAY

8.2 RELAY CHANGEOVER:

A Change- Over relay is the most common type of relay. These have 5 pins and a body with two contacts connected to a common terminal. These are wired to be either Normally Open (NO) or Normally Closed (NC.)

When a relay is NO, it means that it will not conduct electricity until the coil is energized or turned "on." Basically, the circuit is disconnected when the relay is inactive. On the opposite side, a NC relay will conduct electricity until the coil is energized or "closed." This means that the circuit is still connected when the relay is inactive.

The Change-Over relay can control two different circuits, one NO and one NC. As the name suggests, it can also switch between these two types depending on your specific needs. No matter what type of circuit (NO, NC, or both), a change-over relay can switch current from one component to another. It is important to note that even though a Change-Over relay can switch between the NO and NC circuits, both cannot be on at the same time.

CHAPTER - IX
THERMAL OVERLOAD RELAY

9. THERMAL OVERLOAD RELAY:

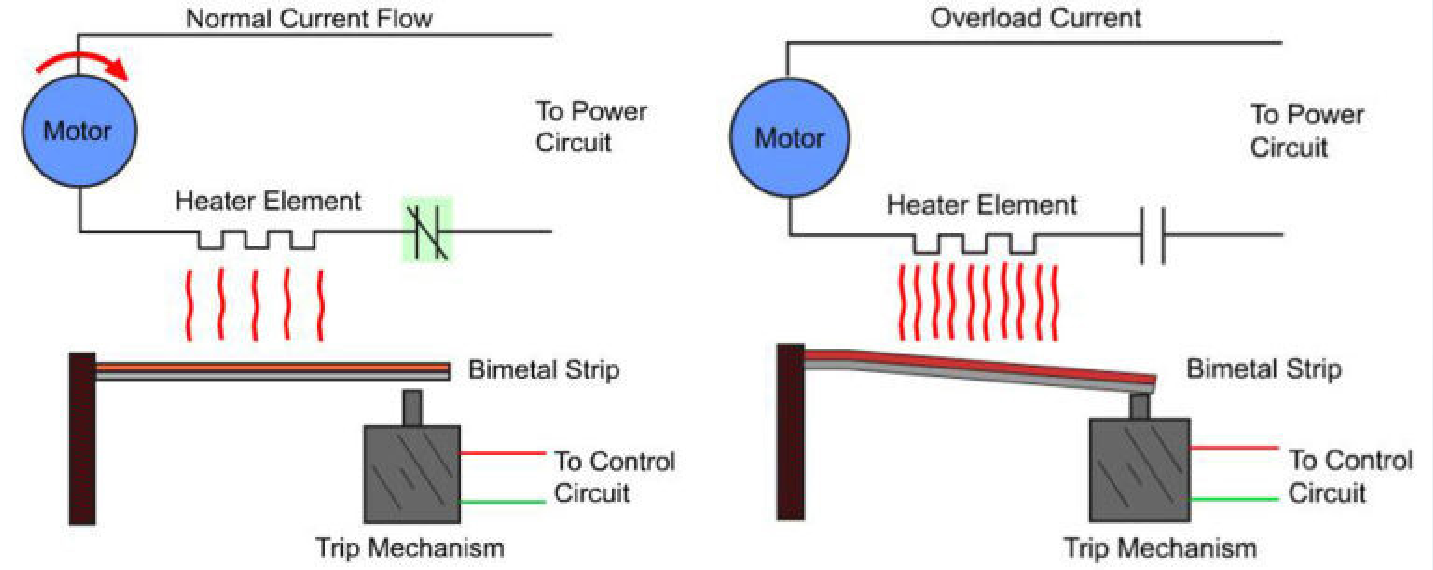
Heat is a major factor in the performance and life of a motor, and one of the primary sources of motor heating is current running through the motor windings. Since heating is an unavoidable condition of motor operation, it's important to protect the motor from overheating, or thermal overload.

In a previous post, we described several types of sensors that can measure the temperature of motor windings directly. But in some cases — particularly for AC induction motors — motor heating can be measured indirectly by thermal overload relays, which determine motor temperature by monitoring the amount of current being delivered to the motor.

FIGURE 9.1 OVER LOAD RELAY

9.1 FUNCTION OF THERMAL OVERLOAD RELAY:

Thermal overload relays are wired in series with the motor, so the current flowing to the motor also flows through the overload relay. When the current reaches or exceeds a pre determined limit for a certain amount of time, the relay activates a mechanism that opens one or more contacts to interrupt current |ow to the motor. Thermal overload relays are rated by their trip class, which depends the amount of time for which the overload can occur before the relay responds, or trips. Common trip classes are 5, 10, 20, and 30 seconds.



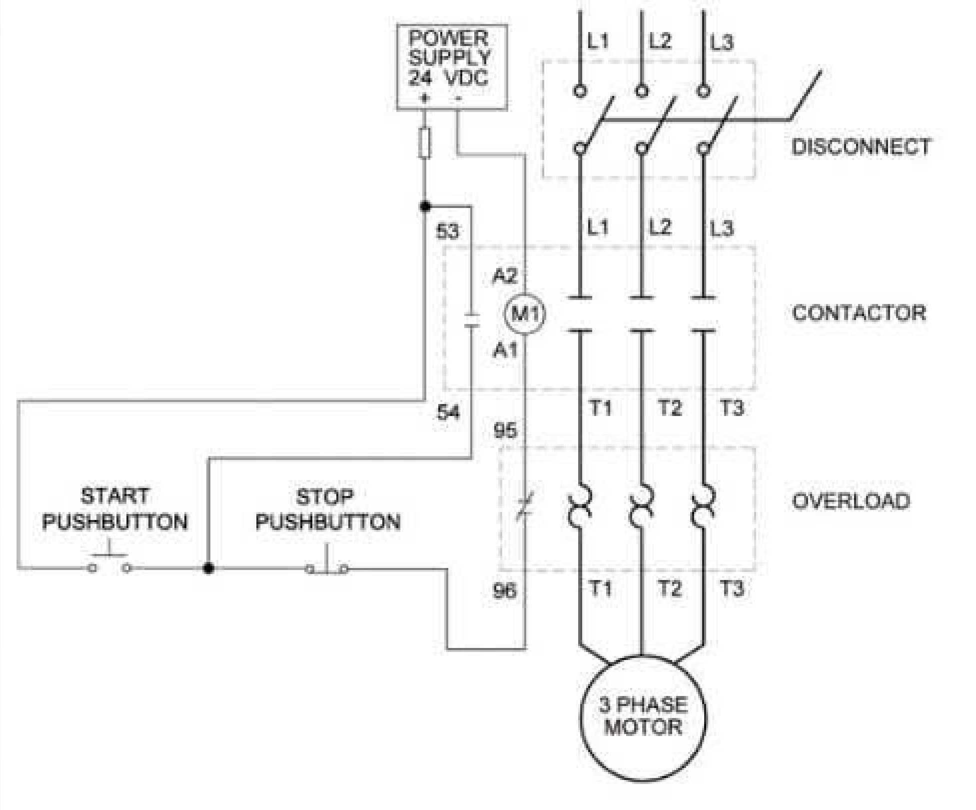


FIGURE 9.2 WORKING OF THERMAL OVERLOAD RELAY

CHAPTER - X
TIMER REALYS

10. TIMER RELAYS:

The time relay is a very important component in the electrical control system. In many control systems, use the time relay to achieve delay control. Time relay is an automatic control electrical appliance that uses the principle of electromagnetic or mechanical action to delay the closing or opening of contacts. Its characteristic is that there is a delay from the time the attracting coil gets the signal to the action of the contact. The time relay is generally used to control the motor starting process with time function.

FIGURE 10.1 TIMER RELAY

10.1 WORKING PRINCIPLE OF TIMER RELAY:

Time relay is widely used in remote control, telecommunication, automatic control and other electronic equipment, and is one of the most important control components. When the coil is energized, the armature and the pallet are attracted by the core and move down instantaneously, making the action contact close or open. However, the piston rod and the lever cannot fall with the armature at the same time, because the upper end of the piston rod is connected to the rubber film in the air chamber.

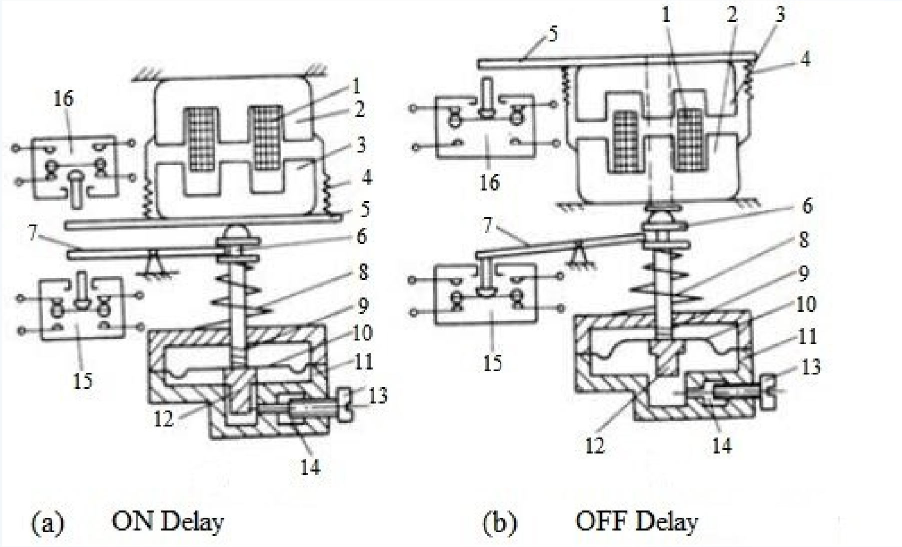


FIGURE 10.2 WORKING PRINCIPLE OF TIMER RELAY

1. Coil	2. Weak Spring
3. Iron Core	4. Rubber Film
5. Armature	6. Air Chamber Wall
7. Reaction Spring	8. Piston
9. Push plate	10. Adjusting Screw
11. Piston rod	12. Air Inlet
13. Lever	14. Micro Switch
15. Spring	16. Micro Switch

When the piston rod starts to move downward under the action of the released spring, the rubber film is concave downward. The air in the air chamber becomes thinner, causing the piston rod to be damped and slowly descend. After a certain period of time, the piston rod descends to a certain position, and then the delay contact action is pushed through the lever to make the moving contacts open and close. The time from when the coil is energized to when the delay contact completes the action is the delay time of the relay. The length of the delay time can be changed by adjusting the size of the air inlet hole of the air chamber with a screw. After the suction coil is de-energized, the relay relies on the spring to recover. And the air is quickly expelled through the air outlet.

