SRI RANGANATHAR INSTITUTE OF POLYTECHNIC COLLEGE - COIMBATORE

MECHANICAL DEPARTRMENT

4020430 – ELECTRICAL DRIVES & CONTROL

NODS OF LESSON

UNIT – 1

DC CIRCUITS AND DC MACHINES

DEFINITION- ELECTRIC CURRENT

An electric current is a stream of charged particles, such as electrons or ions, moving through an electrical conductor or space. It is measured as the net rate of flow of electric charge through a surface or into a control volume.

DEFINITION- VOLTAGE

Voltage is the difference in charge between two points. Current is the rate at which charge is flowing. Resistance is a material's tendency to resist the flow of charge (current).

DEFINITION-Resistance

Resistance is known that the directed movement of electrons constitutes a current flow & NResistance is defined as an opposition to current flow.

OHM'S LAW

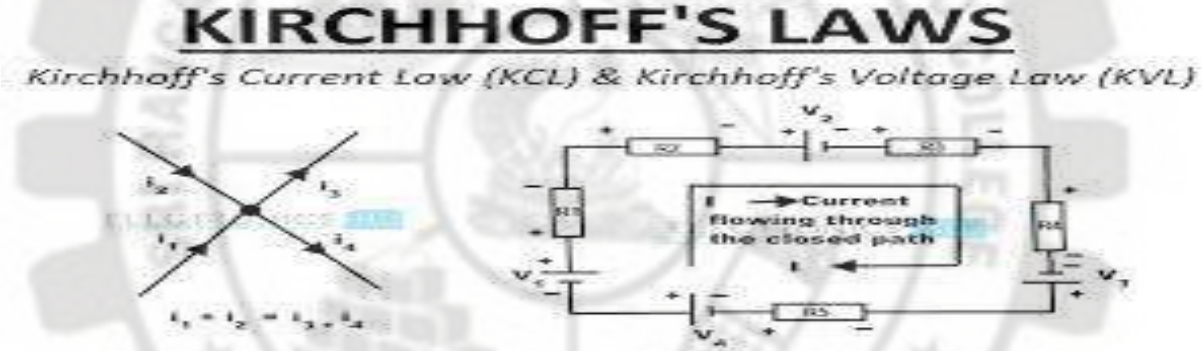
Ohm's law states that the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperatures remain constant.

$$V = I \times R$$

In the equation, the constant of proportionality, R, is called Resistance and has units of ohms, with the symbol Ω.

KIRCH OFF'S LAW

Kirchhoff's circuit laws lie at the heart of circuit analysis. With the help of these laws and the equation for individual components (resistor, capacitor and inductor), we have the basic tool to start analyzing circuits. In this article, we will discuss Kirchhoff's current and voltage law and how to employ them in circuit analysis.



- **Kirchhoff's First Law or Kirchhoff's Current Law**

  According to Kirchhoff's Current Law,

  The total current entering a junction or a node is equal to the charge leaving the node as no charge is lost.

- **Kirchhoff's Second Law or Kirchhoff's Voltage Law**

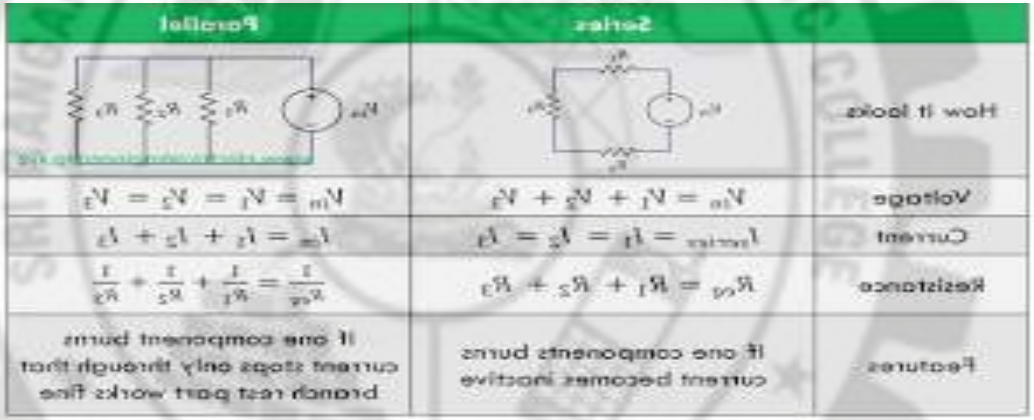
  According to Kirchhoff's Voltage Law,

  The voltage around a loop equals the sum of every voltage drop in the same loop for any closed network and equals zero.

RESISTANCE IN SERIES, PARALLEL AND SERIES PARALLEL

RESISTANCE IN SERIES

In a series circuit, **the total resistance across all of the components (the 'net resistance') increases as more components are added**. The two resistors have the same current through them. The potential difference across them will be different if they have different resistances.



RESISTANCE IN SERIES, PARALLEL

Parallel Resistor Equation

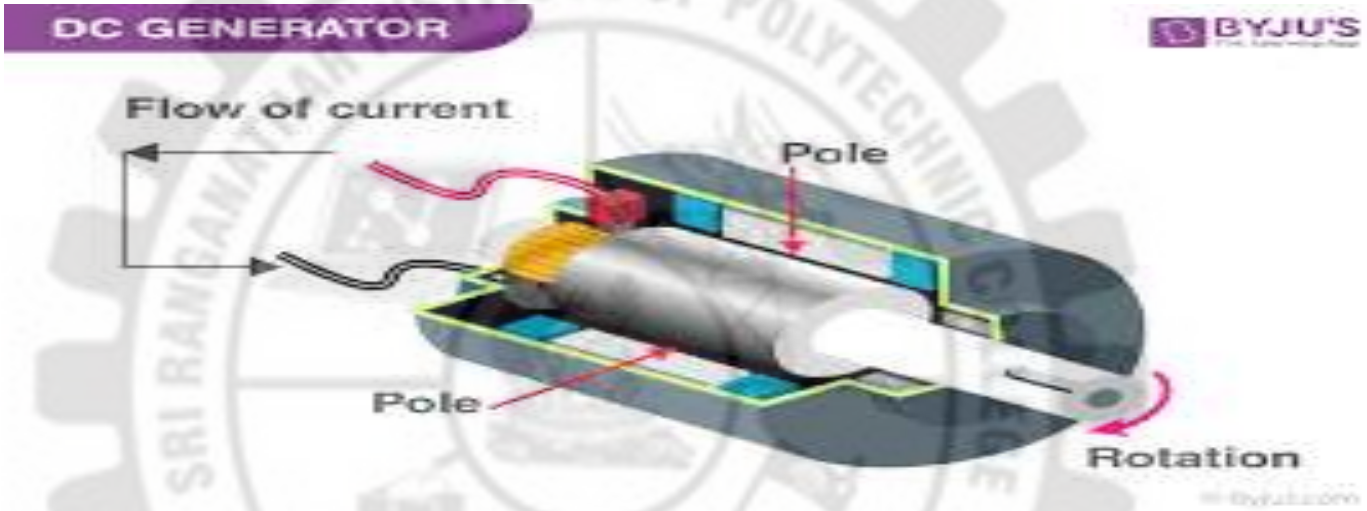
If the two resistances or impedances in parallel are equal and of the same value, then the total or equivalent resistance, R_T is equal to half the value of one resistor. That is equal to R/2 and for three equal resistors in parallel, R/3, etc.

RESISTANCE IN SERIES PARALLEL

In a series circuit, the output current of the first resistor flows into the input of the second resistor; therefore, the current is the same in each resistor. In a parallel circuit, all of the resistor leads on one side of the resistors are connected together and all the leads on the other side are connected together.

DC Generators

- **Construction** Principle of operation



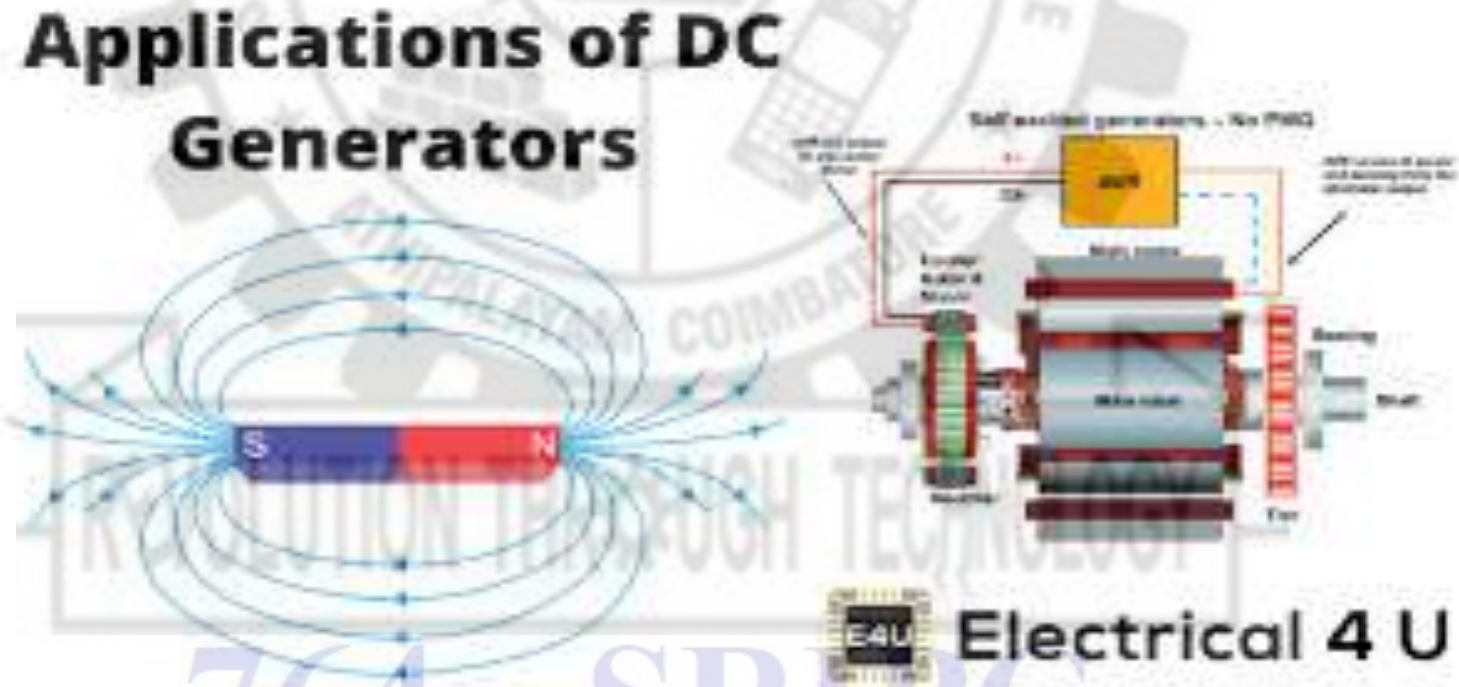
A direct-current (DC) generator is **a rotating machine that supplies an electrical output with unidirectional voltage and current**. The basic principles of operation are the same as those for synchronous generators.

- Stator
- The main function of the stator is to provide magnetic fields where the coil spins. A stator includes two magnets with opposite polarities facing each other. These magnets are located to fit in the region of the rotor.
- Rotor
- A rotor in a DC machine includes slotted iron laminations with slots that are stacked to shape a cylindrical armature core. The function of the lamination is to decrease the loss caused due to eddy current.
-

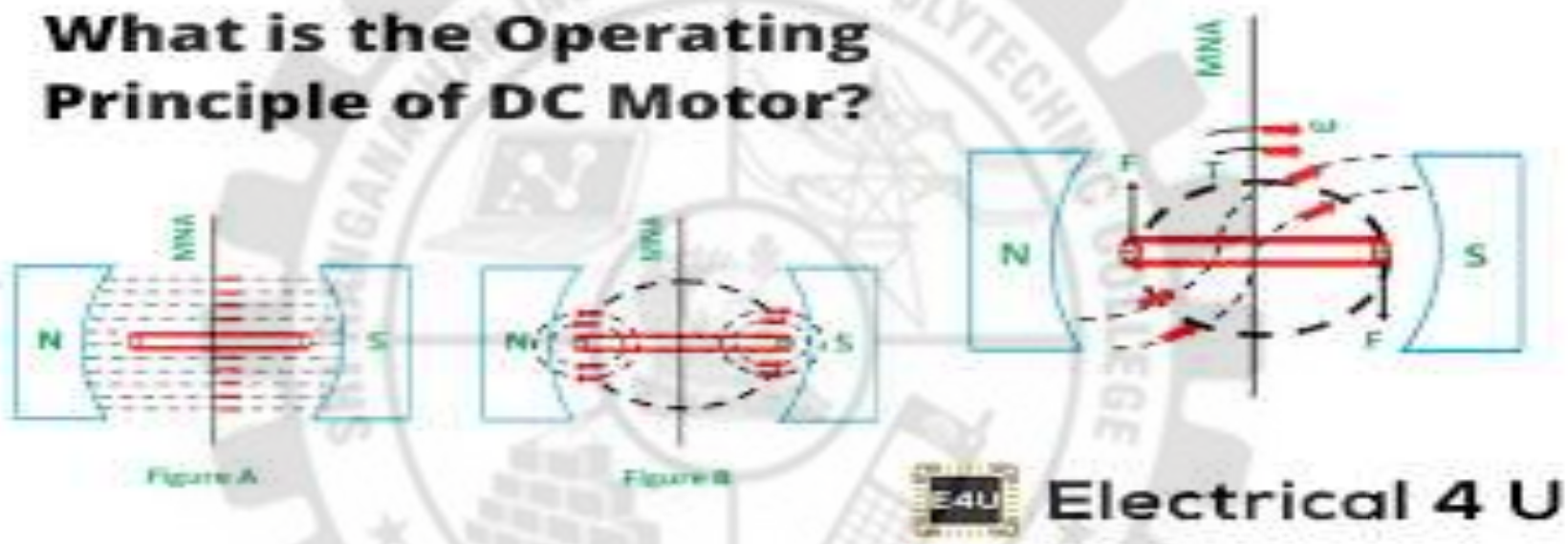
- **Armature Windings**
- Armature windings are in a closed circuit form and are connected in series to parallel to enhance the produced current sum.
- **Yoke**
- The external structure of the DC generator is known as Yoke. It is made of either cast iron or steel. It provides the necessary mechanical power for carrying the magnetic flux given through the poles.
- **Poles**
- The function of a pole is to hold the field windings. These windings are wound on poles and are either connected in series or parallel by the armature windings.
- **Pole Shoe**
- Pole shoe is mainly utilized for spreading the magnetic flux to prevent the field coil from falling.
- **Commutator**
- A commutator works like a rectifier that changes AC voltage to DC voltage within the armature winding. It is designed with a copper segment, and each copper segment is protected from the other with the help of mica sheets. It is located on the shaft of the machine.
- **Brushes**
- The electrical connections can be ensured between the commutator as well as the exterior load circuit with the help of brushes.

APPLICATIONS.

- **Applications of DC Generators**
- These generators are used to charge batteries, provide lighting and provide excitation to alternators.
- They are used to provide field excitation current for regenerative braking in DC locomotives.
- They are used in DC motors where speed control is necessary.



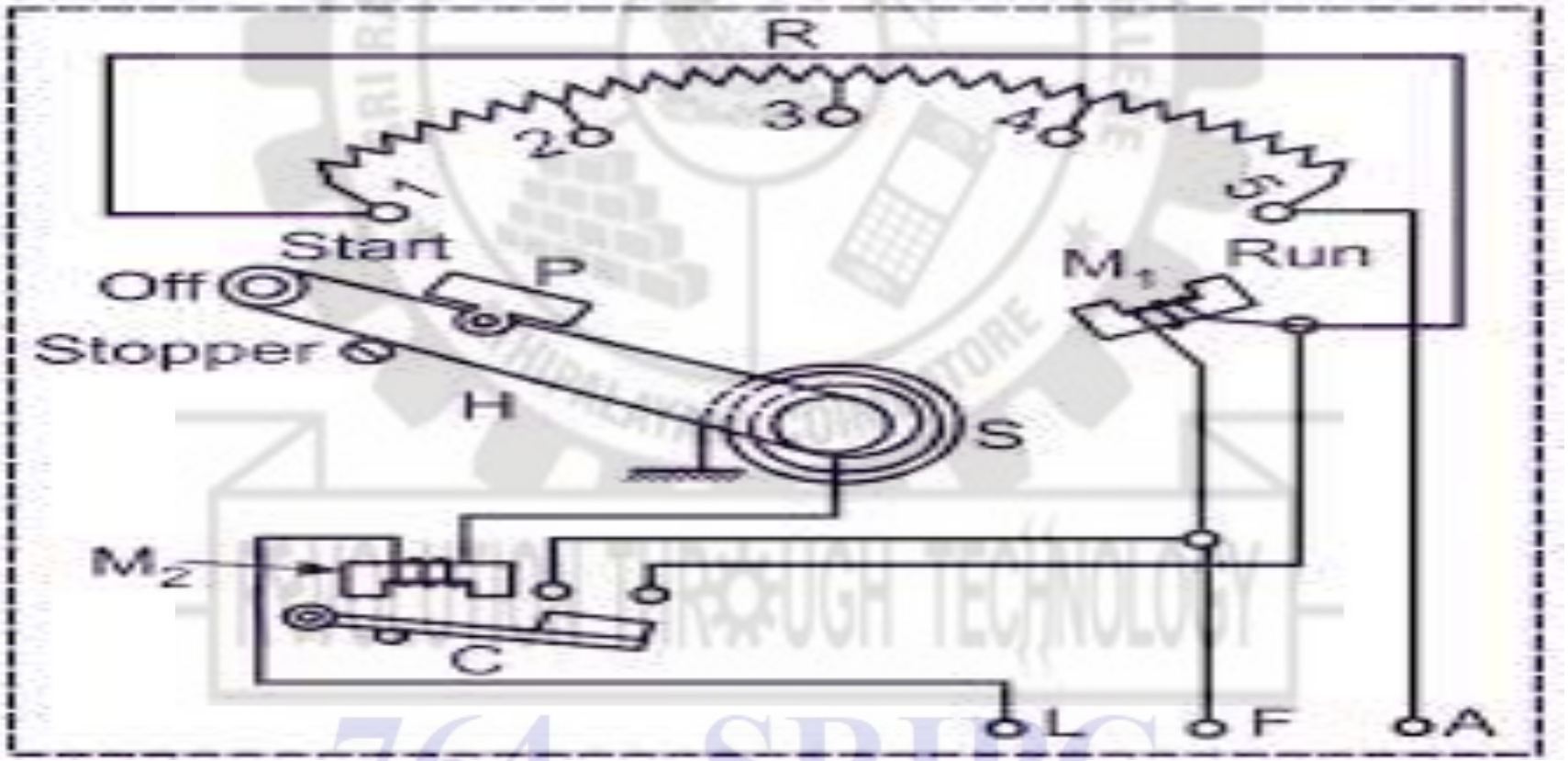
DC MOTORS CONSTRUCTION &PRINCIPLE OF OPERATION



The DC motor is the motor which **converts the direct current into the mechanical work**. It works on the principle of Lorentz Law, which states that "the current carrying conductor placed in a magnetic and electric field experience a force". And that force is the Lorentz force