CHAPTER - XI
CURRENT TRANSFORMER

11. CURRENT TRANSFORMER:

A Current transformer is a type of transformer that is used to reduce or multiply an alternating current. It produces a current in its secondary which is proportional to the current in its primary.

FIGURE 11.1 CURRENT TRANSFORMER

11.1 WORKING PRINCIPLE OF CURRENT TRANSFORMER:

The current transformers operating principle is based on the law of electromagnetic induction. With a certain number of turns, the voltage from the external network is supplied to the primary power winding and overcomes its total resistance. That results in the appearance of a magnetic flux trapped by the magnetic circuit around the coil, which is perpendicular to the current direction . Due to this, there will be minimal loss of electric current during conversion. Flux also varies depending on the type of magnetic material.

The electromotive force stimulates the magnetic flux at the intersection of the secondary winding switches, located perpendicularly. A current occurs under the control of EMF which is required to resolve coil impedance and output load. At the secondary winding source, simultaneously, a voltage drop is observed.

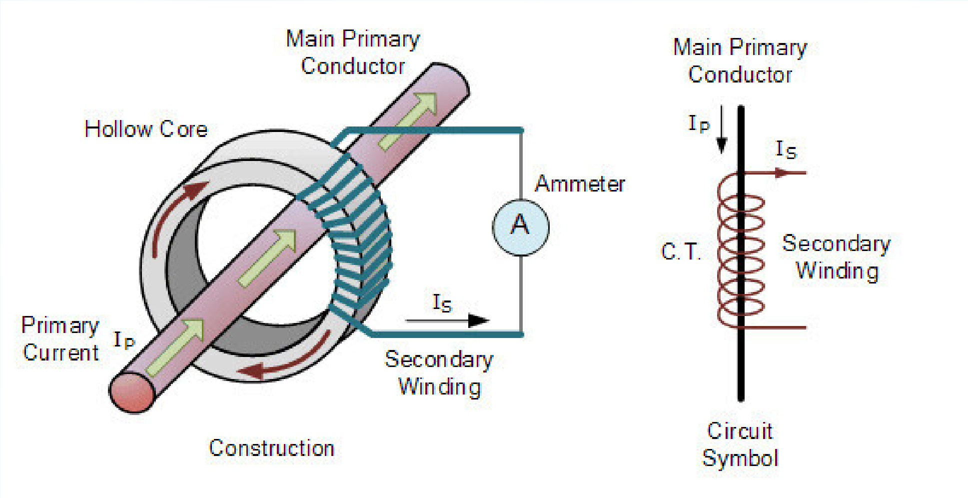


FIGURE 11.2 WORKING PRINCIPLE OF CURRENT TRANSFORMER

CHAPTER - XII
PHASE SEQUENCE RELAY

12. PSR (PHASE SEQUENCE RELAY):

Phase sequence relay can be used in phase sequence protection. When the phase sequence of the circuit does not match the specified phase sequence, the phase sequence relay will trigger the action and cut off the power supply of the control circuit so as to cut off the motor power supply and protect the motor.

FIGURE 12.1 PHASE SEQUENCE RELAY

12.1 WORKING PRINCIPLE OF PHASE SEQUENCE RELAY:

A Phase sequence relay consisting of an operational amplifier is used to compare the amplitude, frequency and phase of the voltage. If the conditional amplifier turns on, if one condition is not attached to the amplifier, the amplifier is closed.

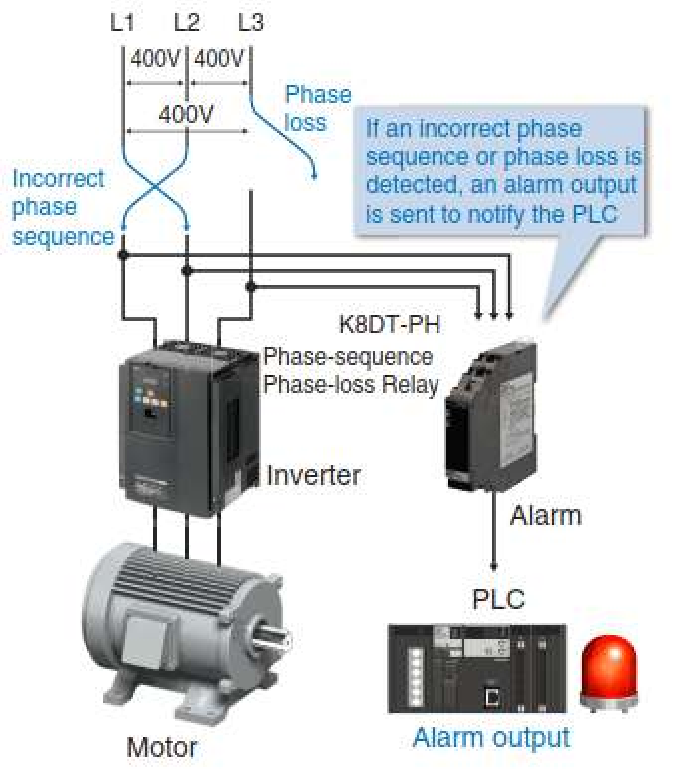


FIGURE 12.2 WORKING PRINCIPLE OF PHASE SEQUENCE RELAY

In general, the wiring sequence of the motor work is prescribed, if the order of phase is disordered for some reason, the motor will not work or even damage. Phase sequence protection is to prevent such accidents.

CHAPTER XIII
MOTOR & ITS TYPE

13. WHY WE NEED A STARTER WITH A MOTOR? :

A motor starter is essential for starting an induction motor. It is because of its low rotor impedance. The rotor impedance depends on the slip of the induction motor which is the relative speed between the rotor & stator. The impedance varies inversely with the slip. The slip of the induction motor is at maximum i.e. 1 at standstill (rest position), thus the impedance is at its minimum & it draws a huge amount of current called inrush current.

The high inrush current magnetizes the air gap between the rotor & stator that induces an EMF in the rotor winding. This EMF produces an electrical current in rotor winding that creates a magnetic field to generate torque in the rotor. As the rotor speed increases the slip of the motor decreases & the current drawn by the motor is reduced.

13.1 Types of Motor Starters:

- Direct Online Starter (DOL)
- Stator Resistance starter
- Rotor Resistance or Slip Ring Motor Starter
- Auto transformer Starter
- Star Delta Starter
- Soft Starter
- Variable frequency drive (VFD)

13.2 Direct Online (DOL) Starter:

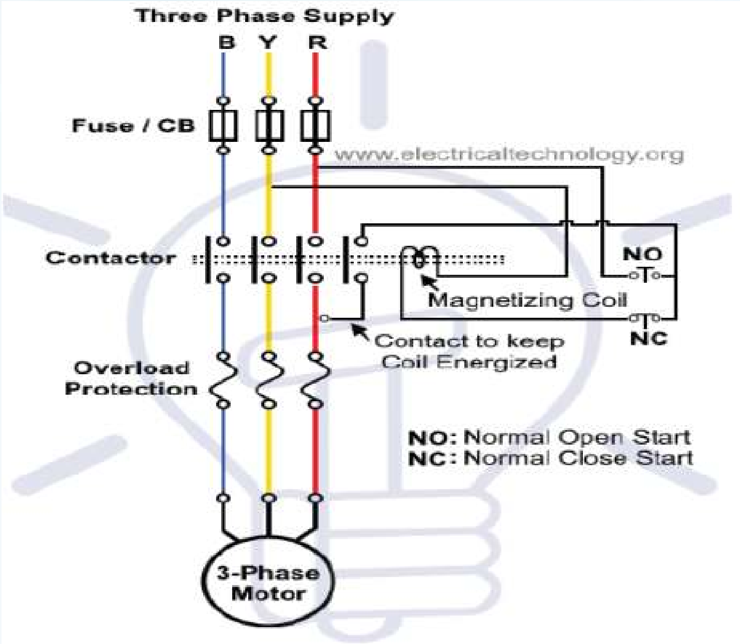


FIGURE 13.1 WORKING OF DIRECT ONLINE STARTER

Direct Online Starter is the simplest form of motor starter that connects the motor directly to the power supply. It consists of a magnetic contactor that connects the motor with a supply line & an overload relay for protection against overcurrent. There is no voltage reduction for safe starting a motor. Therefore the motor used with such starters has below 5 hp rating. It has two simple push buttons that start & stop the motor.

Pressing the start button energizes the coil that pulls the contactors together to close the circuit. And pressing the stop button de-energizes the contactor's coil & pushes its contacts apart thus breaking the circuit. The switch used for turning ON/OFF the power supply can be of any type such as rotary, level, float, etc. Although, this starter does not provide safe starting voltage the overload relay provides protection against overheating & overcurrent. The overload relay has normally closed contacts that energize the contactor's coil. When the relay trips, the contactor's coil de-energize and break the circuit.

13.3 Stator Resistance starter:

Stator resistance starter uses the RVS (reduced voltage starter) technique to start a motor. External resistance is added in series with each phase of a3 phase induction motor's stator. The resistor's job is to reduce the line voltage (subsequently reducing the initial current) applied to the stator.

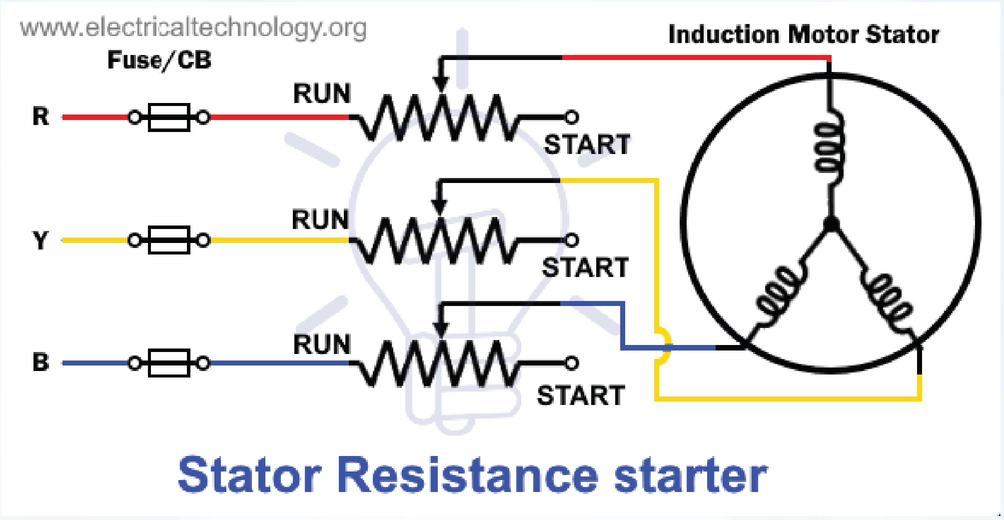


FIGURE 13.2 STATOR RESISTANCE STARTER

Initially, the variable resistor is kept at maximum position offering maximum resistance. Therefore the voltage across the motor is minimum (in safe level) due to the voltage drop across the resistor. The low stator voltage limits the starting inrush current that can damage the motor windings. As the motor picks up the speed, the resistance is reduced & the stator phase is directly connected to the power lines. As the current is directly proportional to the voltage & torque varies to the square of the current, a 2 times decrease in the voltage decreases the torque by 4 times. Thus the starting torque using such a starter is very low & needs to be maintained.

13.4 Rotor Resistance or Slip Ring Motor Starter

This type of motor starter works on a full voltage motor starting technique. It works only on a slip ring induction motor that is why it is also known as a slip ring motor starter.

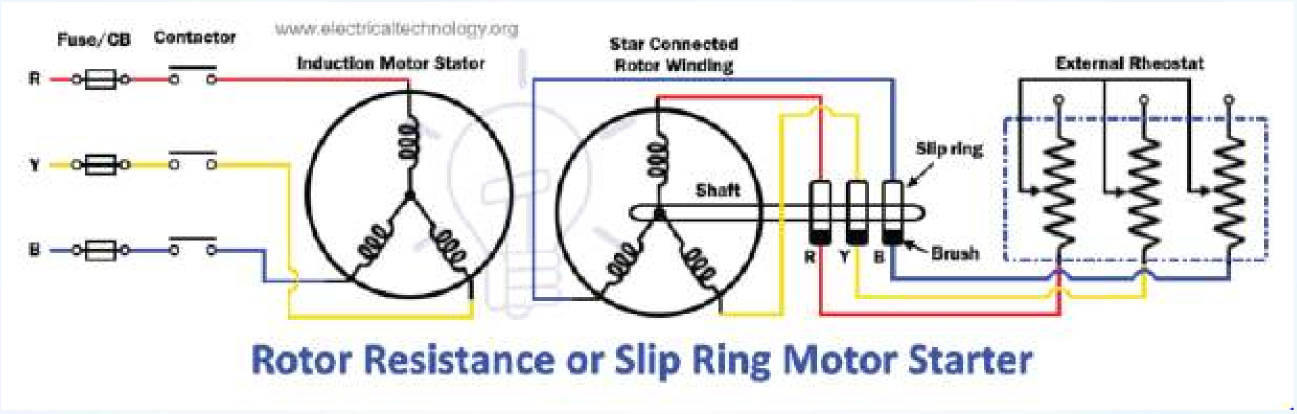


FIGURE 13.3 SLIP RING MOTOR STARTER

External resistances are connected with the rotor in star combination through the slip ring. These resistors limit the rotor current & increase the torque. This, in turn, reduces the starting stator current. It also helps in improving the power factor The resistors are only used during the starting of the motor & it is removed once the motor picks up its rated speed.

13.5 Auto Transformer Starter

Such type of motor starters uses an auto transformer as a step-down transformer to reduce the voltage applied to the stator during the starting stage. It can be connected to both star & delta connected motors.

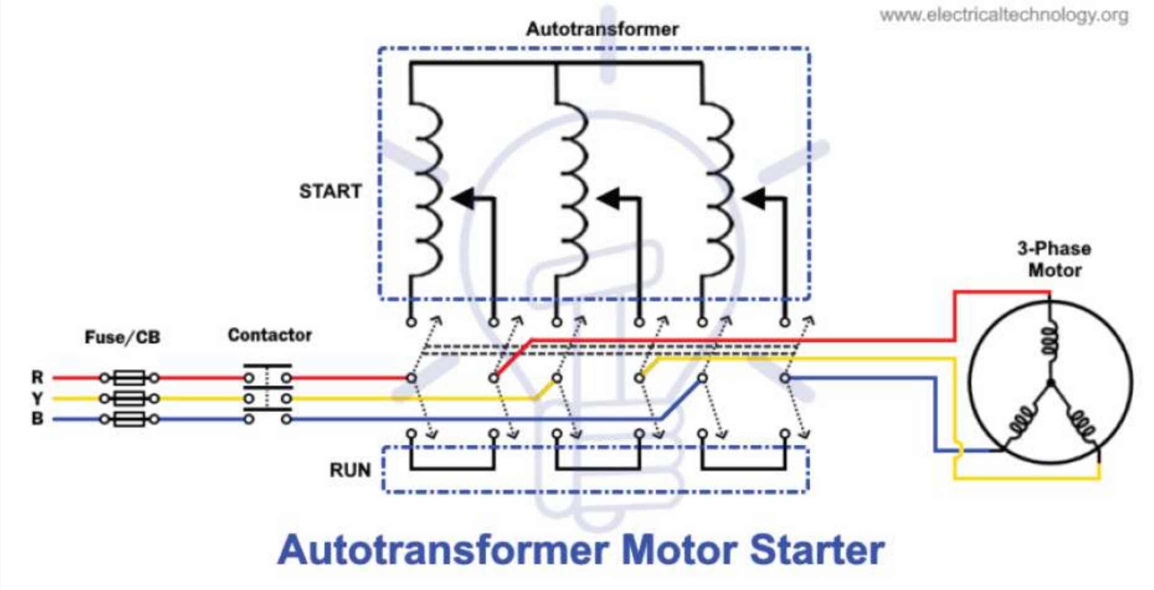


FIGURE 13.4 AUTO TRANSFORMER STARTER

13.6 Star Delta Starter

This is another common starting method used in industries for large motors. The windings of 3 phase induction motor are switched between star and delta connection to start the motor.

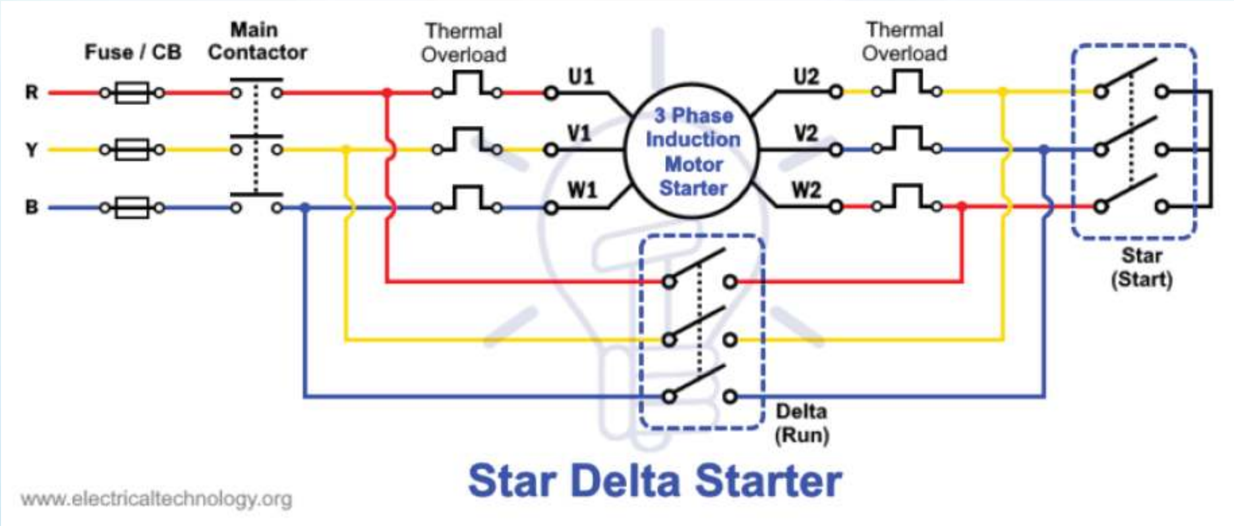


FIGURE 13.5 STAR DELTA STARTER

To start the induction motor, it is connected in star using a triple pole double throw relay. The phase voltage in star connection is reduced by the factor $1/\sqrt{3}$ & it reduces the starting current as well as the starting torque by 1/3 of the normal rated value. When the motor accelerates, a timer relay switches the star connection of the stator windings into the delta connection, allowing the full voltage across each winding. The motor runs at rated speed.