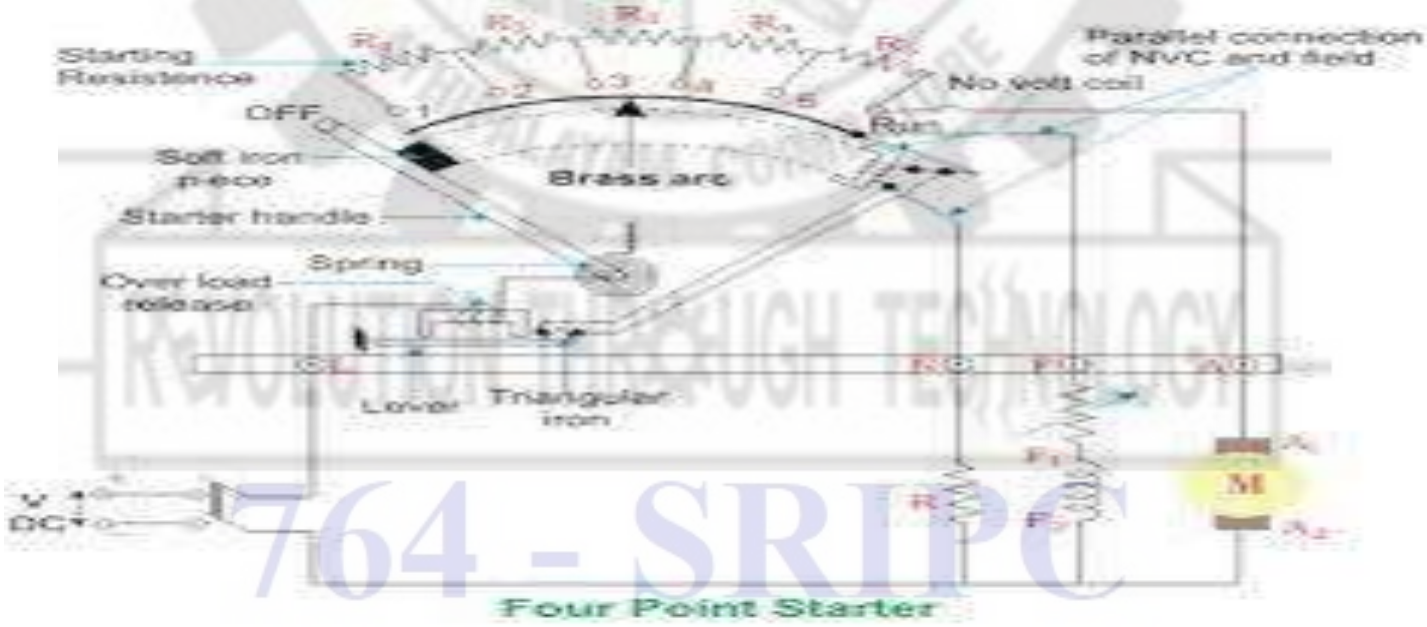
THREE POINT STARTERS

It is called three-point starter because **it has three terminals viz. L, Z and A**. It consists of a graded starting resistance to limit the starting current and is connected in series with the armature of the motor. The tapping points of the starting resistance are taken out to a number of studs.



FOUR POINT STARTERS

- **Working Principle of 4 Point Starter**
- A **4 point starter** protects the armature of a DC shunt motor or compound wound DC motor against the initially high starting current of the DC motor.
- The 4 point starter has a lot of constructional and functional similarity to a 3 point starter, but this special device has an additional point and coil in its construction (as the name suggests). This brings about some difference in its functionality, though the basic operational characteristic remains the same. The basic difference in the circuit of a **4 point starter** as compared to 3 point starter is that the holding coil is removed from the shunt field current and is connected directly across the line with current limiting resistance in series.



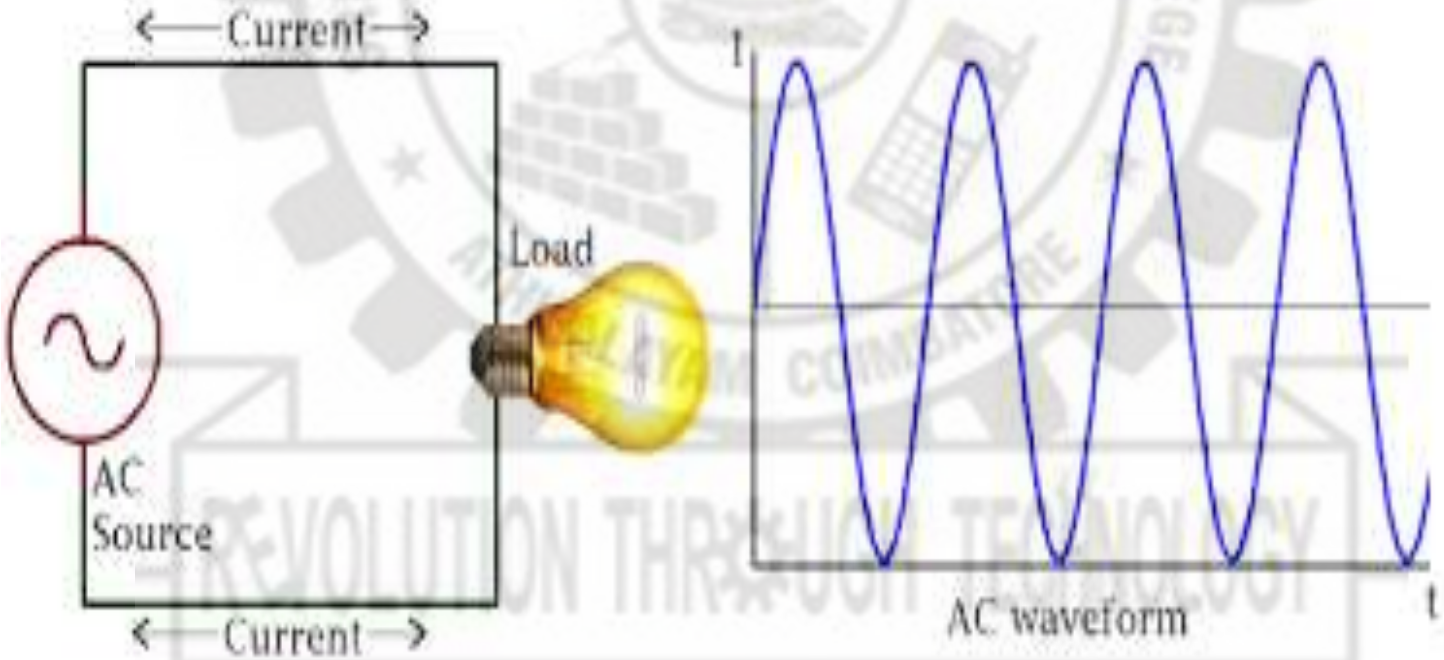
Four Point Starter

UNIT – 2

AC CIRCUITS AND AC MACHINES

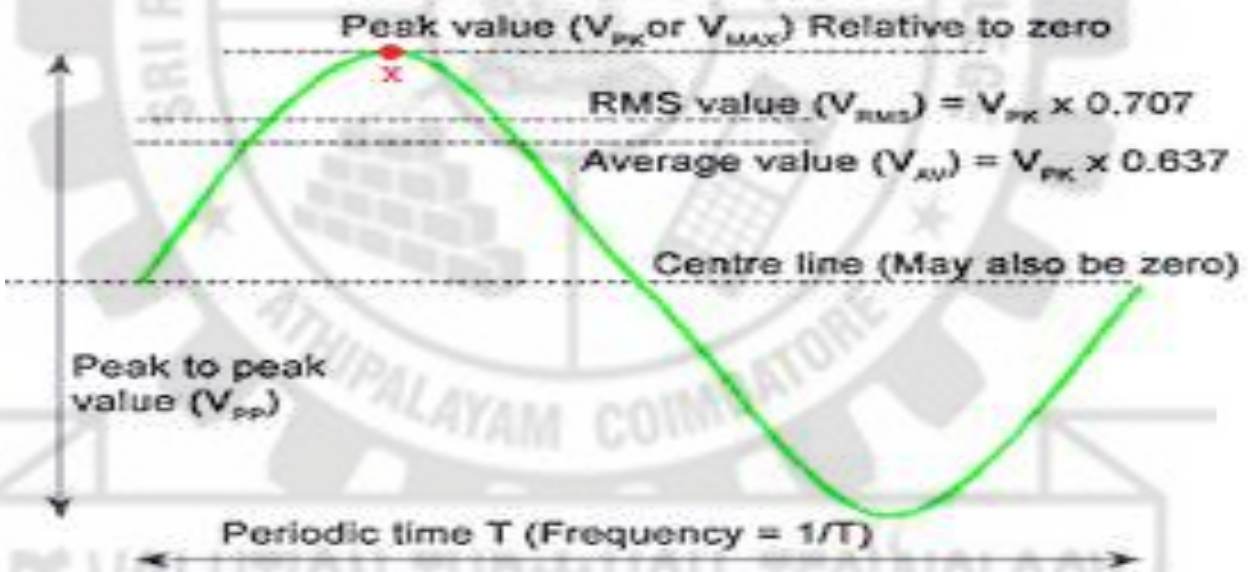
- Fundamentals of AC voltage, and current

The current will have the same frequency as the applied voltage, thus the term alternating current. Since AC voltages are generated by round rotors revolving inside circular stators, the resulting waveform is a sine wave. The height, or amplitude, of a sine wave is called the peak value



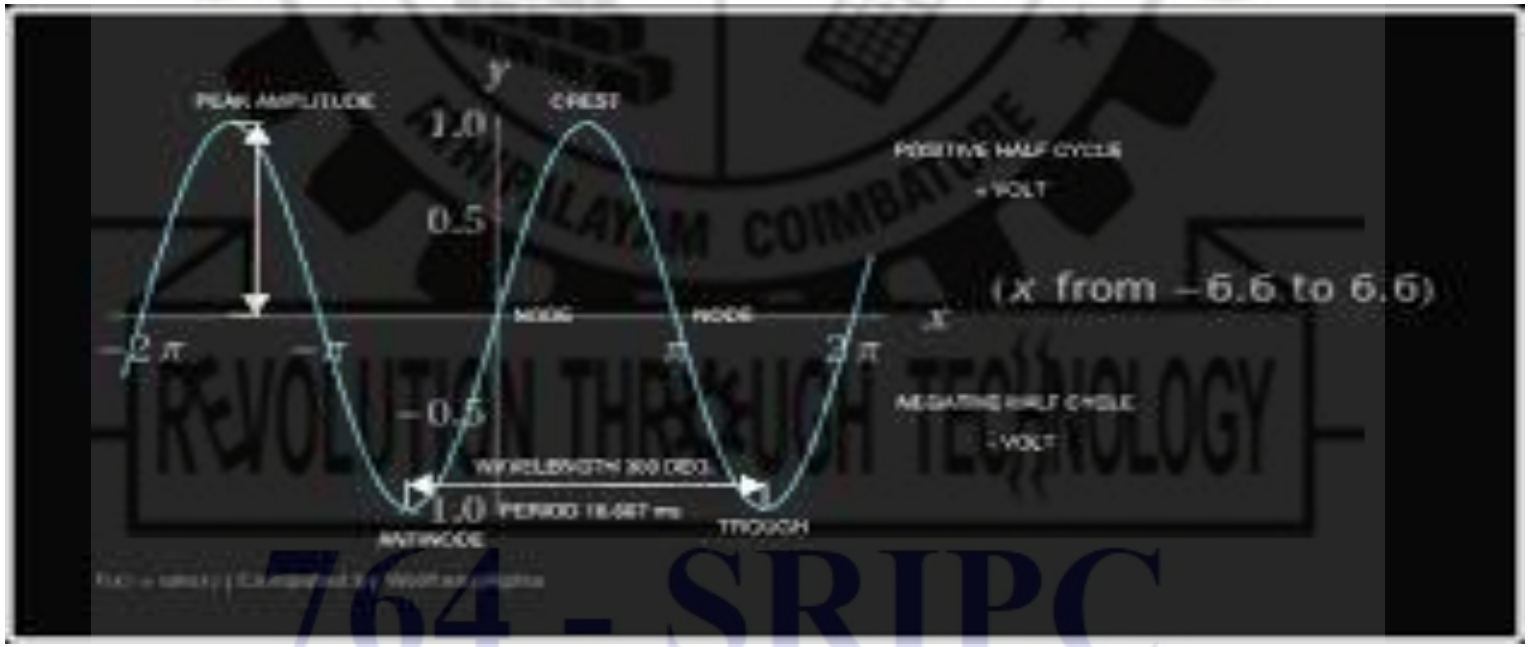
PEAK, AVERAGE, RMS VALUE OF SINE WAVE

- It can be shown that the RMS value of a sine wave is **0.707 of the peak value**. Also, the peak value of a sine wave is equal to 1.414 x the RMS value.
-



FREQUENCY, TIME PERIOD, AMPLITUDE, POWER AND POWER FACTOR

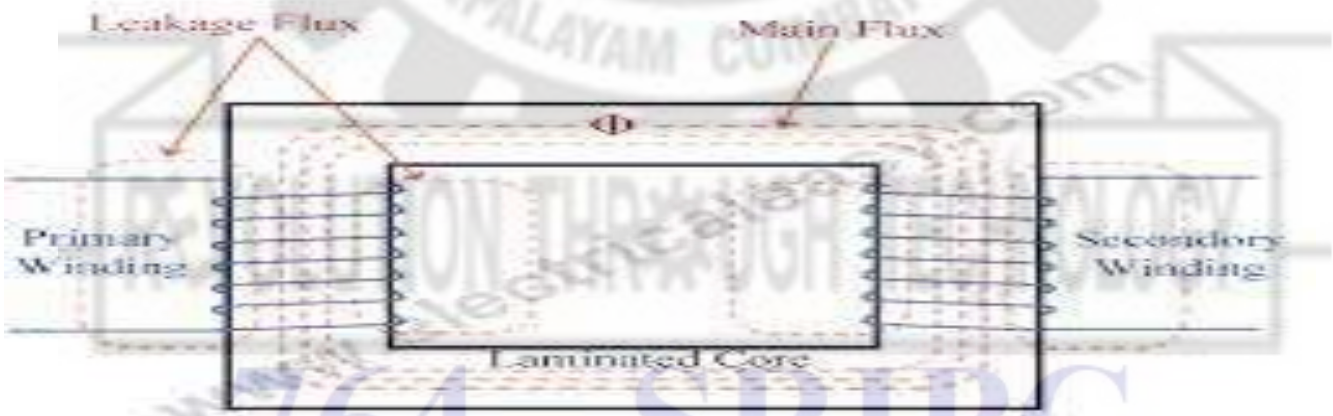
- In the chapter on motion in two dimensions, we defined the following variables to describe harmonic motion:
- Amplitude—maximum displacement from the equilibrium position of an object oscillating around such equilibrium position
- Frequency—number of events per unit of time
- Period—time it takes to complete one oscillation



TRANSFORMER: PRINCIPLE OF OPERATION AND CONSTRUCTION

The transformer works on the principle of **Faraday's law of electromagnetic induction and mutual induction**. There are usually two coils primary coil and secondary coil on the transformer core. The core laminations are joined in the form of strips. The two coils have high mutual inductance

- When an alternating current pass through the primary coil it creates a varying magnetic flux. As per faraday's law of electromagnetic induction, this change in magnetic flux induces an emf (electromotive force) in the secondary coil which is linked to the core having a primary coil. This is mutual induction.
- Overall, a transformer carries the below operations:
- Transfer of electrical energy from circuit to another
- Transfer of electrical power through electromagnetic induction
- Electric power transfer without any change in frequency
- Two circuits are linked with mutual induction



EMF EQUATION

- The emf is equal to the work done on the charge per unit charge (**ϵ=dWdq**) when there is no current flowing. Since the unit for work is the joule and the unit for charge is the coulomb, the unit for emf is the volt (1V=1J/C)
- $\mathbf{N_1}$ = Number of turns in primary windings.
- $\mathbf{N_2}$ = Number of turns in second windings.
- $\mathbf{\Phi_m}$ = Maximum flux in the core in Weber = ($\mathbf{\Phi_m} = B_m.A$)
- *f* = Frequency of A.C input in H_z.
- As shown in fig above- flux increases from its zero value to maximum value $\mathbf{\Phi_m}$ in one quarter of the cycle i.e. in **¼ second**.
- Average rate of change of flux = [$\mathbf{\Phi_m}$ / (**¼ f.**)]
- **= 4*f* $\mathbf{\Phi_m}$ Wb/s or volt**
- **Form Factor** = ***RMS value*** / ***Average value*** **= 1.11**
- RMS value of EMF / turn = **1.11. 4*f* $\mathbf{\Phi_m}$= 4.44f $\mathbf{\Phi_m}$** volt
  - **E_1 = 4.44 x*f* N_1 B_m A …** [*as* ($\Phi_m = B_mA$)]
- Similarly, RMS value of the EMF induced in secondary is,
  - **E_2 = 4.44 x *f* N_2 Φ_m** ……. *(ii)*
  - **E_2 = 4.44 x *f* N_2 B_m A.** … [*as* ($\Phi_m = B_mA$)]
- It's seen from *(i)* and *(ii)* that: **EMF Equation of the Transformer =**
  - **$E_1 / N_1 = E_2 / N_2$ = 4.44 x *f* Φ_m.** …… *(iii)*
- It means that **EMF / turn is the same in both the primary and secondary windings in the transformer** i.e. flux in Primary and Secondary Winding of the Transformer is same.

LOSSES IN TRANSFORMER

- **1. Core Losses Or Iron Losses**
- Eddy current loss and hysteresis loss depend on the magnetic properties of the material used for the construction of the core. So, these losses are also known as core losses or iron losses. **Hysteresis loss in transformer:** The reason is the reversal of magnetization in the transformer core. This loss depends on the volume and grade of the iron, frequency of magnetic reversals and value of flux density. We have the Steinmetz formula:
- Wh= ηBmax1.6fV (watts)
- Where, η = Steinmetz hysteresis constant
- V = volume of the core in m3
- **Eddy current loss in transformer:** The AC current is supplied to the primary winding which sets up alternating magnetizing flux in the transformer. When this flux flow to a secondary winding, it produces induced emf in it. But some part of this flux also gets linked with other conducting parts such as steel core or iron body or the transformer, which will result in induced emf in those parts, causing small circulating current in them. This current is called as eddy current. Due to the current, some energy will be dissipated in the form of heat
- **2. Copper Loss**
- The ohmic resistance of the transformer windings creates copper loss. The copper loss for the primary winding is I12R1 and for the secondary winding is I22R2. Where, I1 and I2 are current in primary and secondary winding respectively, R1 and R2 are the resistances of primary and secondary winding respectively. We can see that Cu loss is proportional to square of the current, and current depends on the load. So that copper loss in transformer varies with the load
- **3. Stray Loss**
- The reason for the types of loss is the occurrence of the leakage field. When compared with copper and iron losses, the percentage of stray losses are less, so these losses can be neglected.