13.7 Soft Starter

The soft starter also uses the voltage reduction technique. It uses the semiconductor switches like TRIAC to control the voltage as well as the starting current supplied to the induction motor.

A phase-controlled TRIAC is used to provide variable voltage. The voltage is varied by varying the conduction angle or firing angle of the TRIAC. The conduction angle is kept at minimum to provide reduced voltage. The voltage is increased gradually by increasing the conduction angle. At maximum conduction angle, the full line voltage is applied to the induction motor & it runs at rated speed. It provides a gradual & smooth increase in the starting voltage, current as well as the torque. Thus there is no mechanical jerk & provide a smooth operation that increases the life span of the machine.

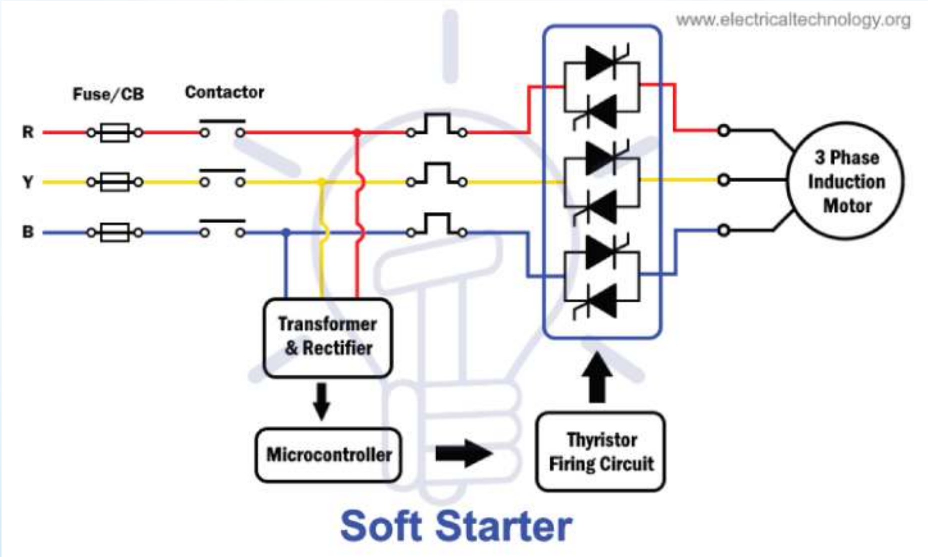


FIGURE 13.6 SOFT STARTER

13.8 Variable Frequency Drive (VFD):

Just like the soft starter, a Variable frequency drive (VFD) can vary the voltage as well as the frequency of the supplying current. It is mainly used for controlling the speed of the induction motor as it depends on the supply frequency.

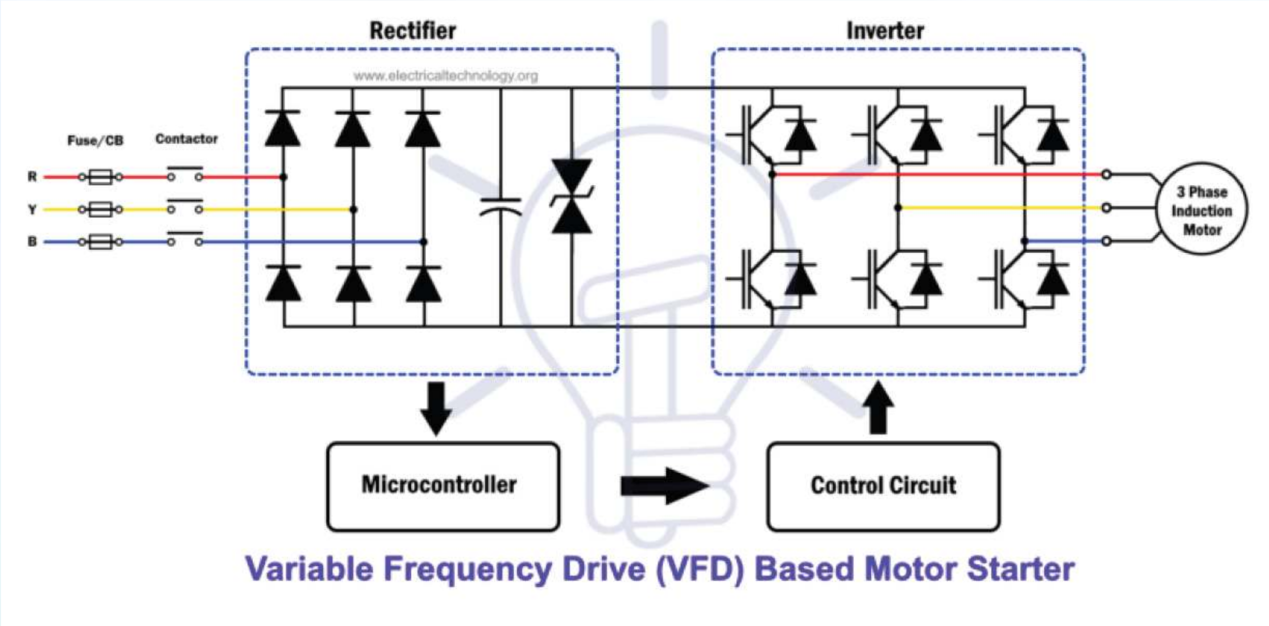


FIGURE 13.7 VARIABLE FREQUENCY DRIVE

The AC from the supply line is converted into DC using rectifiers. The pure DC is converted into AC with adjustable frequency & voltage using pulse width modulation technique through power transistor like IGBTs. It provides full control over the motor speed from 0 to rated speed. The speed adjust option with the variable voltage provides a better starting current & acceleration.

CHAPTER - XIV
TRANSFORMER

14. TRANSFORMER :

A transformer is defined as a passive electrical device that transfers electrical energy from one circuit to another through the process of electromagnetic induction. It is most commonly used to increase ('step up') or decrease ('step down') voltage levels between circuits.

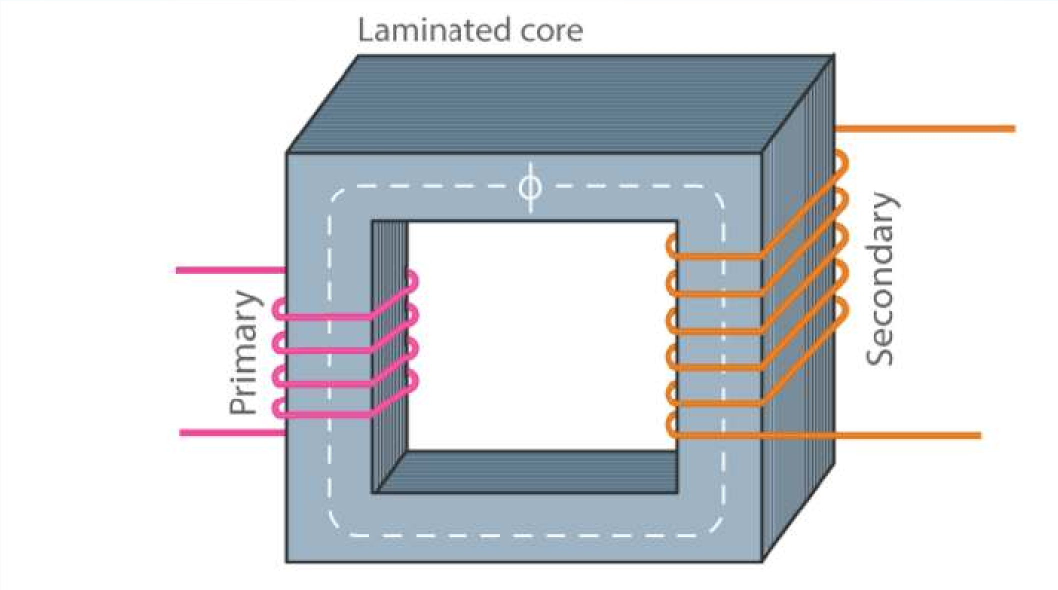


FIGURE 14.1 TRANSFORMER

14.1 FUNCTIONS OF TRANSFORMER:

Say you have one winding (also known as a coil) which is supplied by an alternating electrical source. The alternating current through the winding produces a continually changing and alternating flux that surrounds the winding.

If another winding is brought close to this winding, some portion of this alternating flux will link with the second winding. As this flux is continually changing in its amplitude and direction, there must be a changing flux linkage in the second winding or coil.

According to Faraday's law of electromagnetic induction, there will be an EMF induced in the second winding. If the circuit of this secondary winding is closed, then a current will flow through it. This is the basic working principle of a transformer.

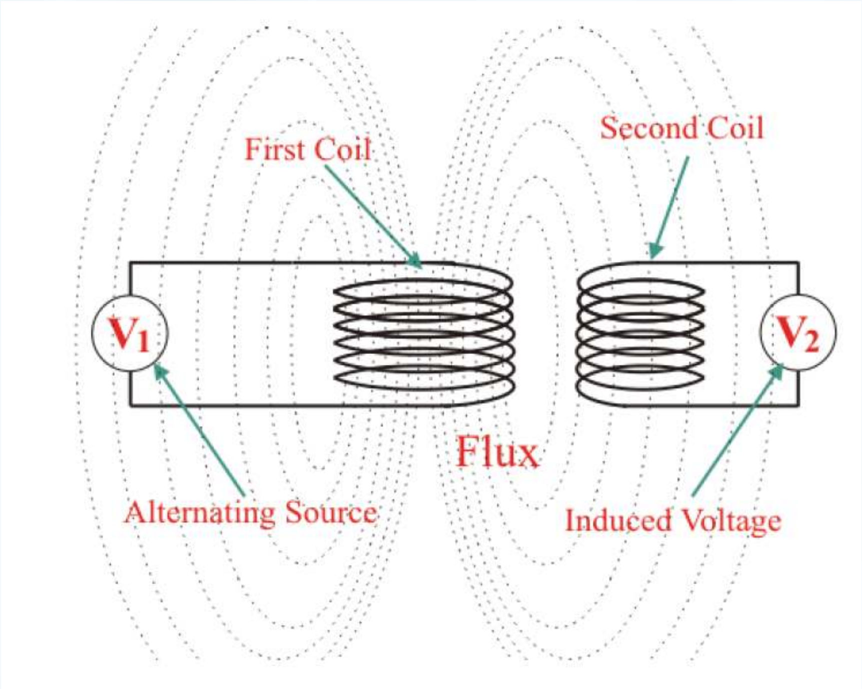


FIGURE 14.2 WORKING OF TRANSFORMER

A transformer that increases voltage between the primary to secondary windings is defined as a step-up transformer. Conversely, a transformer that decreases voltage between the primary to secondary windings is defined as a step-down transformer.