ALTERNATOR CONSTRUCTION – PRINCIPLE OF OPERATION AND APPLICATIONS

The construction of an alternator consists of field poles placed on the rotating fixture of the machine. An alternator is made up of two main parts: a rotor and a stator. The rotor rotates in the stator, and the field poles get projected onto the rotor body of the alternator.

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^o to 0^o and consequently the induced current in the turn is reduced to zero from its maximum value.

PRINCIPLE OF OPERATION AND APPLICATIONS

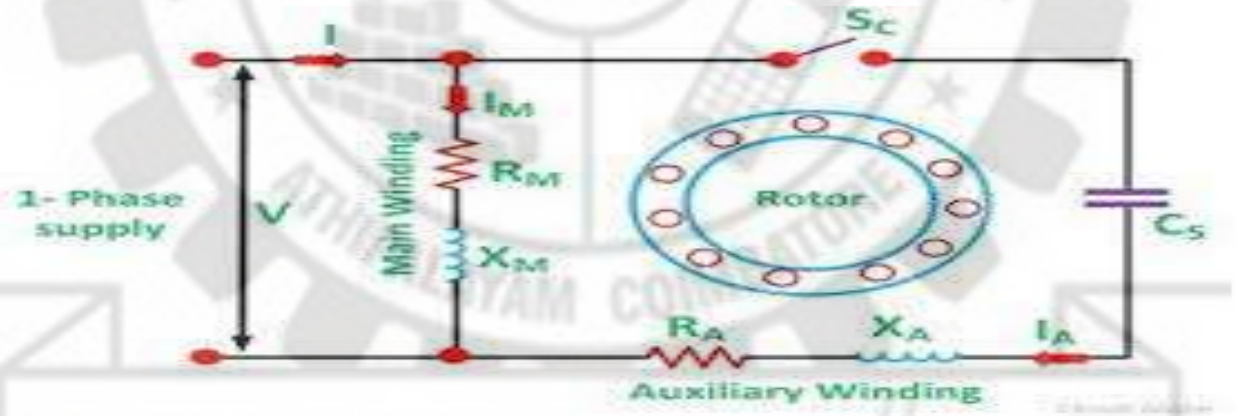
- Other than the types of alternator, you can generally find that there are three parts which are commonly known about the alternator: the stator, the rotor the diode and a voltage regulator.
- **1. Voltage Regulator**
- In order to control the charging process, the voltage regulator are found controlling the power supply from the alternator to the battery. Regulators are referred to as those which are found being designed for the purpose of work which depends on their specifications along with various different functions.
- **2. Rotor and Stator**
- A rotor and an alternator stator is referred to as that mechanical device which are known to be the group of magnets that are found being driven by the help of a belt which is responsible for creating a magnetic field inside the copper wiring.

AC MACHINE: AC MOTORS- PRINCIPLE OF OPERATION OF SINGLE PHASE

Single phase motors work on the same principle as 3 phase motors except they are only run off one phase. A single phase sets up an oscillating magnetic field that goes back and forth rather than a rotating magnetic field (see bottom figure). Because of this a true single phase motor has zero starting torque**.**

CAPACITOR START INDUCTION MOTOR

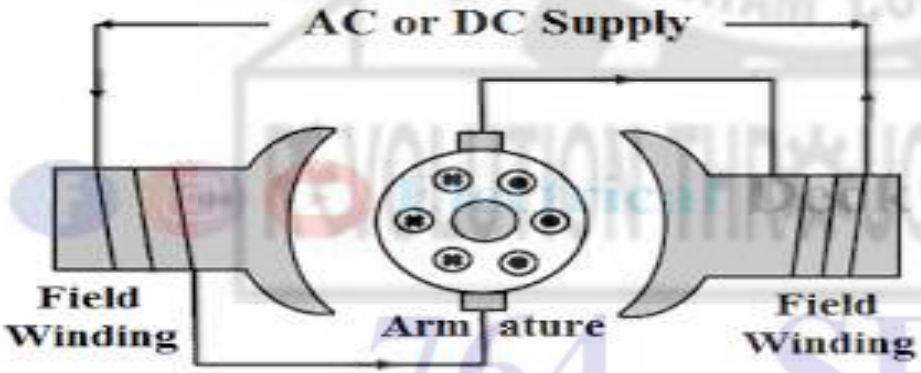
A Capacitor Start Motors is **a single phase Induction Motor that employs a capacitor in the auxiliary winding circuit to produce a greater phase difference between the current in the main and the auxiliary windings**. The name suggests that the motor uses a capacitor to start.

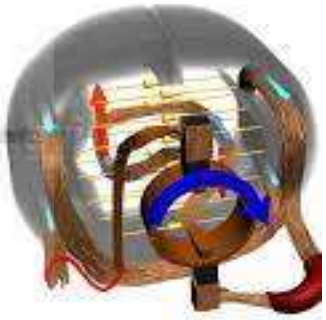


UNIVERSAL MOTOR

The **universal motor** is a type of electric motor that can operate on either AC or DC power and uses an electromagnet as its stator to create its magnetic field

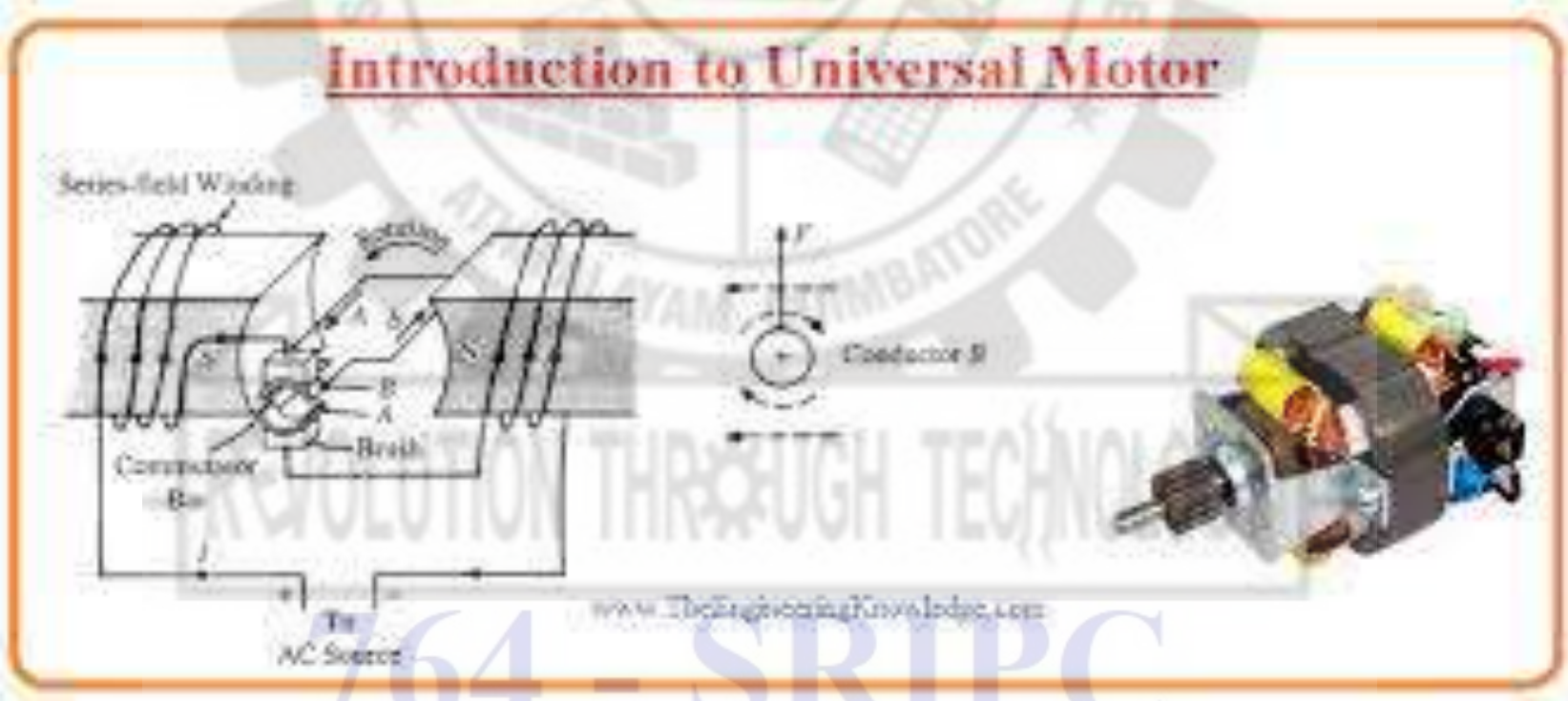
- Operation of Universal Motor
- When fed with a DC supply
- When the universal motor is fed with a DC supply, it works as a DC series motor. In this case, when the current flows in the field winding, it produces an electromagnetic field. The same current also flows in the armature conductors. When a current-carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. This mechanical force causes the rotor to rotate. Fleming's Left-hand rule gives us the direction of this force.





APPLICATIONS

- **Applications of Universal Motor**
- Universal Motors are used in table fans, hairdryers and grinders.
- They are used in portable drill machines.
- They are used in polishers, blowers and kitchen appliances.

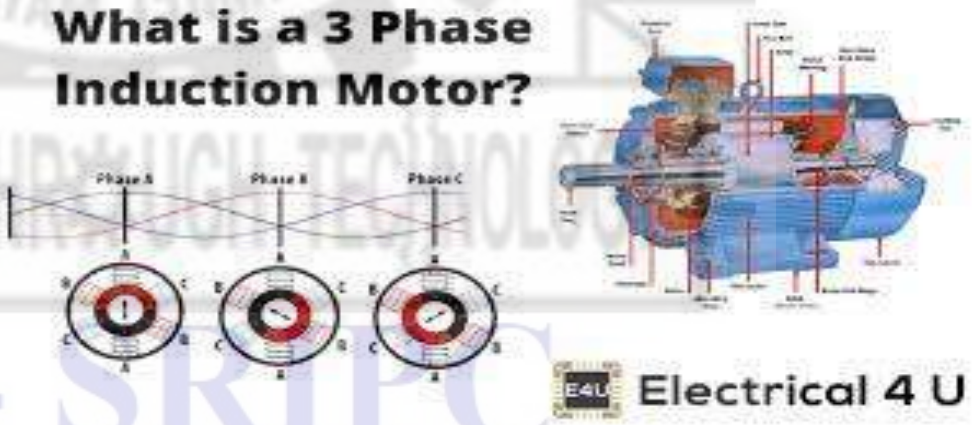


THREE PHASE INDUCTION MOTORS

A 3-phase induction motor is **an electromechanical energy conversion device which converts 3-phase input electrical power into output mechanical power**. A 3-phase induction motor consists of a stator and a rotor.

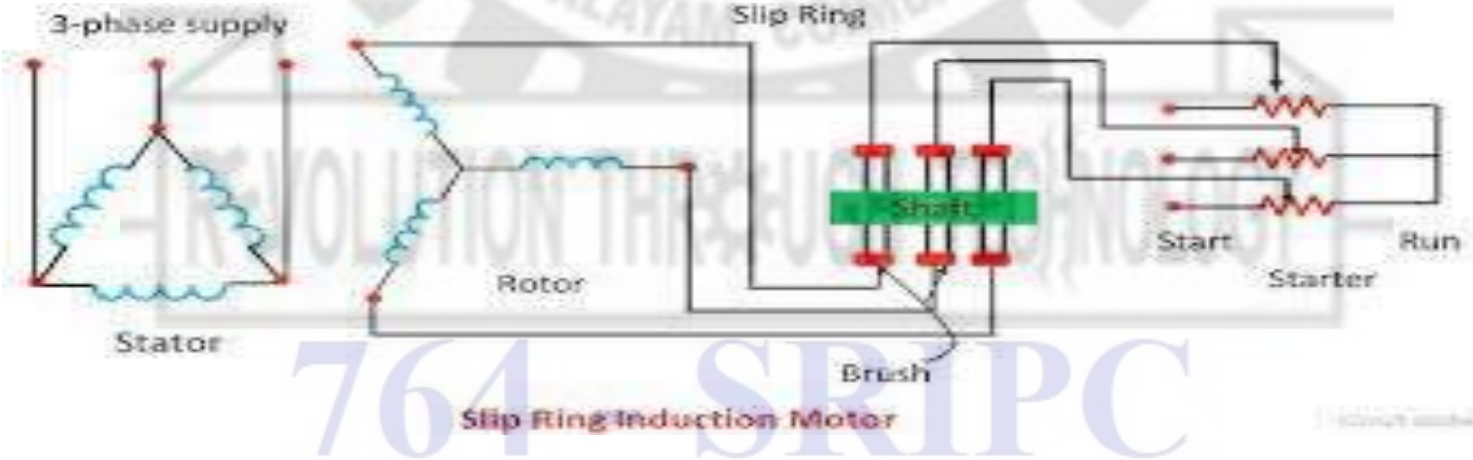
The **stator** of three phase induction motor is made up of numbers of slots to construct a 3 phase winding circuit which we connect with 3 phase AC source. We arrange the three-phase winding in such a manner in the slots that they produce one rotating magnetic field when we switch on the three-phase AC supply source.

- **Rotor of 3 Phase Induction Motor**
- The **rotor** of three phase induction motor consists of a cylindrical laminated core with parallel slots that can carry conductors. The conductors are heavy copper or aluminum bars fitted in each slot and short-circuited by the end rings. The slots are not exactly made parallel to the axis of the shaft but are slotted a little skewed because this arrangement reduces magnetic humming noise and can avoid stalling of the motor.
- Self-starting.
- Less armature reaction and brush sparking because of the absence of commutators and brushes that may cause sparks.
- Robust in construction.
- Economical.
- Easier to maintain.



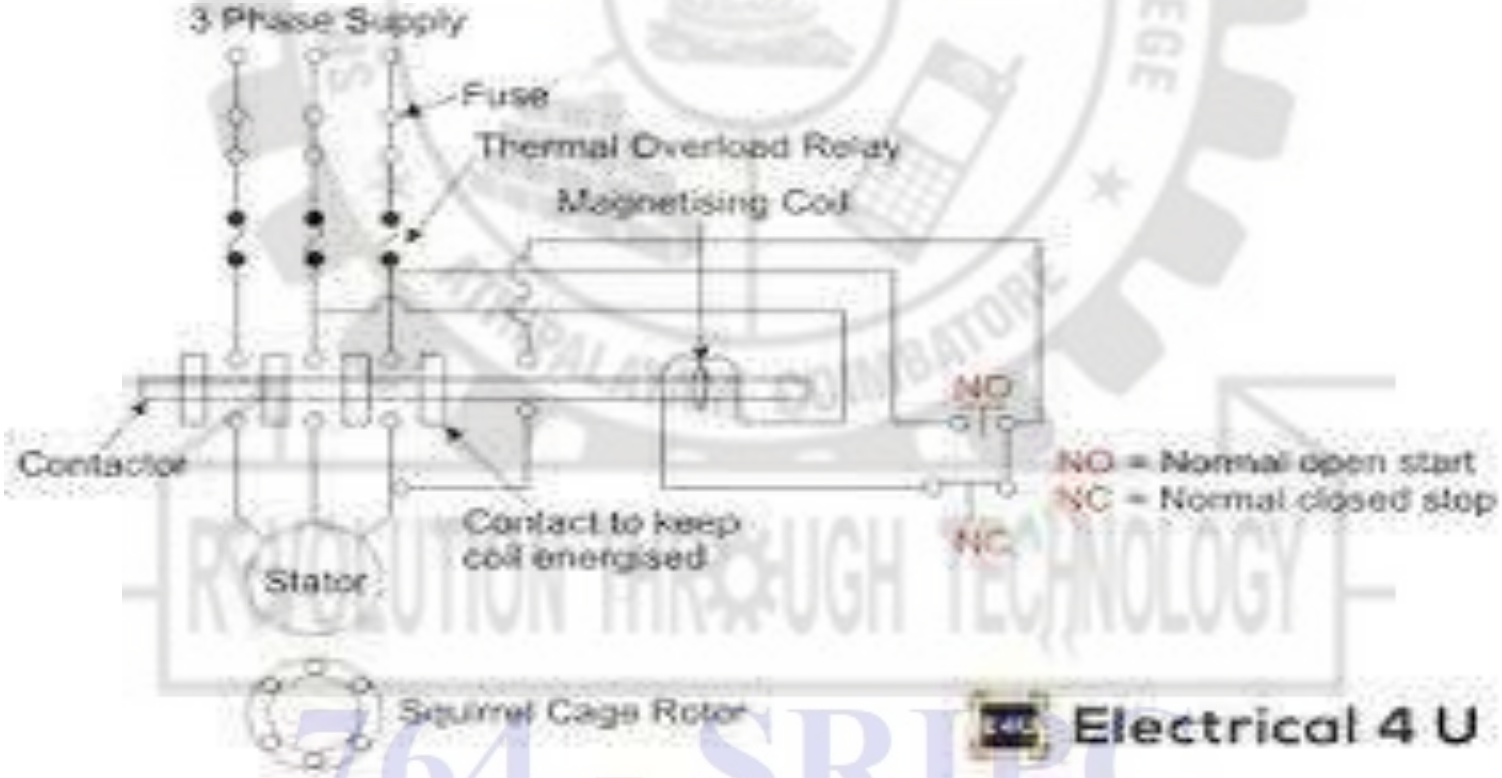
SQUIRREL CAGE AND SLIP RING INDUCTION MOTORS

- Summary of Differences between Squirrel Cage & Slip Ring Induction Motors
- Parameter of ComparisonSquirrel-Cage Induction MotorSlip-Ring Induction MotorStarting TorqueLowHighBrushesNot usedUsedMaintenanceLess maintenance is required.Frequent maintenance is required.Copper LossLowHigh
- Squirrel cage induction motors are widely used in industrial applications because they are very cheap, robust, efficient and reliable.
- On the other hand, slip-ring or wound-rotor induction motors are rarely used in industries since these motors have several disadvantages such as high copper loss and frequent maintenance.



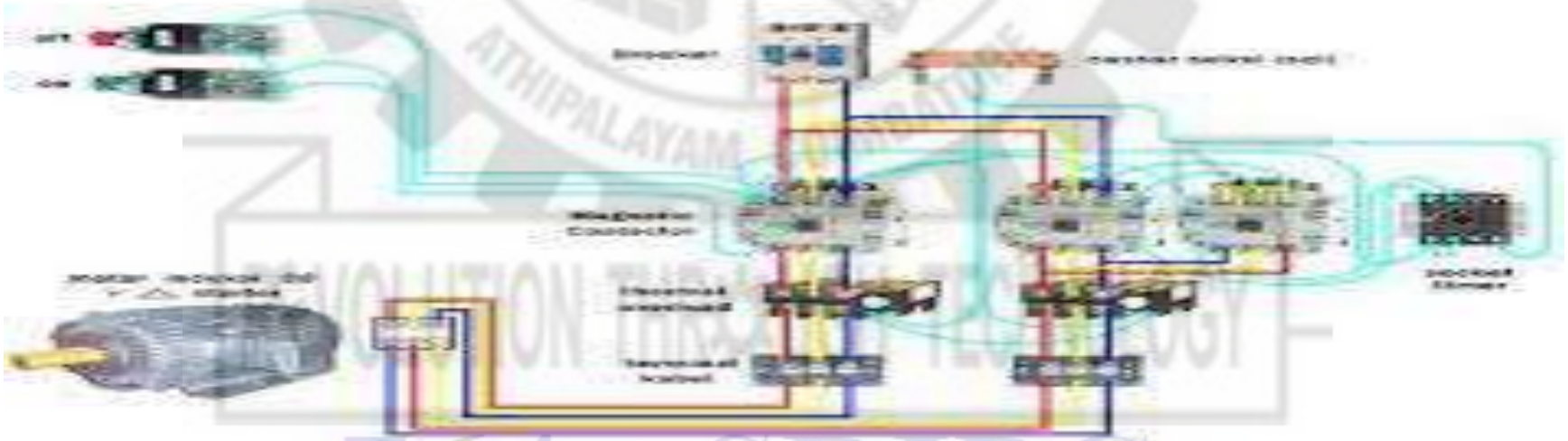
SPEED CONTROL OF 3Φ INDUCTION MOTOR DOL STARTER

A DOL starter (also known as a direct on line starter or across the line starter) is a method of starting a 3 phase induction motor. In a DOL Starter, an induction motor is connected directly across its 3-phase supply, and the DOL starter applies the full line voltage to the motor terminals.



SPEED CONTROL OF 3Φ INDUCTION MOTOR STAR TO DELTA STARTER.

A **star delta starter** is the most commonly used method for the starting of a 3 phase induction motor. In star delta starting an induction motor is connected in through a star connection throughout the starting period. Then once the motor reaches the required speed, the motor is connected in through a delta connection.



UNIT – 3 SPECIAL MACHINES & DRIVES

PMDC MOTOR CONSTRUCTION AND WORKING PRINCIPLE AND APPLICATIONS

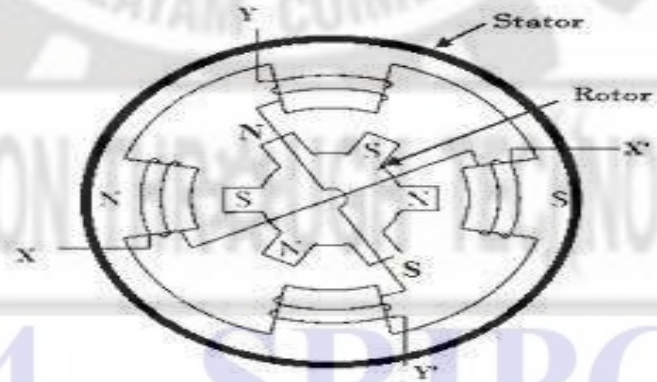
In a DC motor, an armature rotates inside a magnetic field. The basic working principle of a DC motor is based on the fact that **whenever a current carrying conductor is placed inside a magnetic field, there will be mechanical force experienced by that conductor**. All kinds of DC motors work under this principle.

- As it is indicated in name of permanent magnet DC motor, the field poles of this motor are essentially made of permanent magnet.
- A **PMDC motor** mainly consists of two parts. A stator and an armature. Here the stator which is a steel cylinder. The magnets are mounted in the inner periphery of this cylinder.

STEPPER MOTOR CONSTRUCTION AND WORKING PRINCIPLE AND APPLICATIONS

The stepper motor **uses the theory of operation for magnets to make the motor shaft turn a precise distance when a pulse of electricity is provided**. The stator has eight poles, and the rotor has six poles.

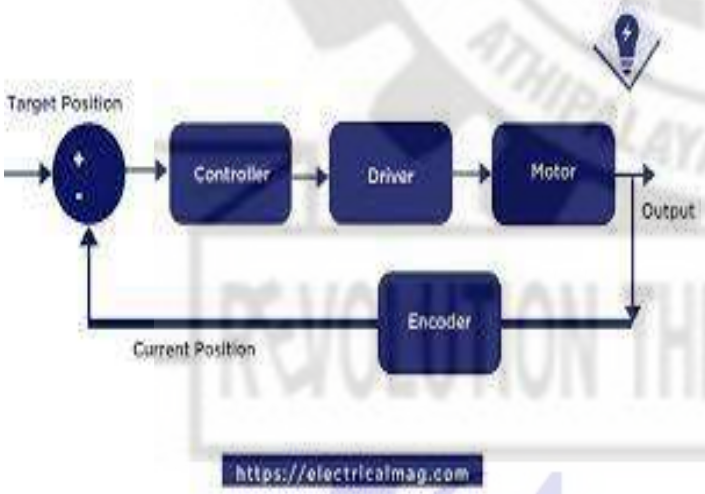
- Stepper Motor Basics
- A stepper motor is an electric motor whose main feature is that its shaft rotates by performing steps, that is, by moving by a fixed amount of degrees. This feature is obtained thanks to the internal structure of the motor, and allows to know the exact angular position of the shaft by simply counting how may steps have been performed, with no need for a sensor. This feature also makes it fit for a wide range of applications.
- Stepper Motor Working Principles
- As all with electric motors, stepper motors have a stationary part (the stator) and a moving part (the rotor). On the stator, there are teeth on which coils are wired, while the rotor is either a permanent magnet or a variable reluctance iron core. We will dive deeper into the different rotor structures later. **Figure 1** shows a drawing representing the section of the motor is shown, where the rotor is a variable-reluctance iron core.

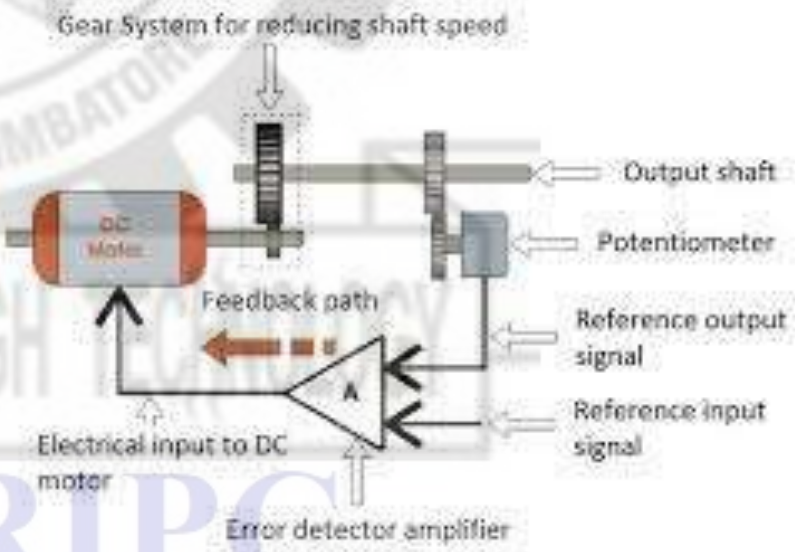


SERVO MOTOR CONSTRUCTION AND WORKING PRINCIPLE AND APPLICATIONS

Servo is an electromagnetic device uses a negative feedback mechanism to converts an electric signal into controlled motion. Basically, servos behave like as actuators which provide precise control over velocity, acceleration, and linear or angular position. It consists of four things: DC motor, position sensor, gear train, and a control circuit. The gear mechanism connected with the motor provides the feedback to the position sensor.

- **Positional Rotation Servos**: Positional servos can rotate the shaft in about half of the circle. Also, it has the feature to protect the rotational sensor from over-rotating. Positional servos are mainly used in limbs, robotic arms, and in many other places.
- **Continuous Rotation Servos**: Continous servos are similar in construction to the positional servo. But, it can move in both clockwise and anticlockwise directions. These types of servos are used in radar systems and robots.
- **Linear Servos**: Again linear servos are also like a positional servo, but with additional gears to the adjust the output from circular to back-and-forth. These type of servos are used in high model airplanes and are rare to find on the stores.

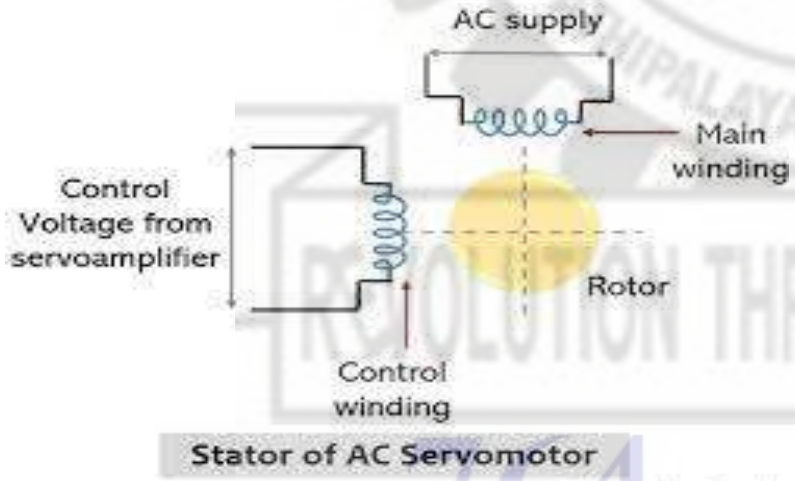




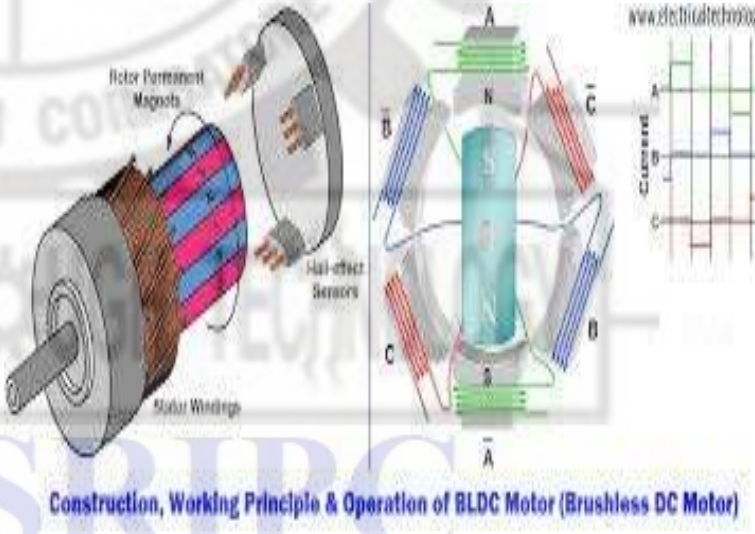
PERMANENT MAGNET SERVO MOTOR CONSTRUCTION AND APPLICATIONS

To choose a motor is the hardest task, based on design criteria such as cost, torque, acceleration, positional accuracy, power and much more. There are many types of motors like **DC, Servo, and Stepper** available for different types of application. But, Servo motors come with **fast functioning, high torque**, and **accurate rotation**. Yes, Stepper Motors are a high-performance alternative of the servo. But to setup a Stepper is more complicated than a **Servo Motor.**

- **Positional Rotation Servos**: Positional servos can rotate the shaft in about half of the circle. Also, it has the feature to protect the rotational sensor from over-rotating. Positional servos are mainly used in limbs, robotic arms, and in many other places.
- **Continuous Rotation Servos**: Continous servos are similar in construction to the positional servo. But, it can move in both clockwise and anticlockwise directions. These types of servos are used in radar systems and robots.
- **Linear Servos**: Again linear servos are also like a positional servo, but with additional gears to the adjust the output from circular to back-and-forth. These type of servos are used in high model airplanes and are rare to find on the stores.



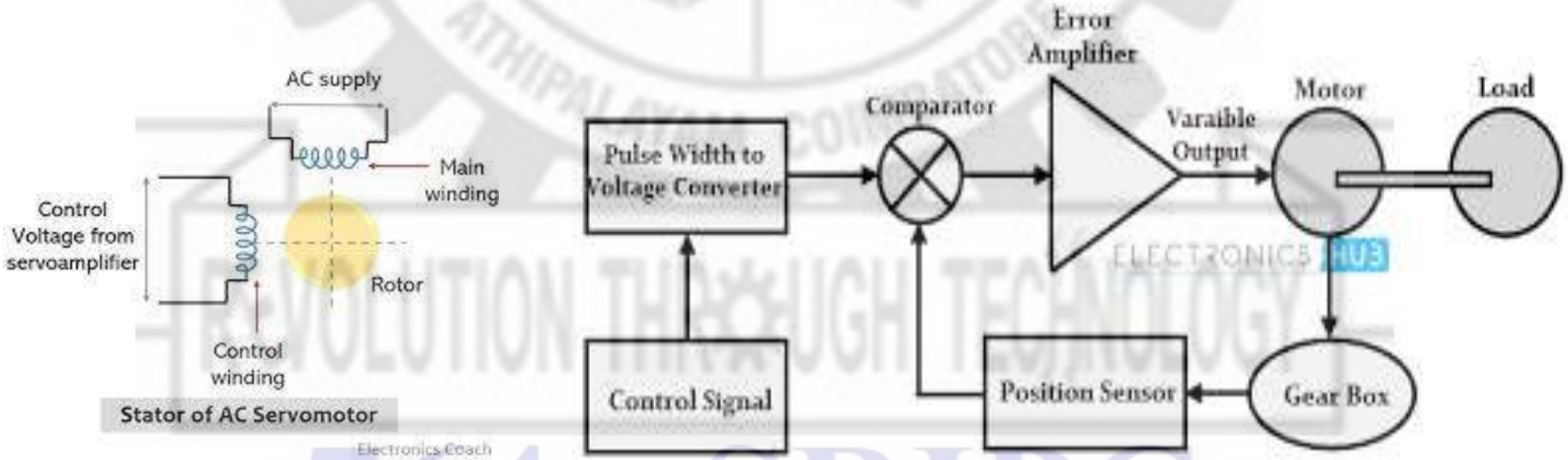
Stator of AC Servomotor



Construction, Working Principle & Operation of BLDC Motor (Brushless DC Motor)

BRUSHLESS SERVO MOTOR - CONSTRUCTION AND APPLICATIONS.

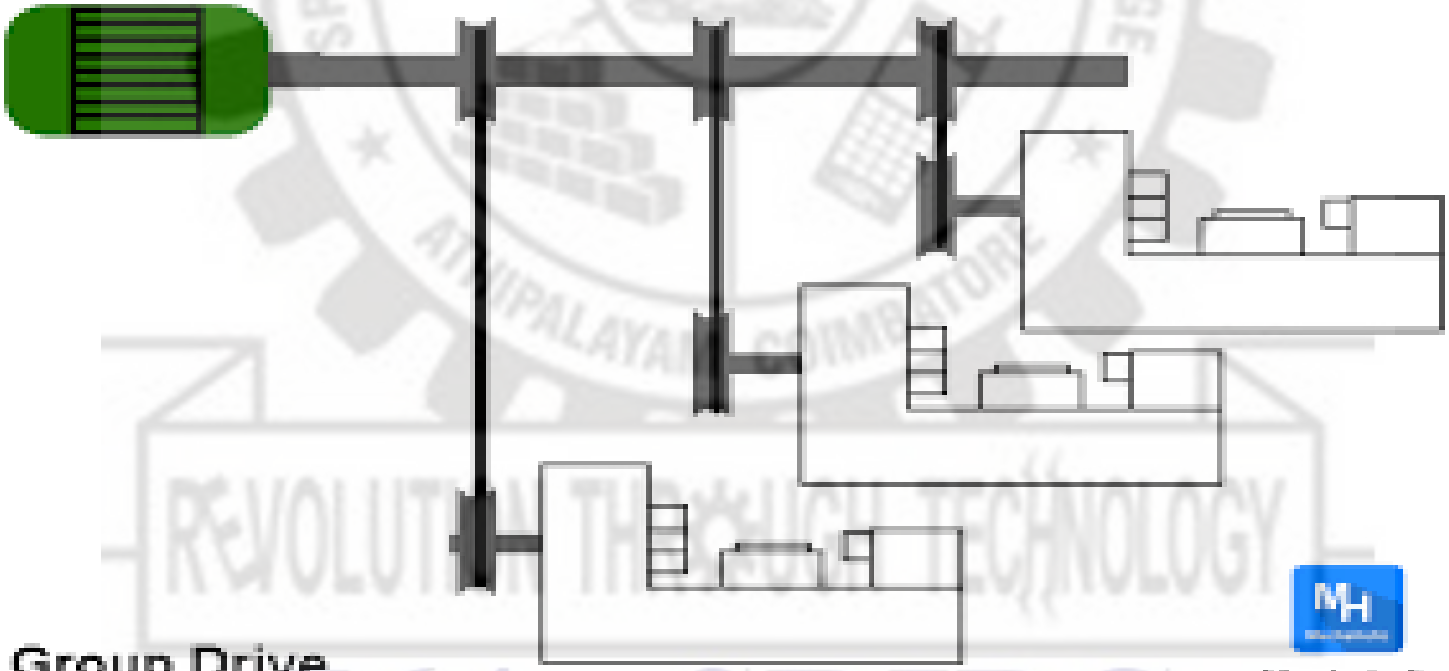
- Servo motors being manufactured by many companies some of them are FUTABA, HITECH, AIRTRONICS, and JR RADIOS. They are the same in manufacturing but different in connector type, wire colors, etc. There are numbers of types of servos are available in the market, AC, DC, continuous, positional and linear servo motor. o choose a motor is the hardest task, based on design criteria such as cost, torque, acceleration, positional accuracy, power and much more. There are many types of motors like **DC, Servo, and Stepper** available for different types of application. But, Servo motors come with **fast functioning, high torque**, and **accurate rotation**. Yes, Stepper Motors are a high-performance alternative of the servo. But to setup a Stepper is more complicated than a **Servo Motor.**