Whether the transformer increases or decreases the voltage level depends on the relative number of turns between the primary and secondary side of the transformer.

If there are more turns on the primary coil than the secondary coil than the voltage will decrease (step down).

If there are less turns on the primary coil than the secondary coil than the voltage will increase (step up).

While the diagram of the transformer above is theoretically possible in an ideal transformer – it is not very practical. This is because in the open air only a very tiny portion of the flux produced from the first coil will link with the second coil. So the current that flows through the closed circuit connected to the secondary winding will be extremely small (and difficult to measure).

The rate of change of flux linkage depends upon the amount of linked flux with the second winding. So ideally almost all of the flux of primary winding should link to the secondary winding. This is effectively and efficiently done by using a core type transformer. This provides a low reluctance path common to both of the windings.

CHAPTER - XV
ALTERNATOR

15. ALTERNATOR :

The working principle of an alternator is very simple. It is just like the basic principle of DC generator. It also depends upon Faraday's law of electromagnetic induction which says the current is induced in the conductor inside a magnetic field when there is a relative motion between that conductor and the magnetic field.

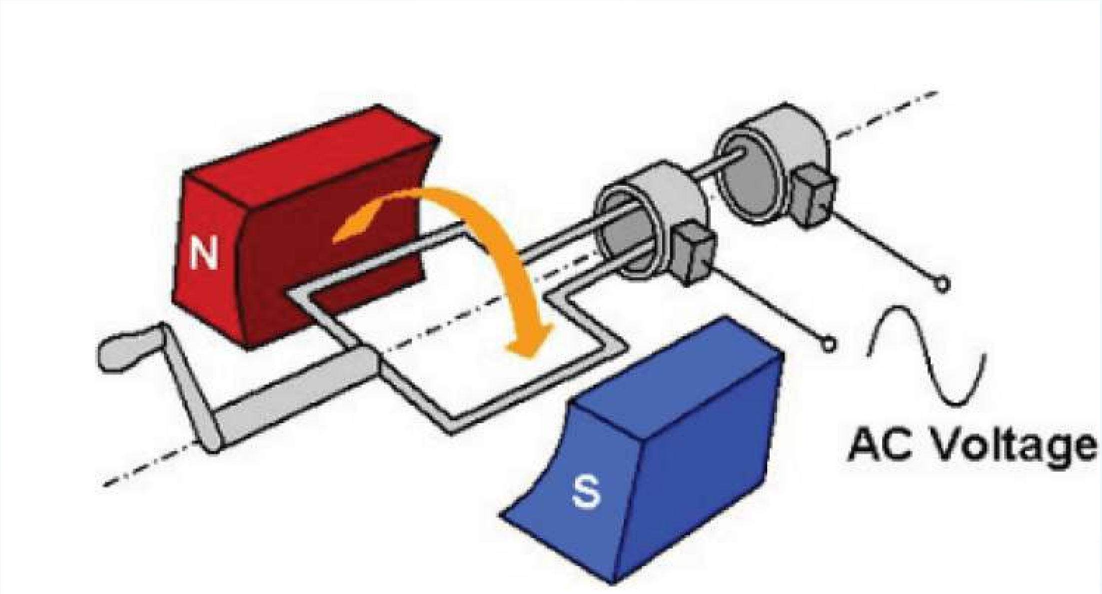


FIGURE 15.1 ALTERNATOR

15.1 FUNCTIONS OF ALTERNATOR:

Say this single turn loop ABCD can rotate against axis a-b. Suppose this loop starts rotating clockwise. After 90rotation the side AB or conductor AB of the loop comes in front of S-pole and conductor CD comes in front of N-pole. At this position the tangential motion of the conductor AB is just perpendicular to the magnetic flux lines from N to S pole.Hence, the rate of flux cuing by the conductor AB is maximum here and for that flux cuing there will be an induced current in the conductor AB and the direction of the induced current can be determined by Fleming's right-hand rule. As per this rule the direction of this current will be from A to B. At the same time conductor CD comes under N pole and here also if we apply Fleming right-hand rule we will get the direction of induced current and it will be from C to D.

Now after clockwise rotation of another 90 the turn ABCD comes at the vertical position as shown below. At this position tangential motion of conductor AB and CD is just parallel to the magnetic flux lines, hence there will be no flux cuing that is no current in the conductor.

While the turn ABCD comes from a horizontal position to a vertical position, the angle between flux lines and direction of motion of conductor, reduces from 90 to 0 and consequently the induced current in the turn is reduced to zero from its maximum value.

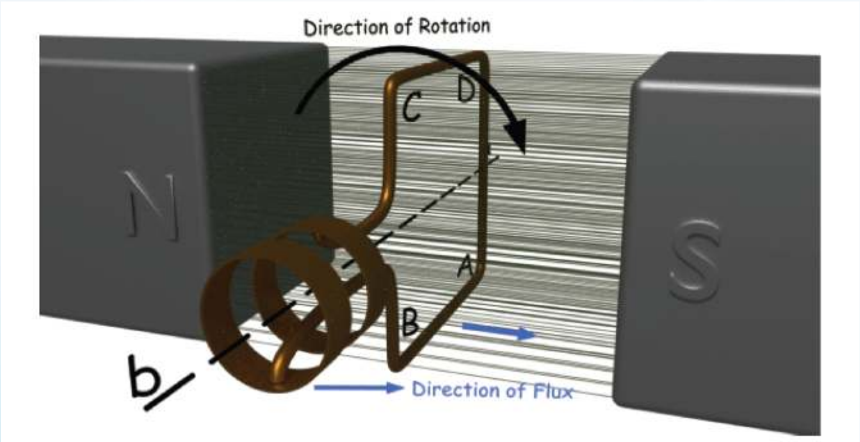


FIGURE 15.2 WORKING OF ALTERNATOR (A)

After another clockwise rotation of 90 the turn again comes to horizontal position, and here conductor AB comes under N-pole and CD comes under S-pole, and here if we again apply Fleming right-hand rule, we will see that induced current in conductor AB, is from point B to A and induced current in the conductor CD is from D to C.

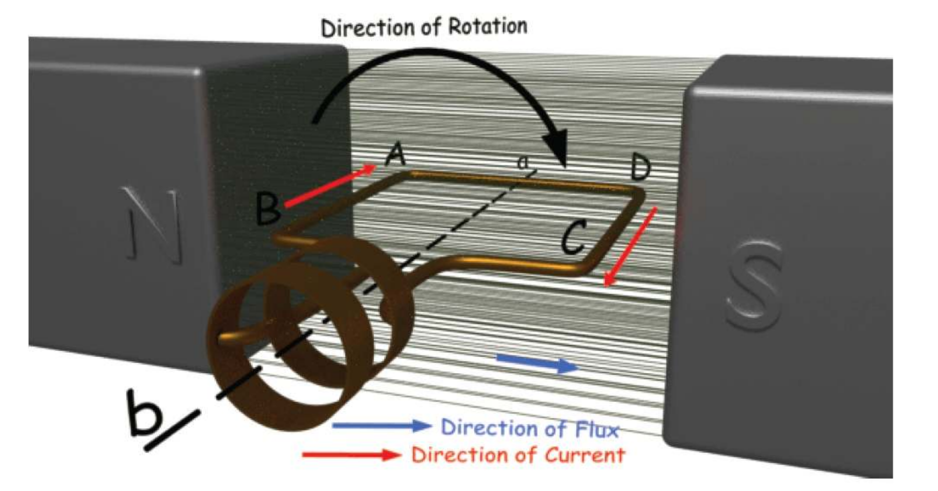


FIGURE 15.3 WORKING OF ALTERNATOR (B)

As at this position the turn comes at a horizontal position from its vertical position, the current in the conductors comes to its maximum value from zero. That means current is circulating in the close turn from point B to A, from A to D, from D to C and from C to B, provided the loop is closed although it is not shown here. That means the current is in reverse of that of the previous horizontal position when the current was circulating as A → B → C → D → A.

While the turn further proceeds to its vertical position the current is again reduced to zero. So if the turn continues to rotate the current in turn continually alternate its direction. During every full revolution of the turn, the current in turn gradually reaches to its maximum value then reduces to zero and then again it comes to its maximum value but in opposite direction and again it comes to zero. In this way, the current completes one full sine wave cycle during each360 revolution of the turn. So, we have seen how alternating current is produced in a turn is rotated inside a magnetic field. From this, we will now come to the actual working principle of an alternator.

CHAPTER - XVI
EMI FILTER

16. EMI FILTER:

EMI filters, also called EMI suppression filters, are an effective way to protect against the harmful impacts of electromagnetic interference. When EMI Filters are attached to devices or circuits, It can suppress the electromagnetic noise transmitted through conduction. These filters extract any unwanted current conducted through wiring or cables, while allowing desirable currents to flow freely. An EMI filter that suppresses noise from grid power is also called an EMI power line filter.