INDUSTRIAL DRIVES

GROUP DRIVE

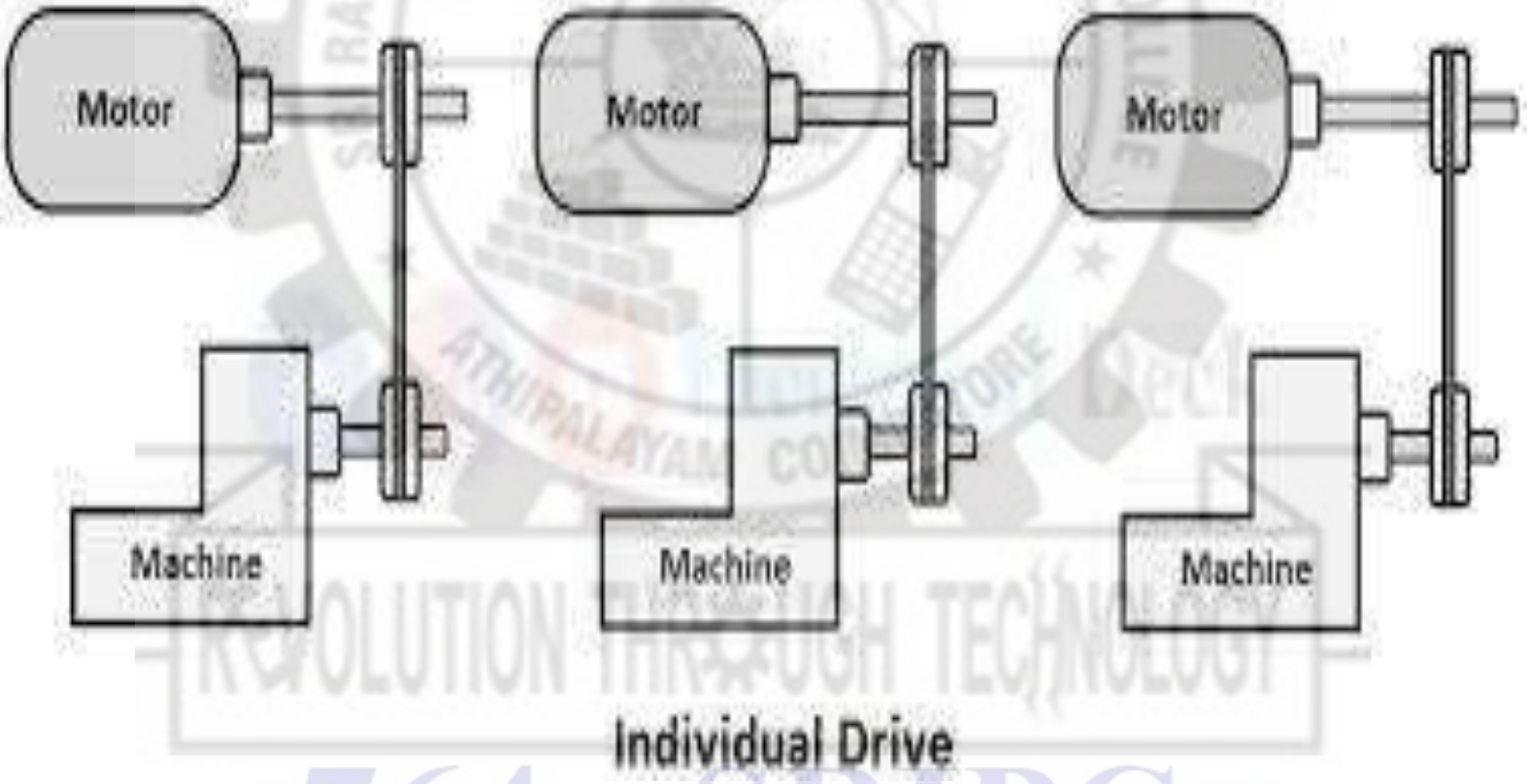
One prime mover or motor is used for the number of machine tools on common shaft then the drive is called as **group drive**



Group Drive

- **INDIVIDUAL DRIVE**

  Individual Drives means that individual motors are combined with each machine. This process is called single conduction.



Individual Drive

- # MULTI MOTOR DRIVE

- There are several methods for controlling multiple motor drives and each has inherent advantages and disadvantages. A primary determining factor for selection concerns whether we're dealing with a **continuous** web or length of product as opposed to individual or "parallel" processes occurring at the same time.
- There are several methods for controlling **multiple motor drives** & each has inherent advantages & disadvantages.

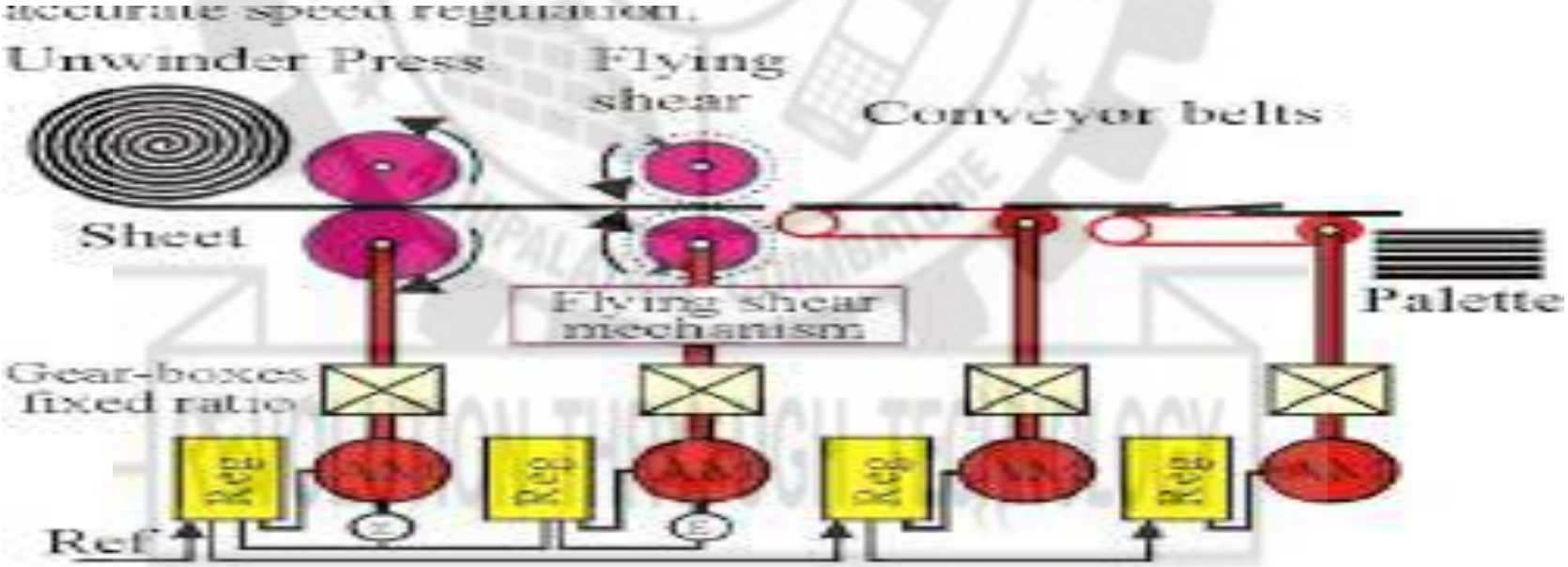
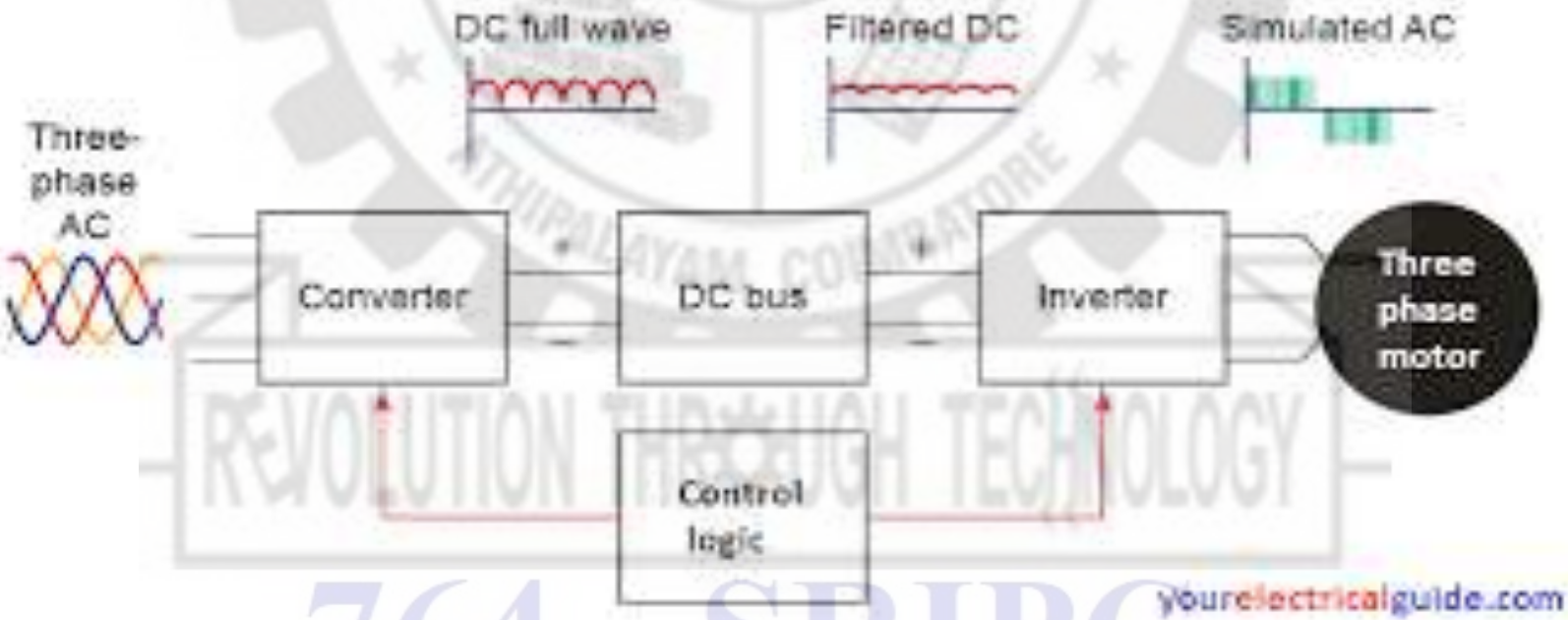


Fig. 6. The flying shear

BLOCK DIAGRAM OF VARIABLE FREQUENCY DRIVE (VFD).

- VFD is a short form of a variable frequency drive also called Frequency converters, which has undergone extremely rapid changes, largely as a result of the development of microprocessor and semiconductor devices and their reduction in prices. However, the basic working principles of frequency converters remain the same. Other names of VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive. Here we are going to discuss working principle and block diagram of VFD.



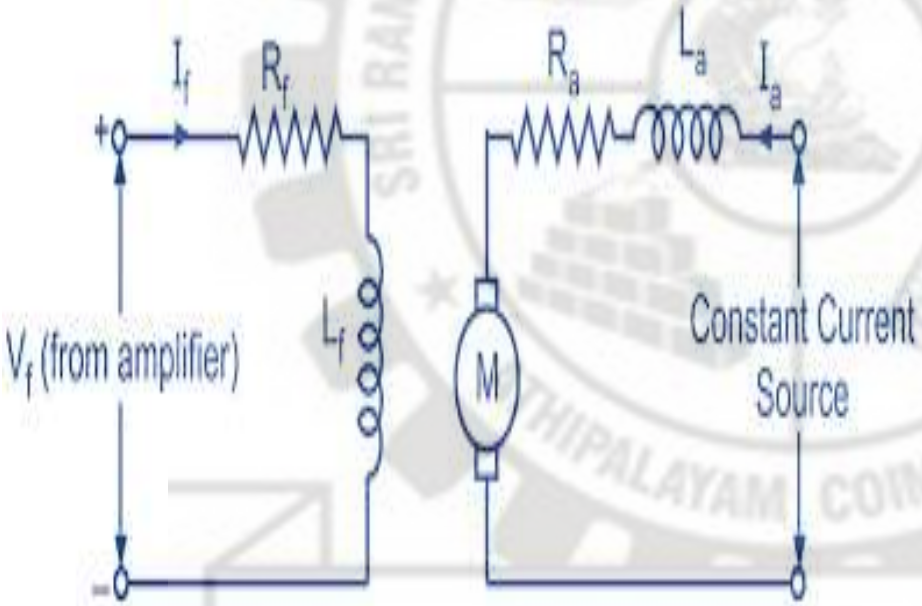
SINGLE STEPPING AND HALF STEPPING SERVO DRIVES.

- **Full step and half step**
- Stepper drives control how a stepper motor operates, there are three commonly used excitation modes for stepper motors, full step, half step and microstepping. These excitation modes have an effect on both the running properties and torque the motor delivers.
- A stepper motor converts electronic signals into mechanical movement each time an incoming pulse is applied to the motor. Each pulse moves the shaft in fixed increments. If the stepper motor has a 1.8° step resolution, then in order for shaft to rotate one complete revolution, in full step operation, the stepper motor would need to receive 200 pulses, 360° ÷ 1.8 = 200.

Step	Phase			
	A	B	$\overline{A}$	$\overline{B}$
1	1	0	0	0
2	1	1	0	0
3	0	1	0	0
4	0	1	1	0
5	0	0	1	0
6	0	0	1	1
7	0	0	0	1
8	1	0	0	1

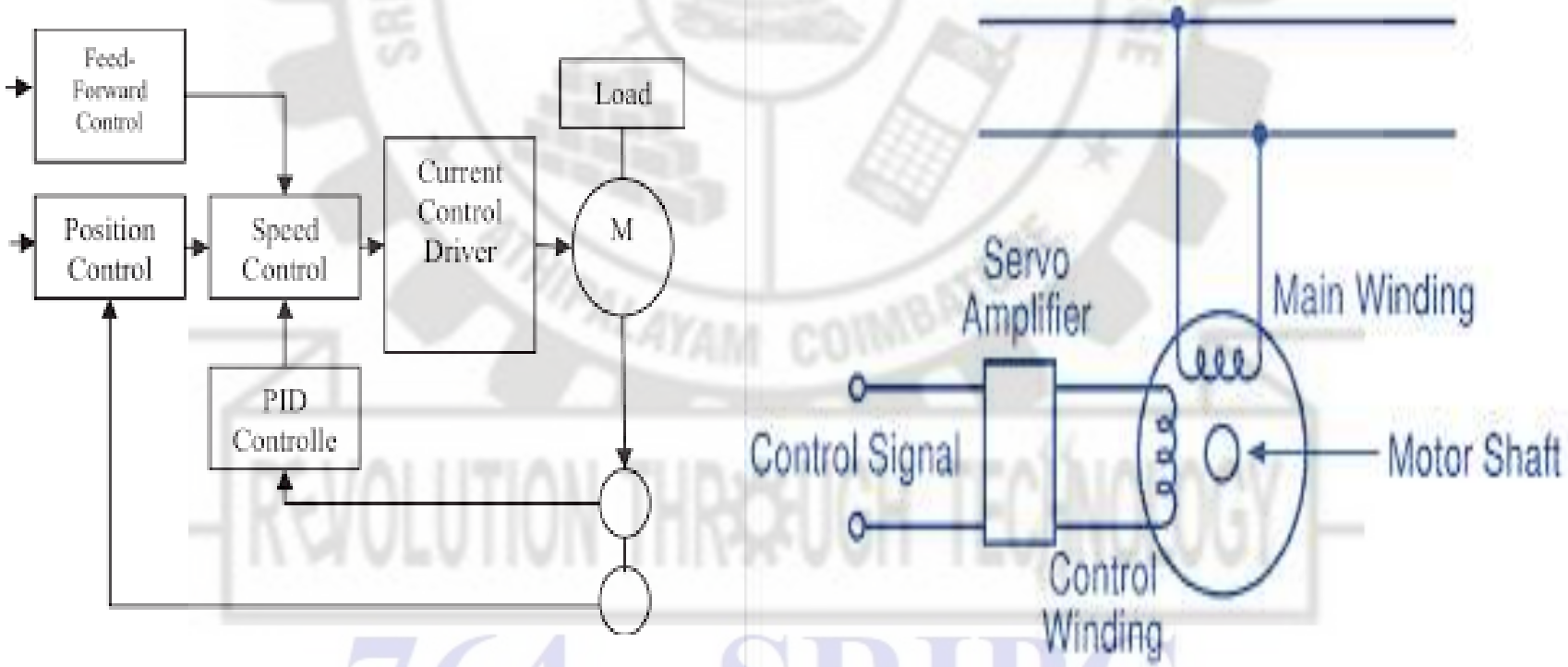
DC SERVO DRIVE

Benchtop controllers are available for brushless DC servo motors. Choose from one-, two-, or three-channel versions. Single-channel K-Cube and T-Cube controllers for both brushed and brushless DC servo motors are also available.



AC SERVO DRIVE

- **Servo drives: high-precision positioning and machining processes with short control cycles. Innovation and efficiency - servo drives, tailor-made for every application. Flexible motor selection. Integrated safety. Active Current Sensing. Multi-feedback interface.**



BLDC SERVO DRIVE

ElectroCraft Brushless DC Motors (BLDC) are designed for high performance. BLDC motors are ideal for applications where rapid acceleration and high accuracy are called for. ElectroCraft Rapid Power and Rapid Power Plus BLDC motors have an efficient, compact design, with high torque density defined by high torque relative to frame size. With efficient design, speed, accuracy, and reliability, ElectroCraft BLDC motors are a found in a variety of mission critical medical, military, automation, and other precision applications

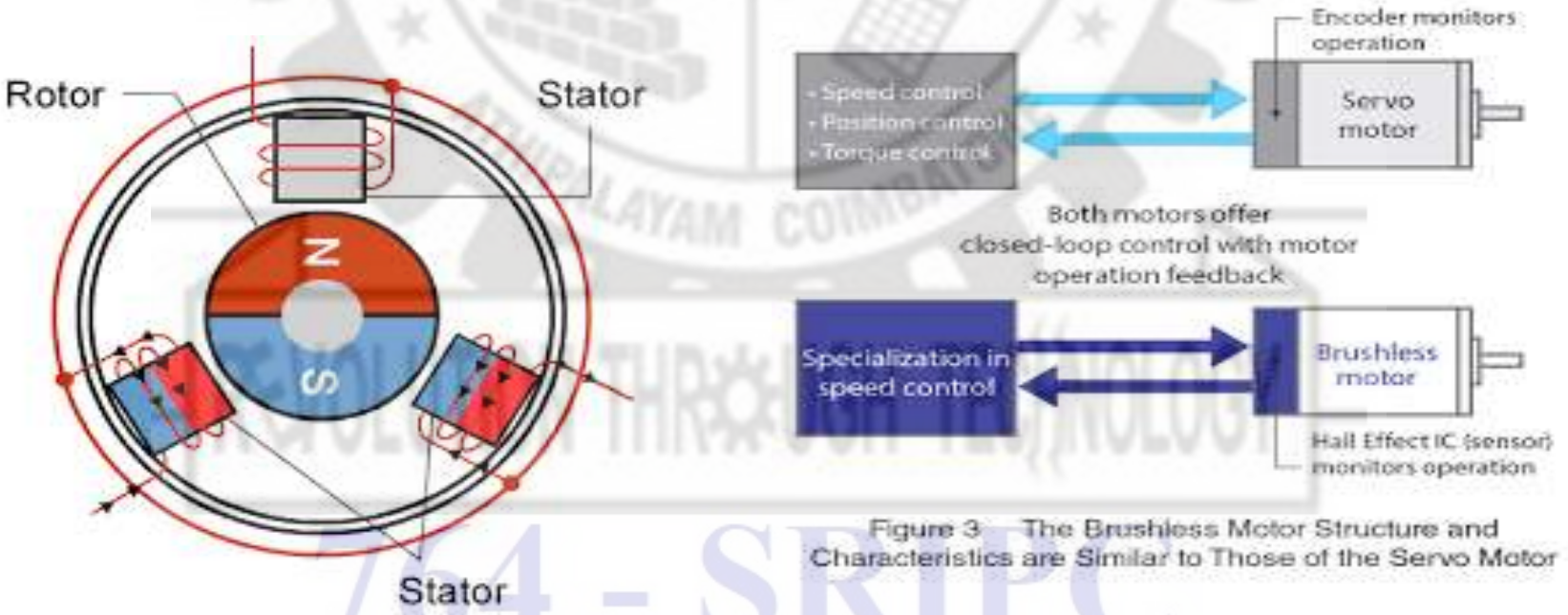


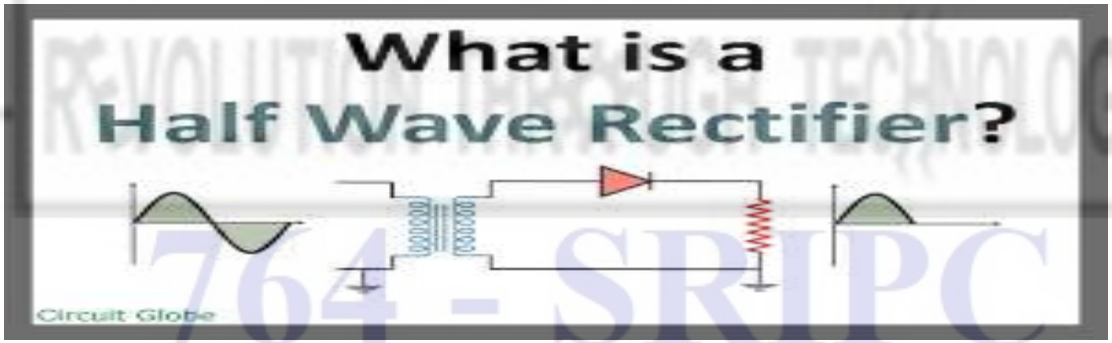
Figure 3 The Brushless Motor Structure and Characteristics are Similar to Those of the Servo Motor

UNIT – 4 POWER SUPPLIES, CONTROL ELEMENTS AND ELECTRICAL SAFETY

HALF WAVE RECTIFIERS

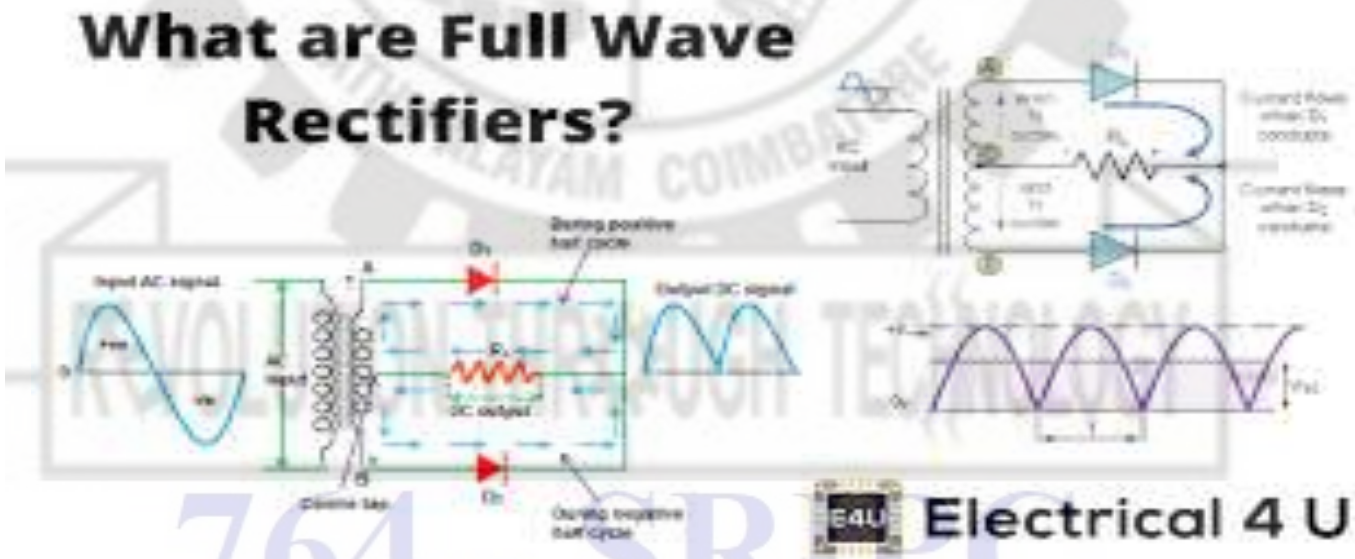
Halfwave rectifier is a type of rectifier that allows only one-half cycle of an AC voltage waveform while blocking the other half of the waveform.

- Working of Half Wave Rectifier
- In this section, let us understand how a half-wave rectifier transforms AC into DC.
- A high AC voltage is applied to the primary side of the step-down transformer. The obtained secondary low voltage is applied to the diode.
- The diode is forward biased during the positive half cycle of the AC voltage and reverse biased during the negative half cycle.
- The final output voltage waveform is as shown in the figure below:



FULL WAVE RECTIFIERS

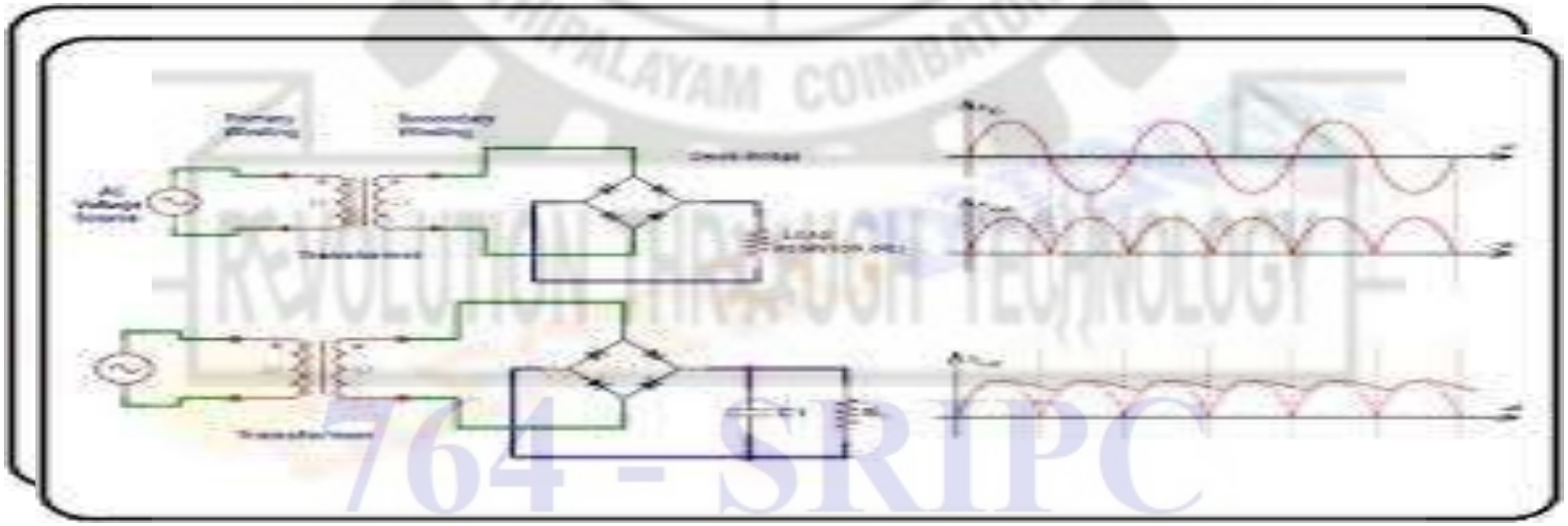
- A full wave rectifier is defined as a type of rectifier that converts both halves of each cycle of an alternating wave (AC signal) into a pulsating DC signal. Full-wave rectifiers are used to convert AC voltage to DC voltage, requiring multiple diodes to construct. Full wave rectification is the process of converting an AC signal to a DC signal.
- Circuits that convert alternating current (AC) into direct current (DC) are known as rectifiers. If such rectifiers rectify both the positive and negative half cycles of an input alternating waveform, the rectifiers are full-wave rectifiers.



BRIDGE RECTIFIERS

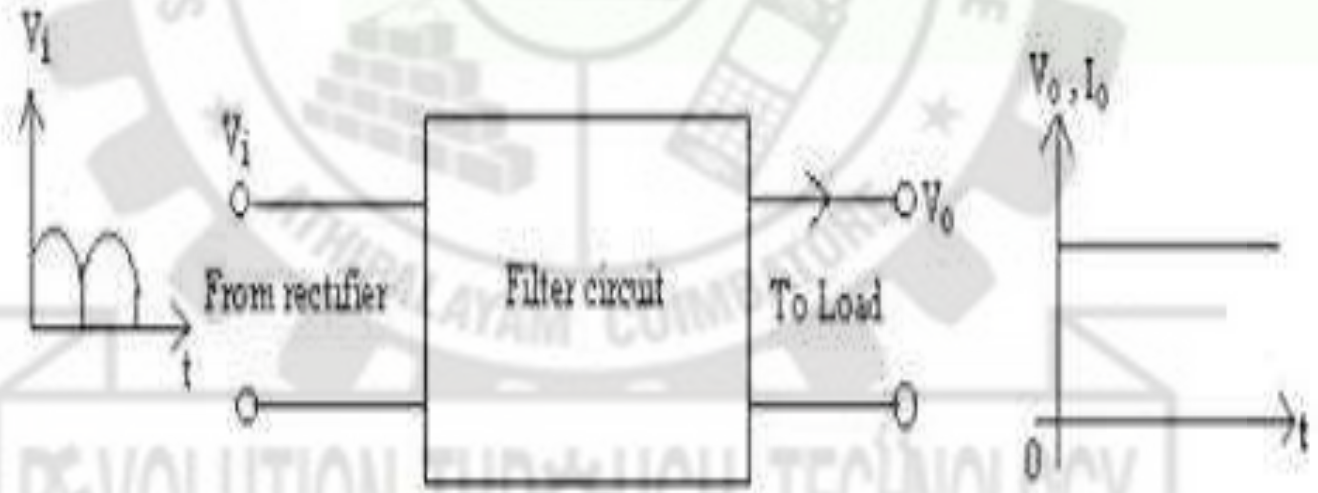
`Many electronic circuits require a rectified DC power supply to power various electronic basic components from the available AC mains supply. Rectifiers are used to convert an AC power to a DC power. Among the rectifiers, the bridge rectifier is the most efficient rectifier circuit.

The construction of a bridge rectifier is shown in the figure below. The bridge rectifier circuit is made of four diodes D_1, D_2, D_3, D_4, and a load resistor R_L. The four diodes are connected in a closed-loop configuration to efficiently convert the alternating current (AC) into Direct Current (DC). The main advantage of this configuration is the absence of the expensive centre-tapped transformer. Therefore, the size and cost are reduced.



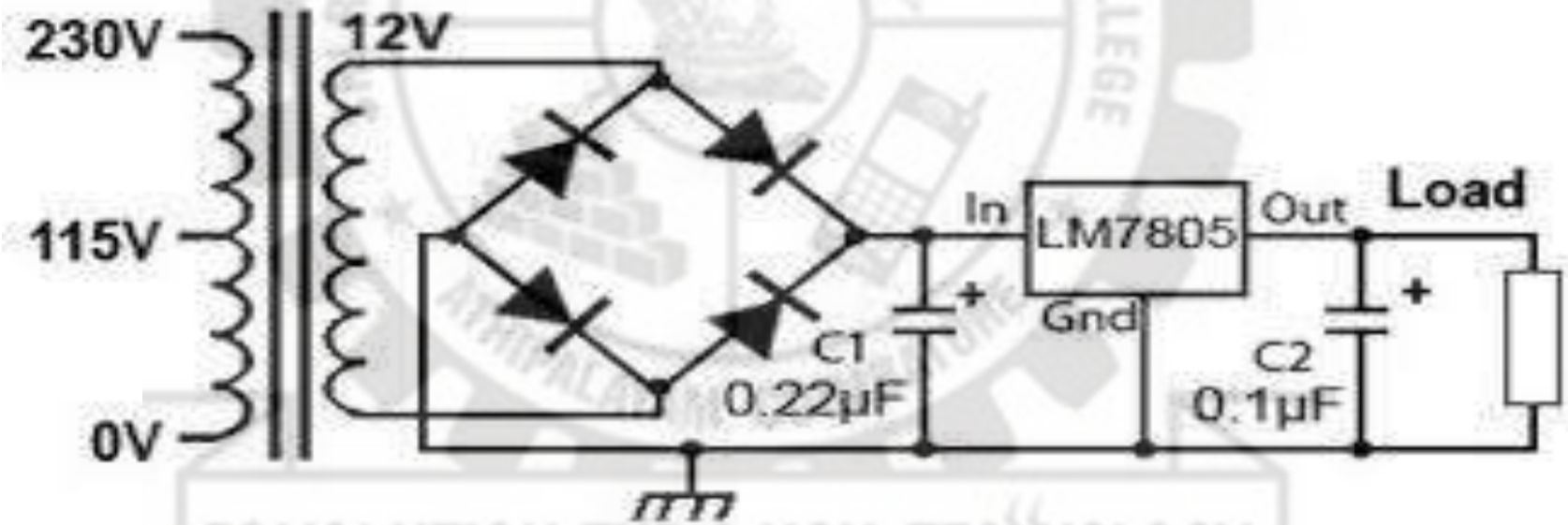
NECESSITY OF FILTERS

A circuit designed to perform this frequency selection is called a filter circuit, or simply a filter. A common need for filter circuits is in **high-performance stereo systems, where certain ranges of audio frequencies need to be amplified or suppressed for best sound quality and power efficiency**.



IC Voltage Regulators

IC voltage regulators are three-terminal devices that provide a constant DC output voltage that is independent of the input voltage, output load current, and temperature.

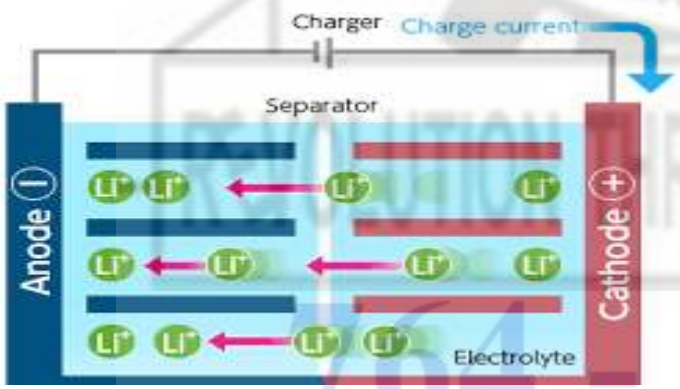


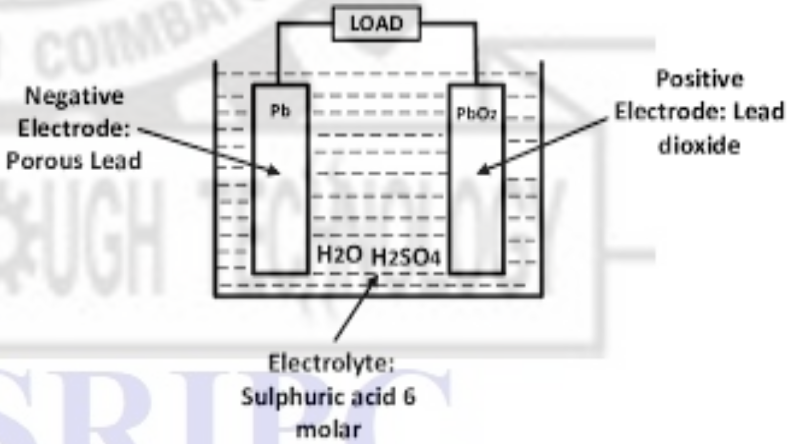
BATTERIES

An electric **battery** is a source of electric power consisting of one or moreelectrochemical cells with external connections for powering ele

In the batteries, the plates are of two types, positive and negative. The positive one consists of Lead dioxide and negative one consists of Sponge Lead. These two plates are separated using a separator which is an insulating material. This total construction is kept in a hard plastic case with an electrolytectrical devices**.**

- **Negative:**
- $Pb(s) + HSO_4^- + H_2O(l) \rightarrow 2e^- + PbSO_4(s) + H_3O^+(aq)$ (oxidation)
- **Positive:**
- $PbO_2(s) + HSO_4^-(aq) + 3H_3O^+(aq) + 2e^- \rightarrow PbSO_4(s) + 5H_2O(l)$ (reduction)

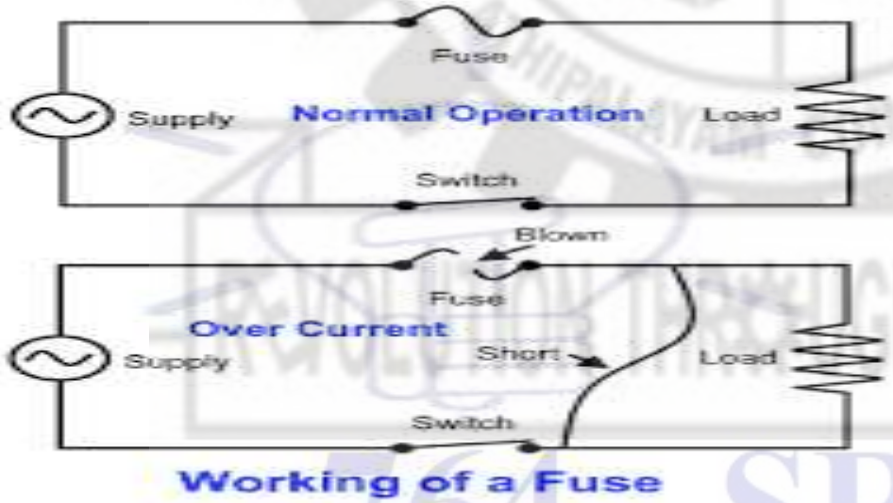




FUSES – SELECTION OF FUSE – NECESSITY OF FUSE- FUSE SWITCH UNITS

In electronics and electrical engineering, a fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit.

A **fuse** is an **electric / electronic or mechanical device**, which is used to protect circuits from over current, overload and ensure the protection of the circuit. Electric fuse was invented by Thomas Alva Edison in 1890. There are many types of fuses, but the function of all these fuses is the same. In this article, we will discuss the different types of fuses, its construction, working and operation and their application in various electronics and electrical systems.