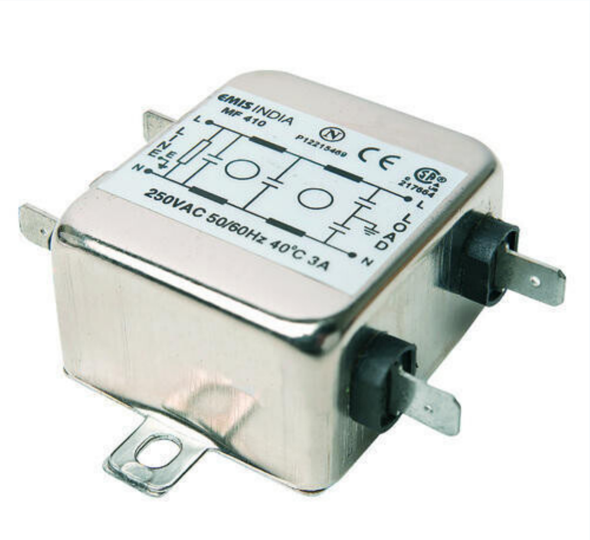


FIGURE 16.1 EMI FILTER

16.1 WORKING PRINCIPLE OF EMI FILTER:

Most electromagnetic noise is in a higher frequency range, so EMI filters are often low-pass filters that shift out high frequencies while letting lower frequencies pass through. Different EMI line filters suppress specific frequencies of noise, while allowing others to flow unimpeded. After the filtering process, electromagnetic noise gets diverted away from the device and to the ground. Some EMI filters may also route unwanted currents back to the noise source or absorb them.

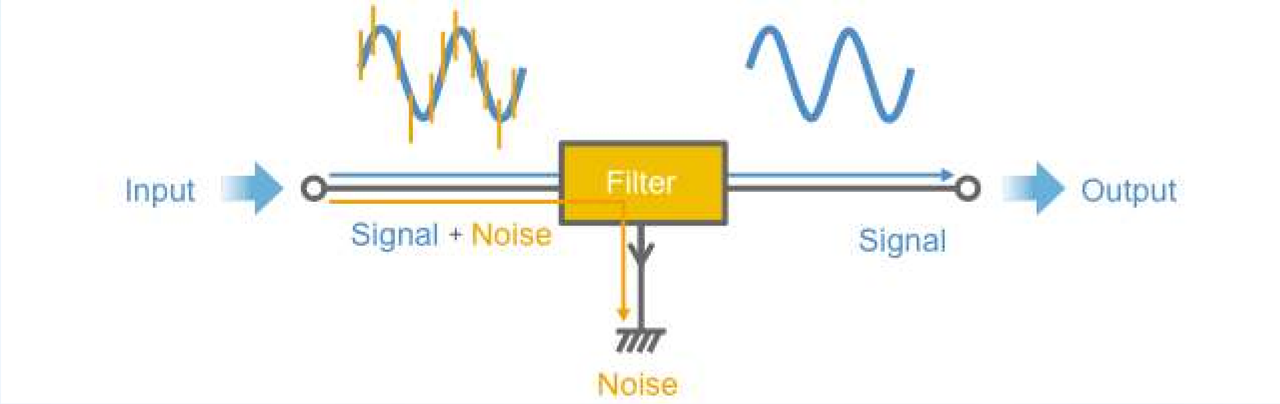


FIGURE 16.2 WORKING OF EMI FILTER

Because EMI filters only protect against conducted EMI, they often pair with shields that block radiated EMI. An unshielded EMI filter can still transmit noise through the air to damage the device. Noise can get emitted from a wire on one side of the EMI filter and then travel to the device by recoupling with the wire on the other side.

Adding a shield at the attachment point of the electromagnetic interference filter can effectively block all forms of EMI. However, if there is only a small length of conductor between the filter and the source of EMI, using a filter alone can be sufficient.

CHAPTER - VII
HUMAN -MACHINE INTERFACE

17. HMI (HUMAN-MACHINE INTERFACE):

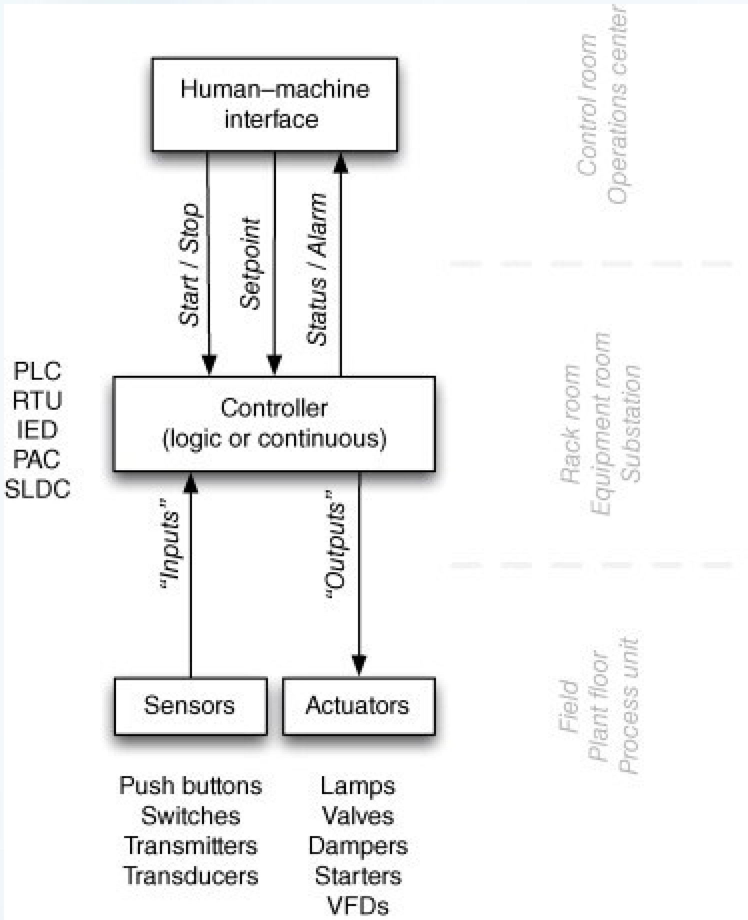


FIGURE 17.1 HUMAN MACHINE INTERFACE - FUNCTION

HMIs allow operators to start and stop cycles, adjust set points, and perform other functions required to adjust and interact with a control process. Because the HMI is software based, they replace physical wires and controls with software parameters, allowing them to be adapted and adjusted very easily.

Human–machine interfaces are used as an operator's means to interact with PLCs, RTUs, and IEDs. HMIs replace manually activated switches, dials, and other electrical controls with graphical representations of the digital controls used to sense and influence that process. HMIs allow operators to start and stop cycles, adjust set points, and perform other functions required to adjust and interact with a control process. Because the HMI is software based, they replace physical wires and controls with software parameters, allowing them to be adapted and adjusted very easily.

CHAPTER - XVIII
LUGS AND ITS TYPE

18. LUGS:

Lugs are devices used for connecting cables to electrical appliances, other cables, surfaces, or mechanisms. Types of Lugs are as follows:

18.1 PLUGIN TYPE LUG:

FIGURE 18.1 PLUGIN TYPE LUG

18.2 PRESS SLEEVE LUG:

FIGURE 18.2 PRESS SLEEVE LUG

18.3 BORE LUG (RING LUG):

FIGURE 18.3 BORE LUG

18.4 U-CON MALE & FEMALE LUGS:

FIGURE 18.4 U-CON MALE & FEMALE LUGS

18.5 FORK LUG:

FIGURE 18.5 FORK LUG

CHAPTER - XIX
BATTERY

19. BATTERY IN PARALLEL & SERIES CONNECTION:

The main difference in wiring batteries in series vs. parallel is the impact on the output voltage and the capacity of the battery system. Batteries wired in series will have their voltages added together. Batteries wired in parallel will have their capacities (measured in amp-hours) added together. However, the total available energy (measured in watt-hours) in both configurations is the same.

For example, wiring two 12-volt batteries with 100 Ah capacities in series will output 24 volts with a 100 Ah capacity. Wiring the same two batteries in parallel will output 12 volts with a 200 Ah capacity. Thus, both systems have a total available energy of 240 watt-hours (watt-hours = volts x amp-hours).

Additionally, batteries wired in series and parallel configurations should all have the same voltage and capacity rating. Mixing and matching voltages and capacities can lead to problems that may damage your batteries.

19.1 BATTERIES IN SERIES CONNECTION:

To wire multiple batteries in series, connect the positive terminal of each battery to the negative terminal of the next. Then, measure the system's total output voltage between the negative terminal of the first battery and the positive terminal of the last battery in series.

$V_{total} = V_1 + V_2$ etc.

$I_{total} = I_1 = I_2$ etc.

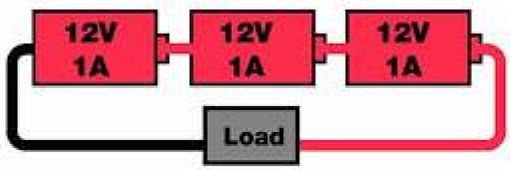


FIGURE 19.1 BATTERY IN SERIES CONNECTION

ADVANTAGES:

Wiring batteries in series provides a higher system voltage which results in a lower system current. Less current means you can use thinner wiring and will suffer less voltage drop in the system.

DISADVANTAGES:

In a battery system wired in series, you cannot get lower voltages off the battery bank without using a converter. Either all equipment needs to function at the higher voltage or an additional converter is needed to use 12V appliances on the system.

19.2 BATTERIES IN PARALLEL CONNECTION:

To wire multiple batteries in parallel, you connect all of the positive terminals together and all of the negative terminals together. Since all of the positive and negative terminals are connected, you can measure the system output voltage across any two positive and negative battery terminals.