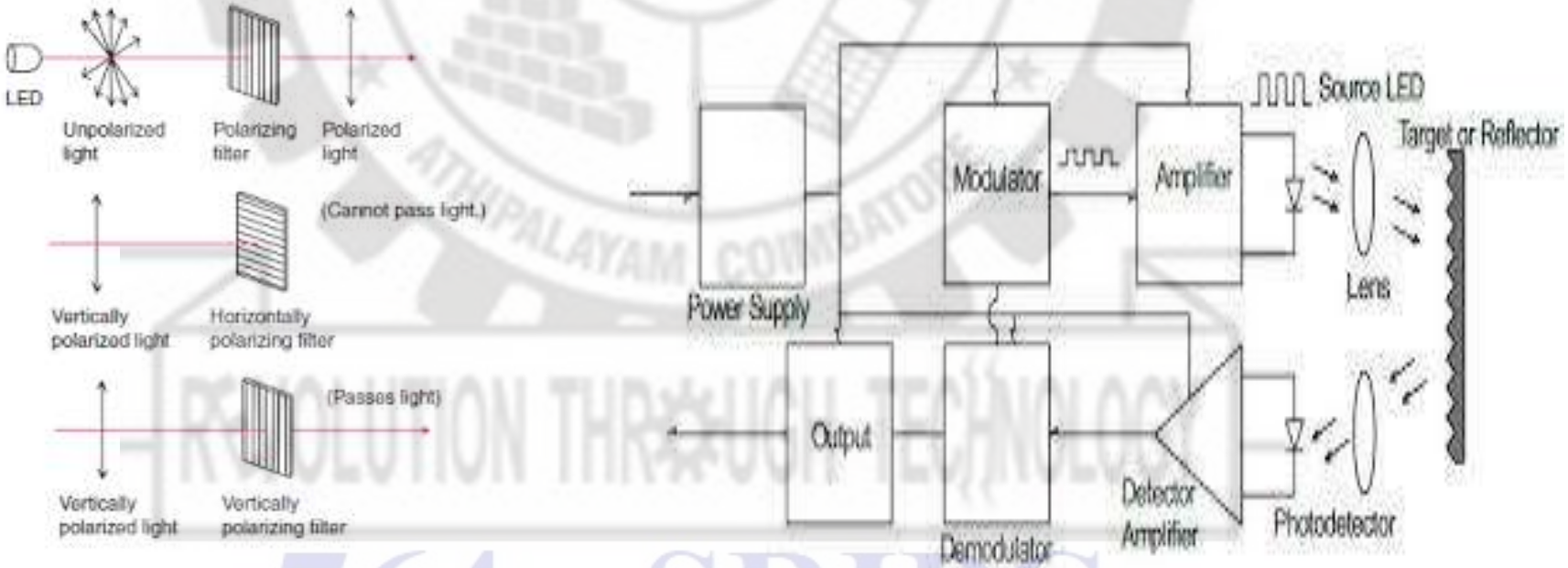


Working of a Fuse

SENSORS: PHOTO ELECTRIC SENSOR

TRI-TRONICS Smart **Sensing** Solutions since 1954. High-quality high-performance **photoelectric sensors** and fiber optic light guides. Made In America. Custom Solutions. Precise & Accurate. Styles: Thru-Beam **Sensors**, Diffuse **Sensors**, Clear Object **Sensors**.

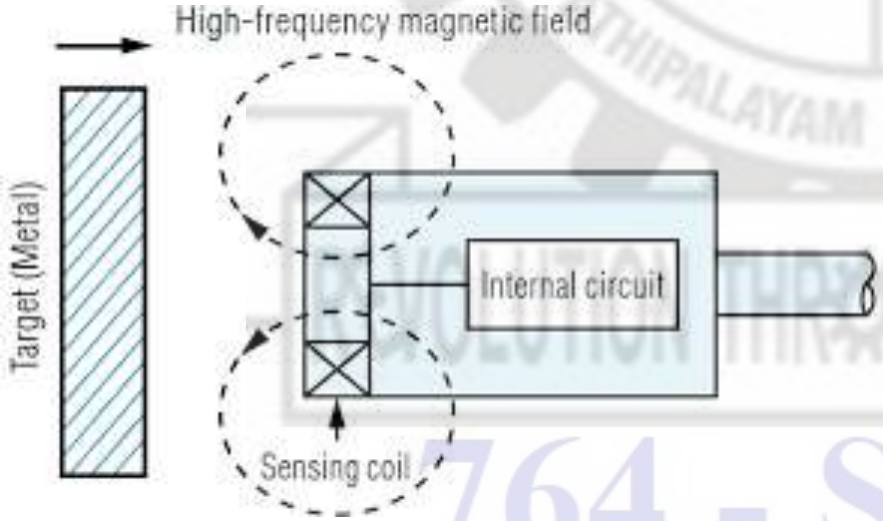
A photoelectric sensor emits a light beam (visible or infrared) from its light-emitting element. A reflective-type photoelectric sensor is used to detect the light beam reflected from the target. A thru beam type sensor is used to measure the change in light quantity caused by the target crossing the optical axis.

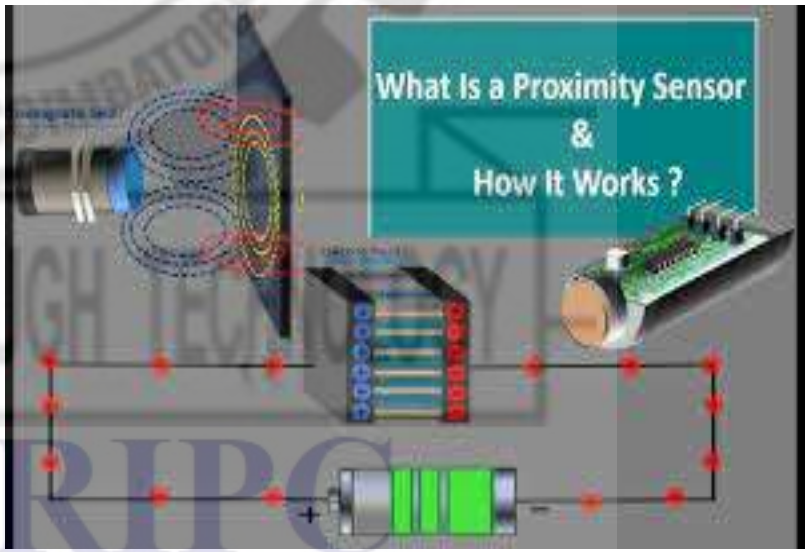


INDUCTIVE PROXIMITY SENSORS

An inductive proximity sensor is **a sensing device that detects metal targets using electromagnetic energy and without contact**. The sensing range of an inductive proximity sensor changes based on the type of metal being detected.

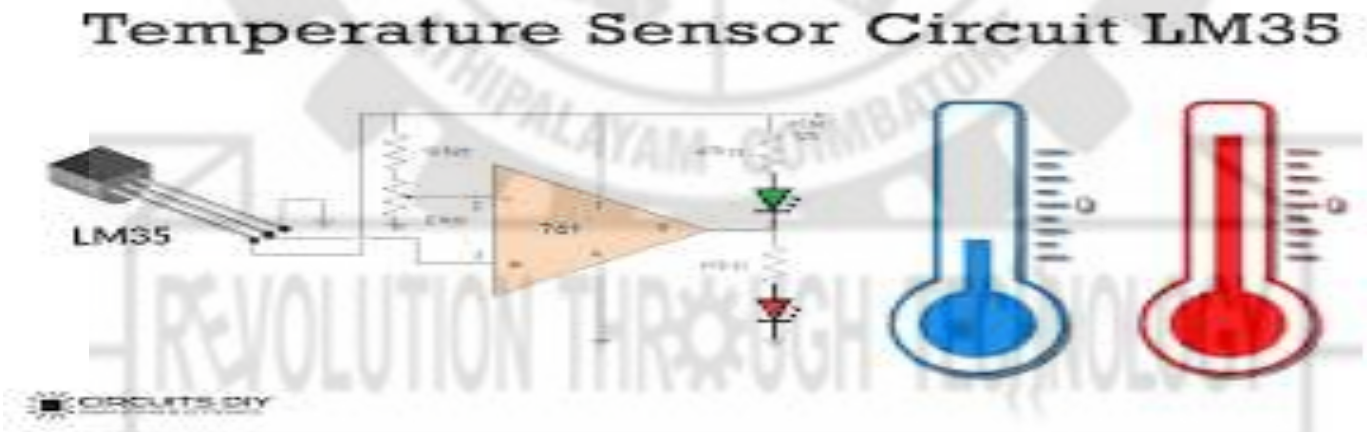
A inductive proximity sensor can detect metal targets approaching the sensor, without physical contact with the target. Inductive Proximity Sensors are roughly classified into the following three types according to the operating principle: the high-frequency oscillation type using electromagnetic induction, the magnetic type using a magnet, and the capacitance type using the change in capacitance.





TEMPERATURE SENSORS

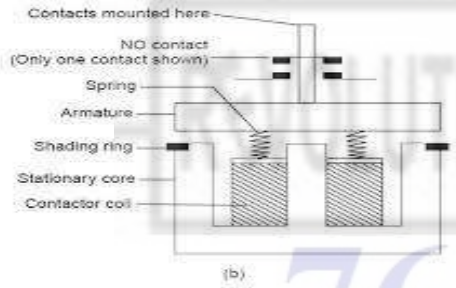
- A temperature sensor is **a device, typically, a thermocouple or resistance temperature detector, that provides temperature measurement in a readable form through an electrical signal**. A thermometer is the most basic form of a temperature meter that is used to measure the degree of hotness and coolness.
- **Sensor type:** Pt 100
- **Range:** -20o to 80o C
- **Accuracy:** ± 0.5 % fs standard; ± 0.1 %



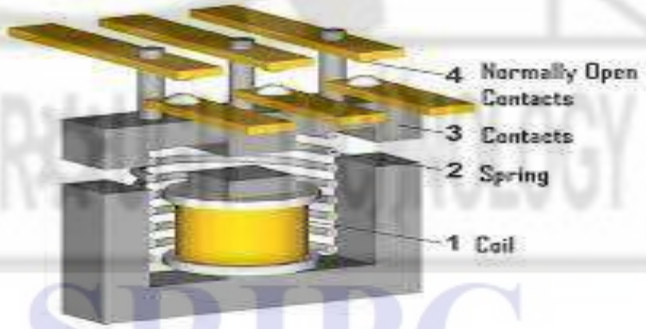
NECESSITY OF CONTACTOR- SOLENOID TYPE CONTACTOR.

Relays, solenoids, and contactors are all switches—whether electro-mechanical or solid state—but there are critical differences that make each suitable for different applications. In this article, we will explain how each of these devices work and discuss some key selection considerations

- **Solenoids**
- Solenoids are a type of relay engineered to remotely switch a heavier current (typically ranging from 85-200 amps). In contrast to the smaller electromechanical cube relays, a coil is used to generate a magnetic field when electricity is passed through it, which effectively opens or closes the circuit.
- **Contactors**
- The contactor is the relay to use when a circuit must support an even heavier current load (typically 100-600 amps). With voltage ratings from 12V DC up to 1200V DC, contactors are a cost-effective, safe, lightweight solution for DC high-voltage power systems.



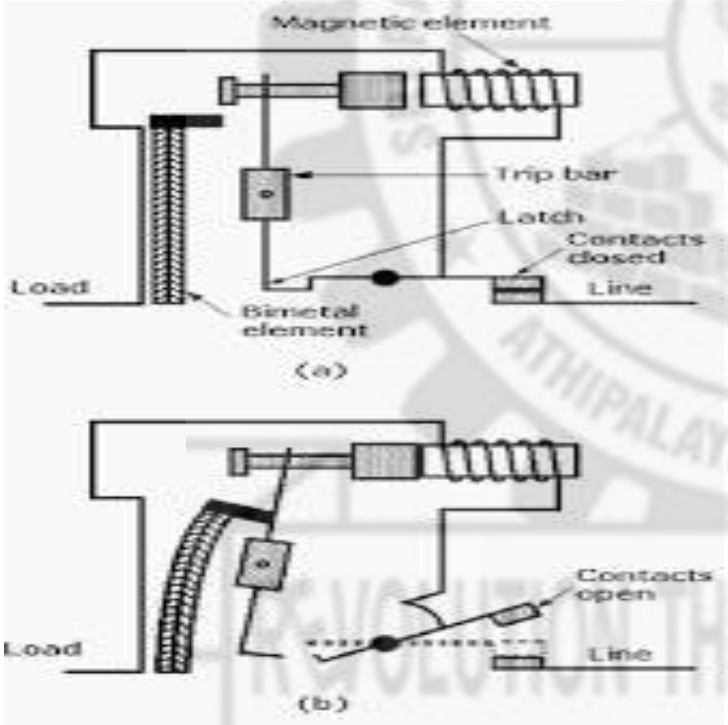
(b) Contactor with E-type magnetic core

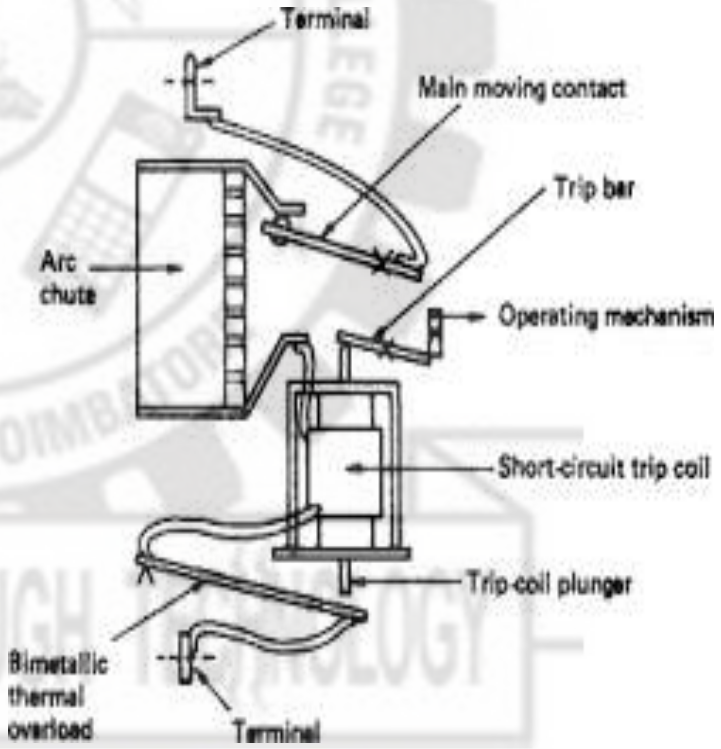


CIRCUIT BREAKERS

- ## MINIATURE CIRCUIT BREAKER (MCB)

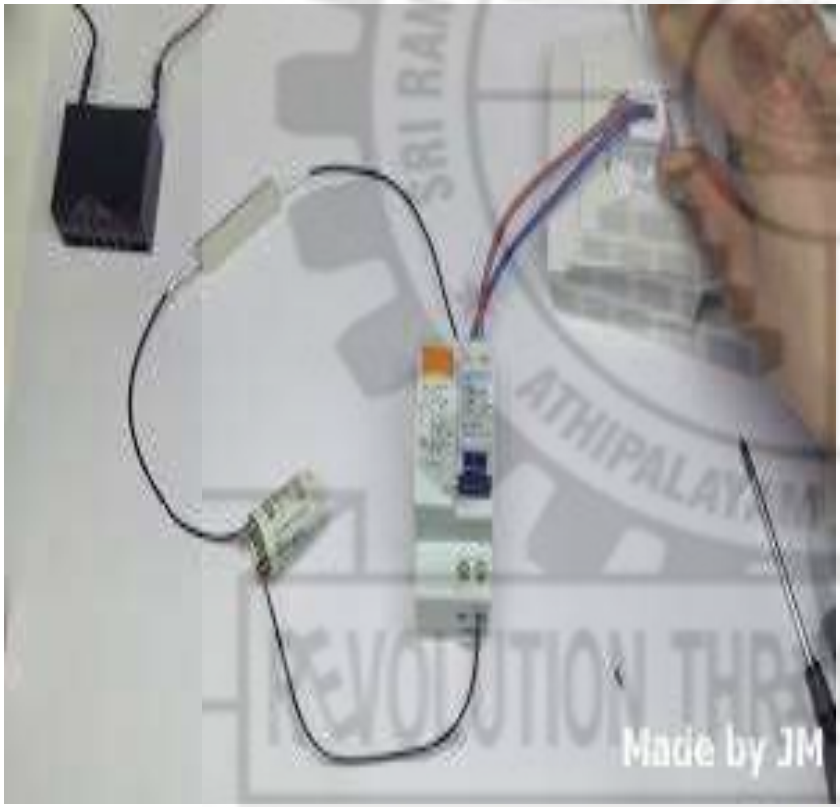
- A Miniature Circuit Breaker (MCB) is **an automatically operated electrical switch used to protect low voltage electrical circuits from damage caused by excess current from an overload or short circuit.**

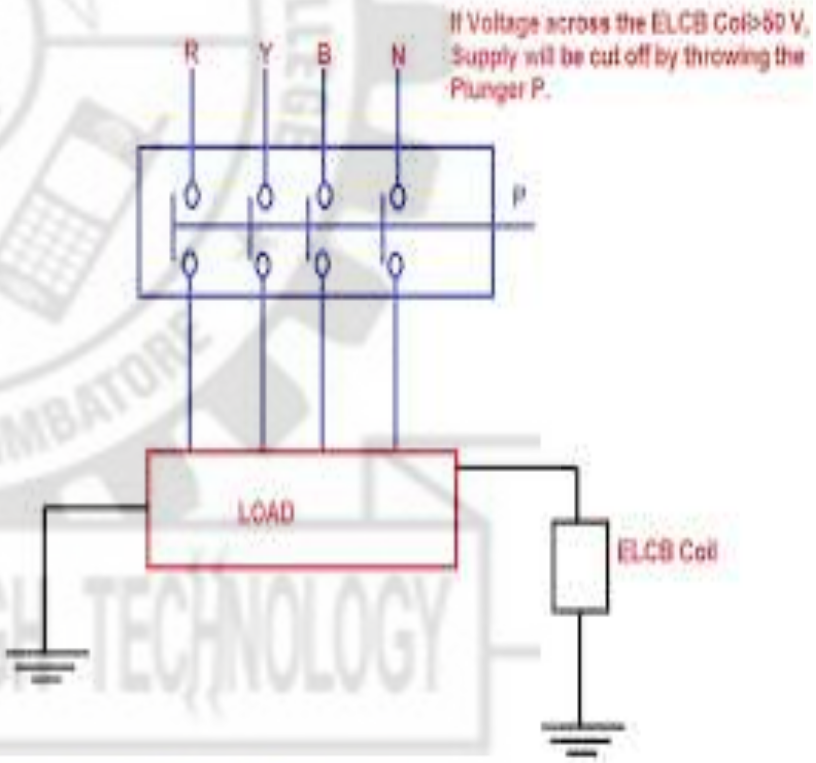




• EARTH LEAKAGE CIRCUIT BREAKER (ELCB).