$V_{total} = V_1 = V_2$ etc.

Itotal = I1+I2 etc.

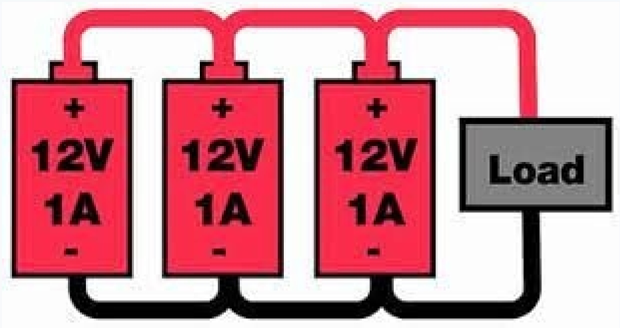


FIGURE 19.2 BATTERY IN PARALLEL CONNECTION

ADVANTAGES:

The main advantage of wiring batteries in parallel is that you increase the available runtime of your system while maintaining the voltage. Since the amp-hour capacities are additive, two batteries in series double your runtime, three batteries triple it, and so on.

Another advantage to wiring batteries in parallel is that if one of your batteries dies or has an issue, the remaining batteries in the system can still provide power.

DISADVANTAGES:

The main drawback to wiring batteries in parallel vs. series is that the system voltage will be lower, resulting in a higher current draw. Higher current means thicker cables and more voltage drop. Larger power appliances and generation are harder to operate and less efficient when operating at lower voltages.

CHAPTER- XX
METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTOR

20. MOSFET(METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTOR):

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device that is widely used for switching purposes and for the amplification of electronic signals in electronic devices. A MOSFET is either a core or integrated circuit where it is designed and fabricated in a single chip because the device is available in very small sizes.

A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terminals. In general, The body of the MOSFET is in connection with the source terminal thus forming a three-terminal device such as a field-effect transistor. MOSFET is generally considered as a transistor and employed in both the analog and digital circuits.

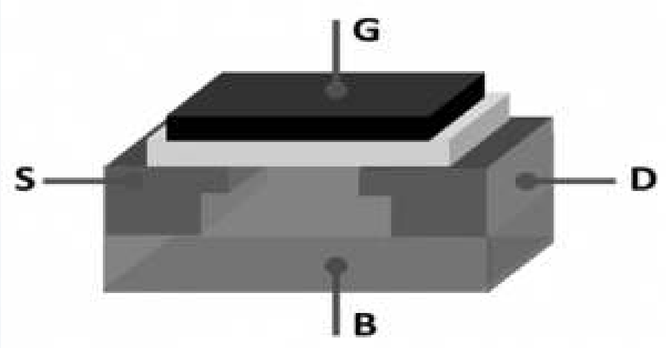


FIGURE 20.1 MOSFET

MOSFET can function in two ways:

- Depletion Mode
- Enhancement Mode

20.1 DEPLETION MODE:

When there is no voltage across the gate terminal, the channel shows its maximum conductance. Whereas when the voltage across the gate terminal is either positive or negative, then the channel conductivity decreases.

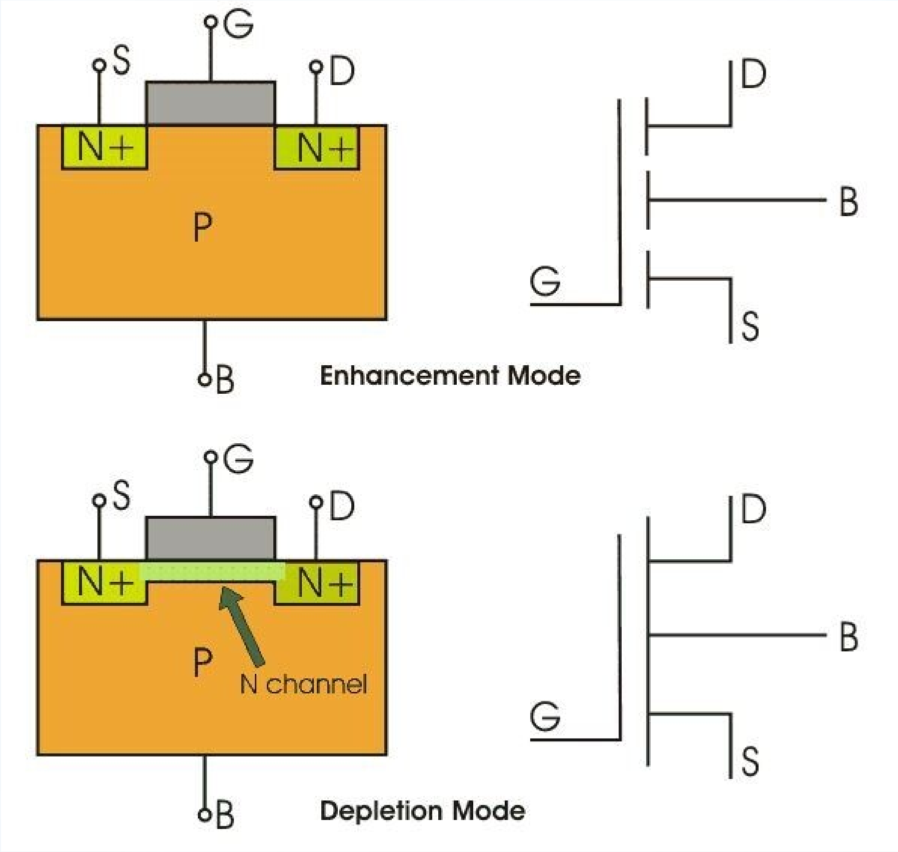


FIGURE 20.2 FUNCTION OF MOSFET

20.2 ENHANCEMENT MODE:

When there is no voltage across the gate terminal, then the device does not conduct. When there is the maximum voltage across the gate terminal, then the device shows enhanced conductivity.

CHAPTER - XXI
SILICON CONTROLLED RECTIFIER

21. SCR (SILICON CONTROLLED RECTIFIER):

A solid state-operated device with a four-layered structure, its flow of current in the one direction just like a diode where it has three junctions along with the three terminals. These devices are defined as silicon-controlled rectifiers (SCR). The other name for this is Thyristor. These are the devices that are operated with the current. A large value of the current at the anode terminal is controlled by the value of the current applied at the terminal gate. Hence these are the current-controlled devices.

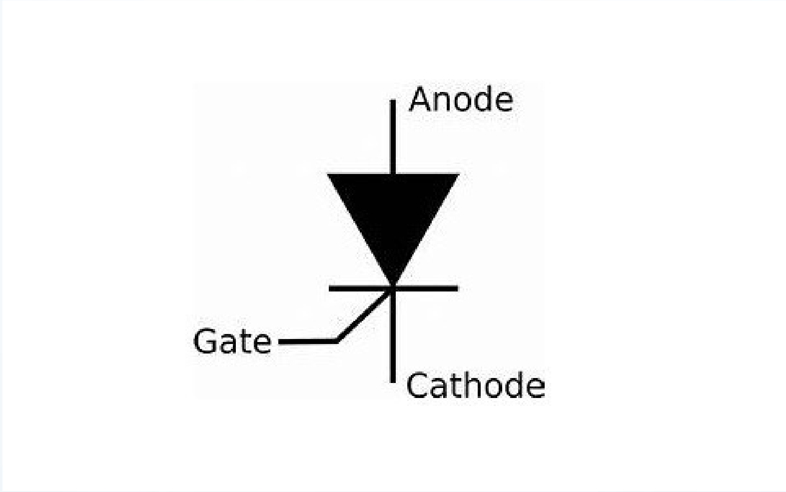


FIGURE 21.1 SYMBOLIC REPRESENTATION OF SCR

21.1 WORKING/OPERATION OF SCR:

The basic working principle in the SCR is that as the triggering or the biasing is applied at the terminal gate then the conduction begins. As it is a unidirectional device the current will be in a single direction. It resembles the operation of the diode but the only difference is that this can withstand the high amount of voltages and powers.

CHAPTER - XXII
INSULATED GATE BIPOLAR TRANSISTOR

22. IGBT (INSULATED GATE BIPOLAR TRANSISTOR):

IGBT (Insulated Gate Bipolar Transistor) is a three terminal power switch having high input impedance like PMOSFET and low on-state power loss as in BJT (Bipolar Junction Transistor). Thus, IGBT is a combined form of best qualities of both BJT and PMOSFET. This is the most popular power switch among the power-electronics engineers and find a great variety of applications.

IGBT is a three-terminal device. The three terminals are Gate (G), Emitter (E) and Collector (C).

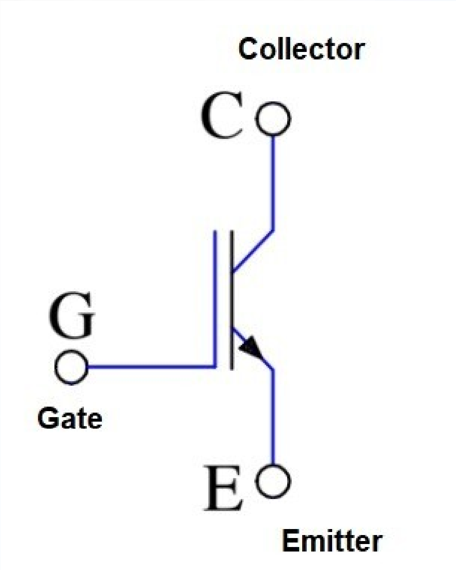


FIGURE 22.1 SYMBOLIC REPRESENTATION OF IGBT

22.1 WORKING PRINCIPLE OF IGBT:

The working principle of IGBT is based on the biasing of Gate to Emitter terminals and Collector to Emitter terminals. When collector is made positive with respect to emitter, IGBT gets forward biased. With no voltage between Gate and Emitter, two junctions between n-region & p region i.e. junction J2 are reversed biased. Therefore, no current flows from collector to emitter. You may refer figure-1 for better understanding.

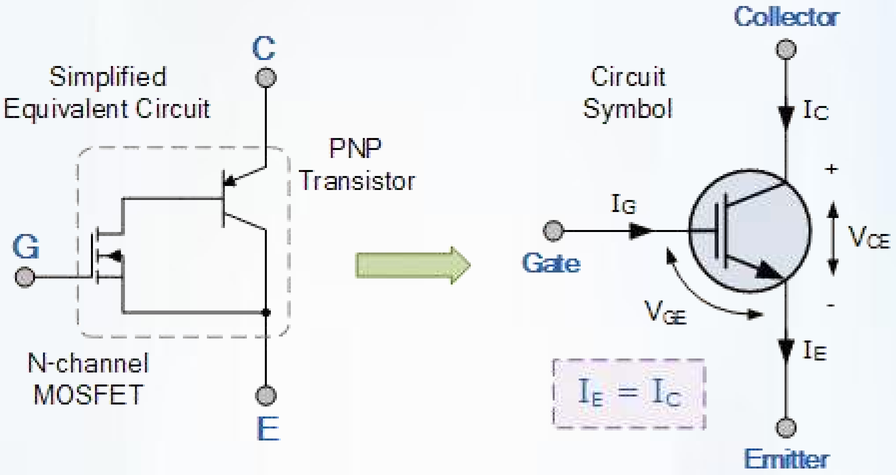


FIGURE 22.2 IGBT SYMBOL AND EQUIVALENT CIRCUIT

When Gate is made positive with respect to Emitter by some voltage VG (this voltage should be more than the threshold voltage VGET of IGBT), an n-channel is formed in the upper part of the p-region just beneath the Gate. This n-channel is called the inversion layer. This n-channel short circuits the n- region with n+ emitter region. Electrons from n+ emitter begins to flow to n- drift region through n-channel.

As IGBT is forward biased with collector positive and emitter negative, p+ collector region injects holes into n- drift region. Thus, n- drift region is flooded with electrons from p-body region and holes from p+ collector region. With this, the injection carrier density in n-drift region increases considerably and subsequently, conductivity of n- region enhances. Therefore, IGBT gets turned ON and begins to conduct forward current IC.

CHAPTER - XXIII
RECTIFIER , INVERTER AND TRANSISTOR

23. RECTIFIER:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The reverse operation is performed by the inverter. The process is known as rectification, since it "straightens" the direction of current.

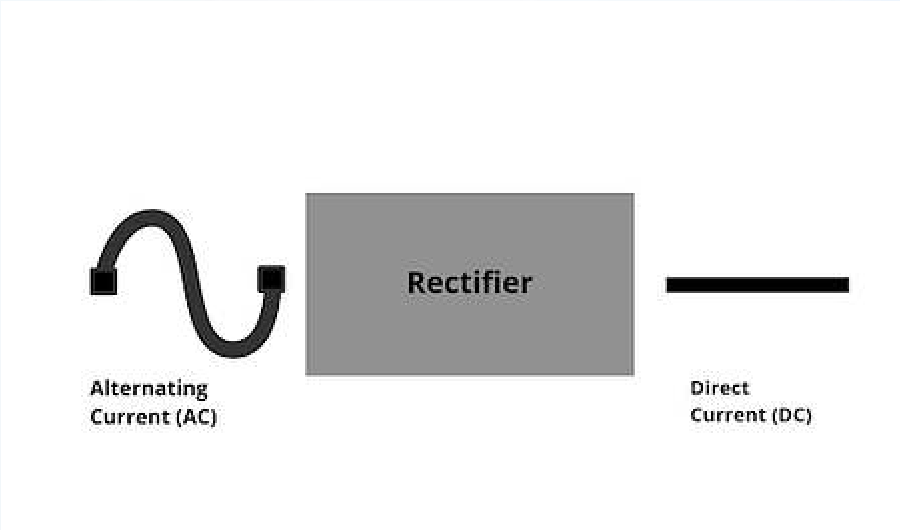


FIGURE 23.1 RECTIFIER

23.1 WORKING PRINCIPLE OF RECTIFIER:

In forward bias, the resistance of a p-n junction diode is extremely low, while in reverse bias, the resistance is extremely high. Because of this condition, a p-n junction diode only enables the current to travel in one direction.

When an alternating voltage is applied across a diode, current flows during the forward biassed portion of the cycle. Rectifier is a circuit that uses the p-n junction diode's ability to correct alternating voltages.

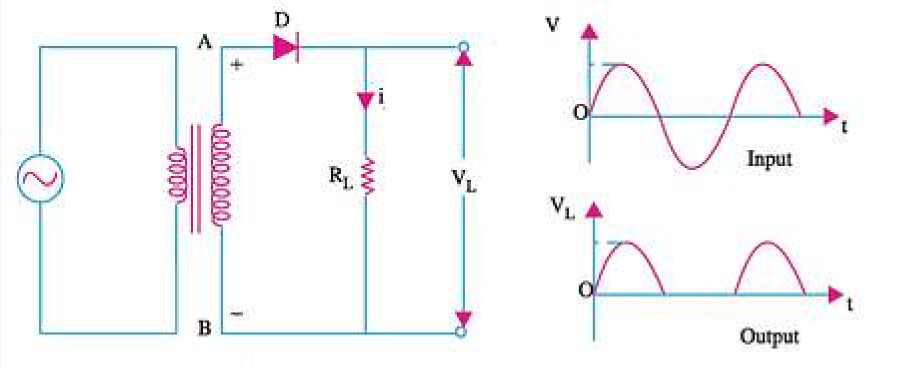


FIGURE 23.2 RECTIFIER WORKING PRINCIPLE

23.2 INVERTER:

An inverter can be defined as it is an electrical equipment used to convert direct current (DC) voltage to alternating current (AC) voltage in common appliances. The applications of DC involves several small types of equipment like solar power systems. Direct current is used in many of the small electrical equipment such as solar power systems, power batteries, power-sources, fuel cells because these are simply produced direct current.

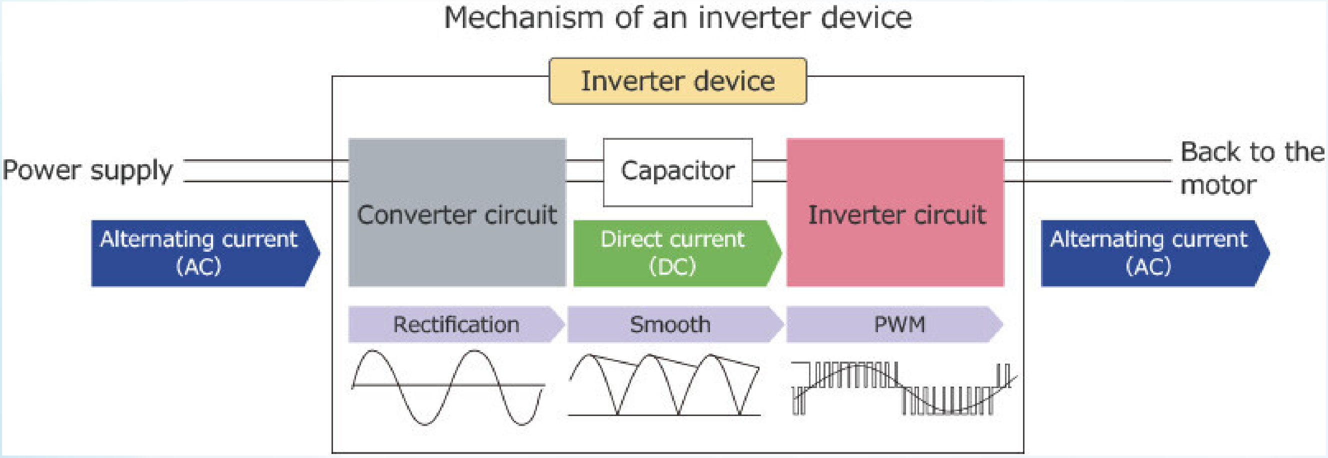


FIGURE 24.1 WORKING OF INVERTER

23.4 WORKING OF INVERTER:

The working of an inverter is, it converts DC to AC, and these devices never generate any kind of power because the power is generated by the DC source. In some situations like when the DC voltage is low then we cannot use the low DC voltage in a home appliance. So due to this reason, an inverter can be used whenever we utilize solar power panel.

23.5 TRANSISTOR:

A transistor is an electronic component that is used in circuits to either amplify or switch electrical signals or power, allowing it to be used in a wide array of electronic devices. A transistor consists of two PN diodes connected back to back.

It has three terminals namely emitter, base and collector. The basic idea behind a transistor is that it lets you control the flow of current through one channel by varying the intensity of a much smaller current that's flowing through a second channel. A transistor is a semiconductor device with three terminals, capable of amplification and rectification.

வையத்தலைமை கொள் - Lead the World

Ananda Chaitanya Foundation's Skill Development Initiative

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Our Mission:

This initiative nurtures talent, enhance employability, and create a future-ready workforce through industry-relevant skill development.

SUMMARY

This book contains the information of Electrical design that broadly outlines the minimum requirements for the design, selection, sizing and installation of the electrical equipments and associated systems of the installation.
The electrical design refers to conceptualizing, planning, and detailing systems where electric current flows to perform a specific function. It's about ensuring these systems work efficiently, safely, and by established regulations.

Note: This e-book has been compiled from various resources of Internet and by the personal knowledge of the team involved. It covers the basic topics as required by the Industries.

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Ananda Chaitanya Training Academy is a skill development initiative of Ananda Chaitanya Foundation's "Vaiya Thalaimai Kol" Project.