- An Earth-leakage circuit breaker (ELCB) is **a safety device used in electrical installations with high Earth impedance to prevent shock**. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected.



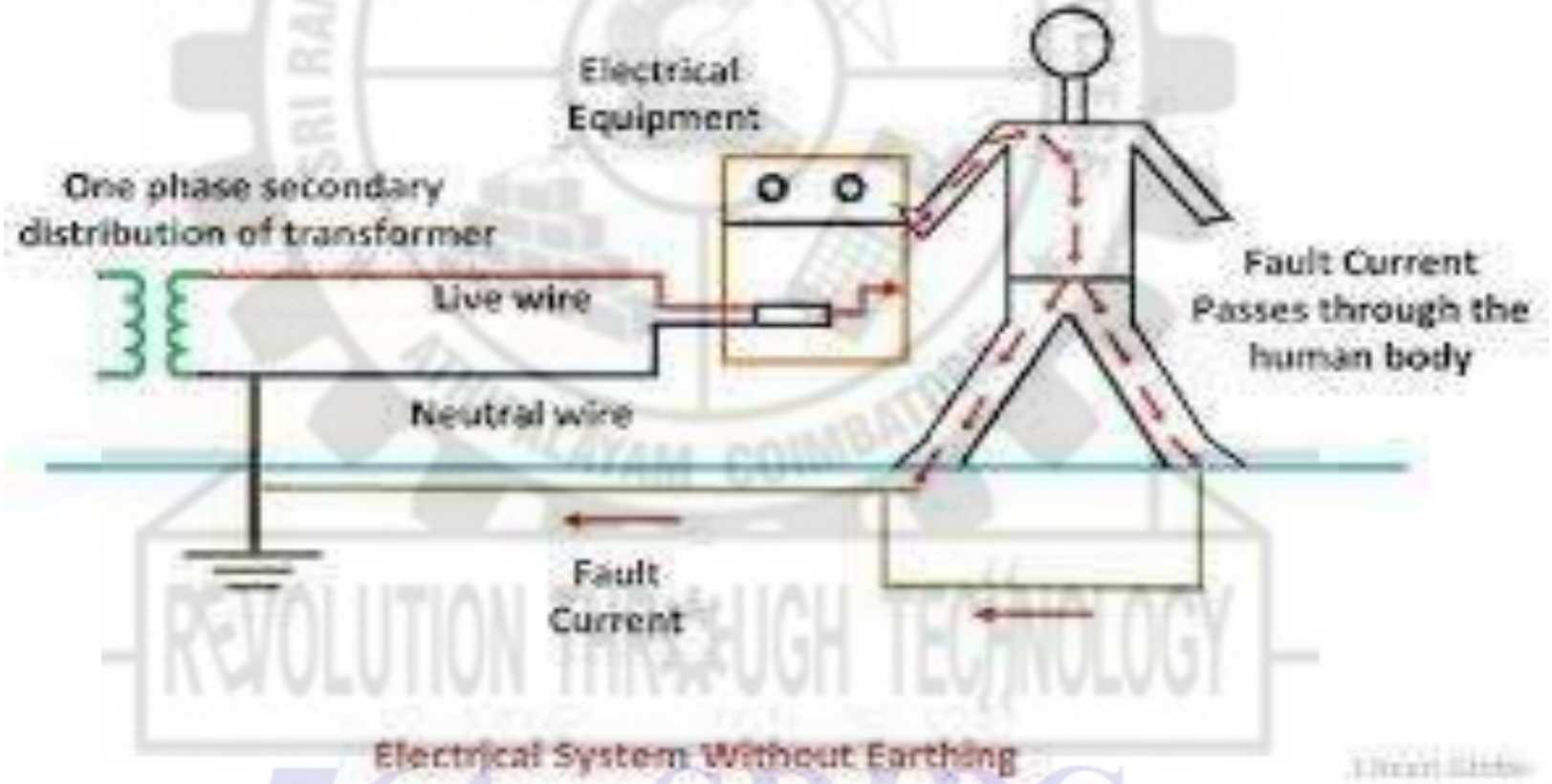


ELECTRICAL SAFETY

Keep your feet, legs, and arms close to your body. Keep your feet together (touching), and move away by shuffling your feet. Never let your feet separate or you may be shocked or electrocuted. Shuffle at least 10 metres away from your vehicle before you take a normal step.

IMPORTANCE OF EARTHING

Earthing is used **to protect you from an electric shock**. It does this by providing a path (a protective conductor) for a fault current to flow to earth. It also causes the protective device (either a circuit-breaker or fuse) to switch off the electric current to the circuit that has the fault.

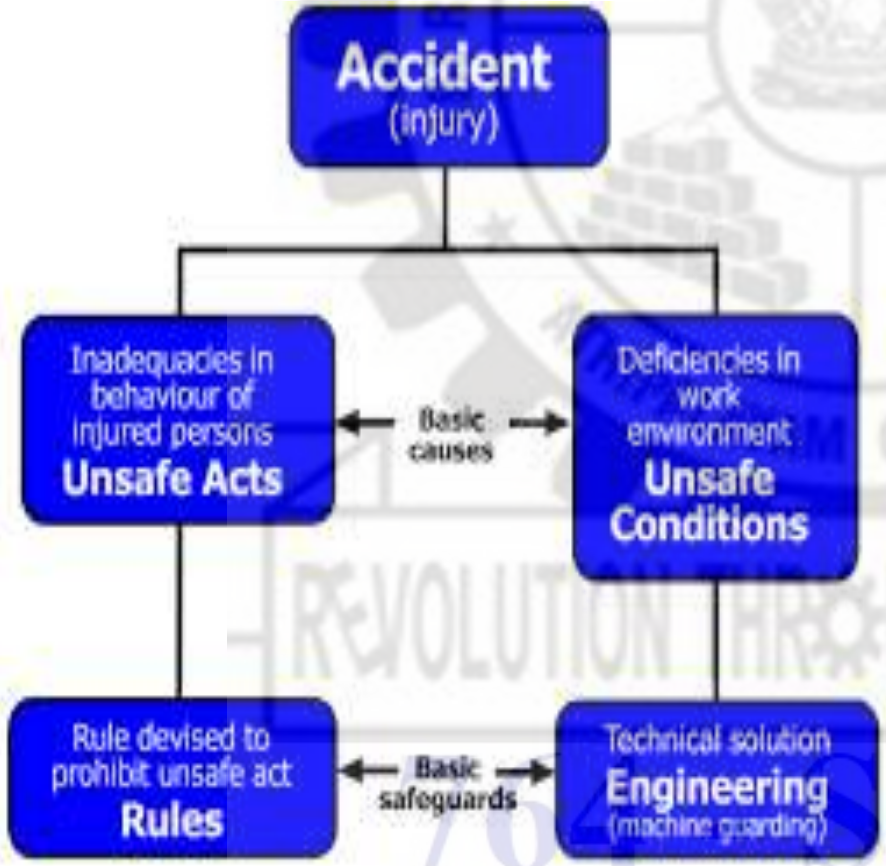


ELECTRIC SHOCK & FIRST AID

- Turn off the source of electricity, if possible. If not, move the source away from you and the person, using a dry, nonconducting object made of cardboard, plastic or wood. Begin CPR if the person shows no signs of circulation, such as breathing, coughing or movement.

CAUSES OF ACCIDENT AND THEIR PREVENTIVE MEASURES.

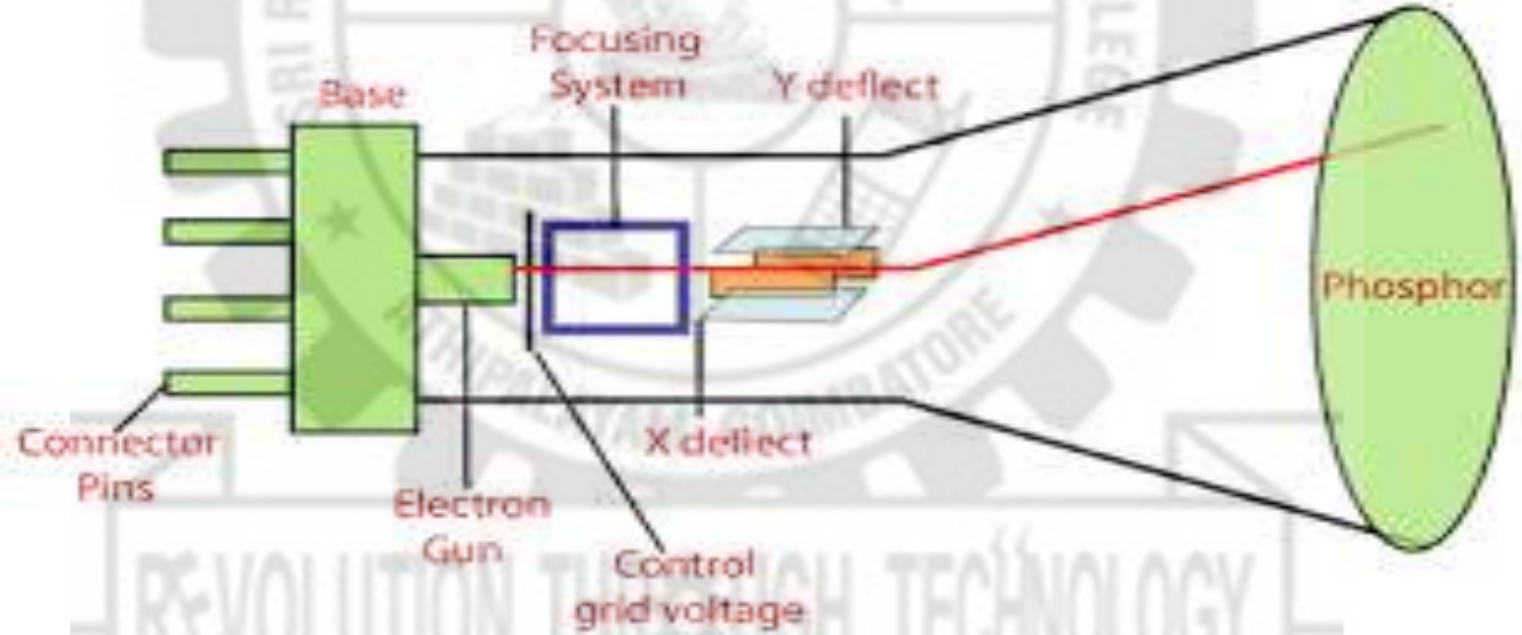
Primary prevention: removal of circumstances causing injury - eg, traffic speed reduction, fitting stair gates for young children, reducing alcohol consumption. Secondary prevention: reduces severity of injury should an accident occur - eg, use child safety car seats, bicycle helmets, smoke alarms.



UNIT – 5 DISPLAY DEVICES, LOGIC GATES AND PLC

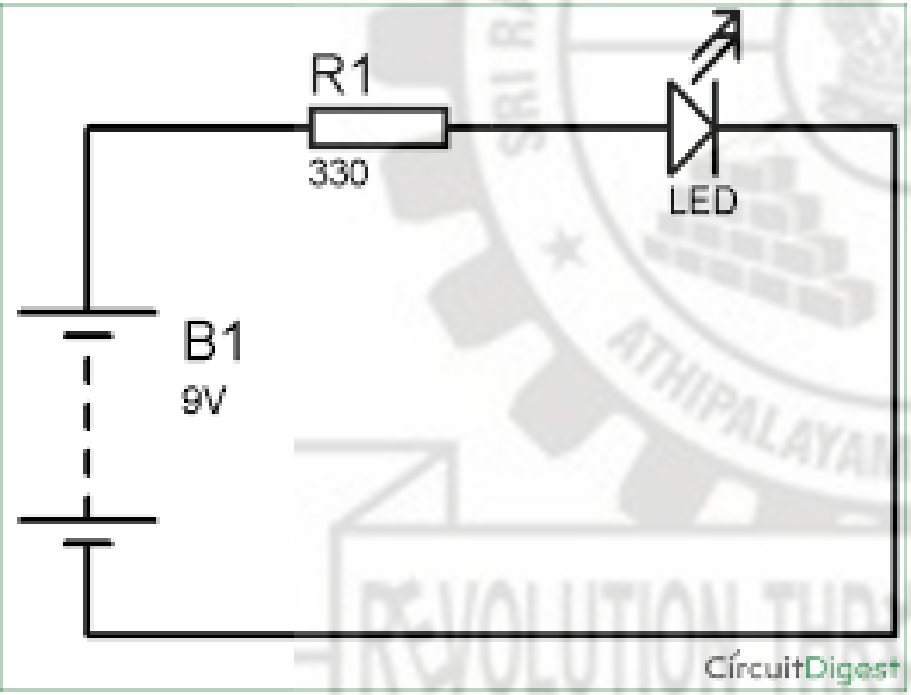
DISPLAY DEVICES

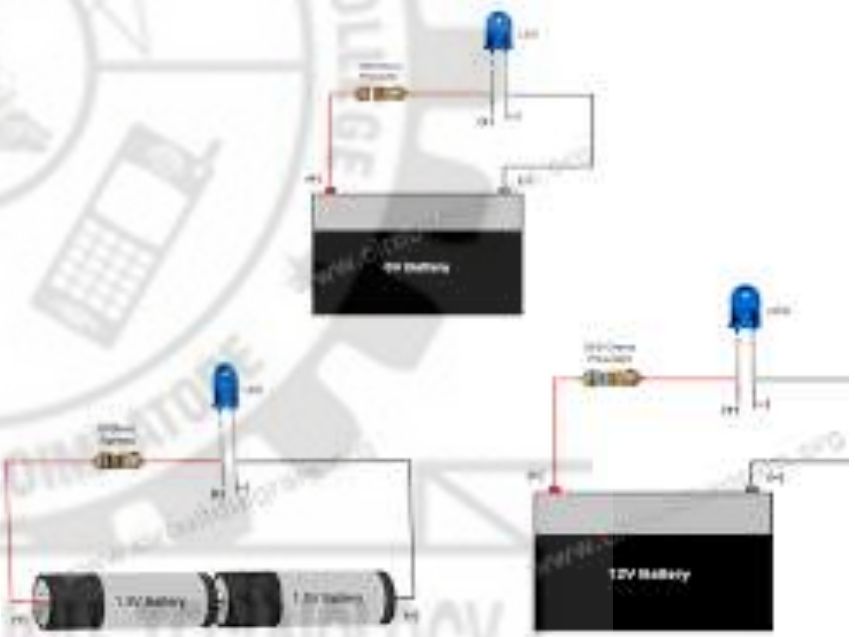
The **display device** is an output device used to represent the information in the form of images (visual form). Display systems are mostly called as a display devices.



LED

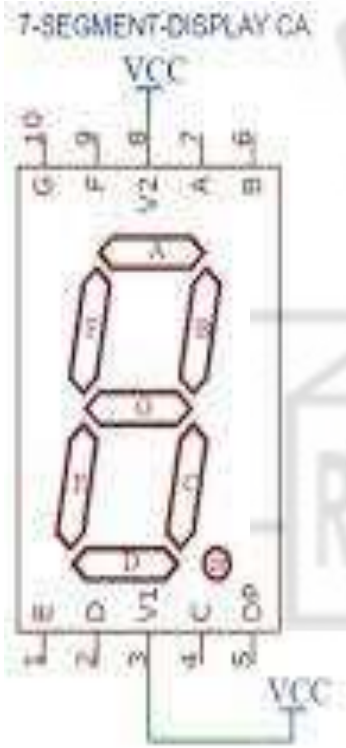
- Light-emitting diode (LED) is a widely used standard source of light in electrical equipment. It has a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display different types of data.

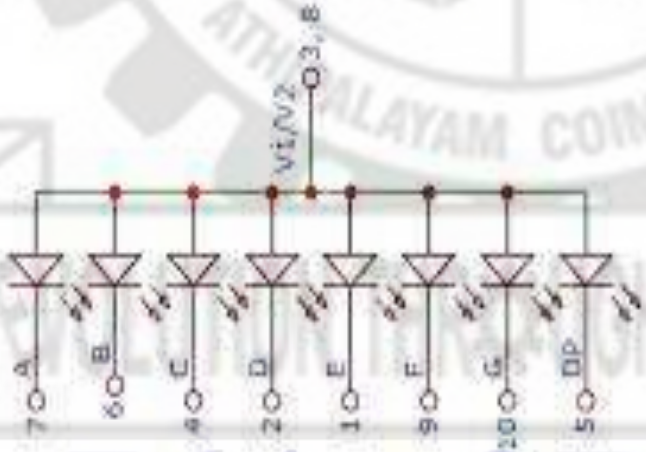


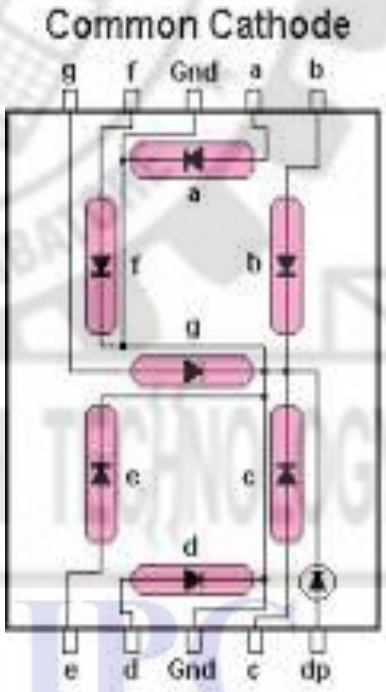


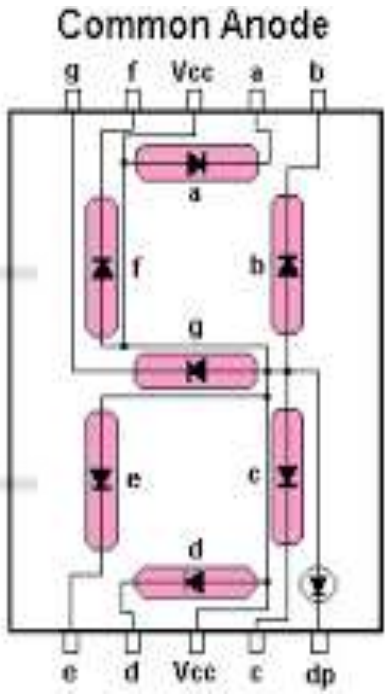
7 segments LED

- he emission of these photons occurs when the diode junction is forward biased by an external voltage allowing current to flow across its junction, and in Electronics we call this process electroluminescence.
- The actual colour of the visible light emitted by an LED, ranging from blue to red to orange, is decided by the spectral wavelength of the emitted light which itself is dependent upon the mixture of the various impurities added to the semiconductor materials used to produce it.



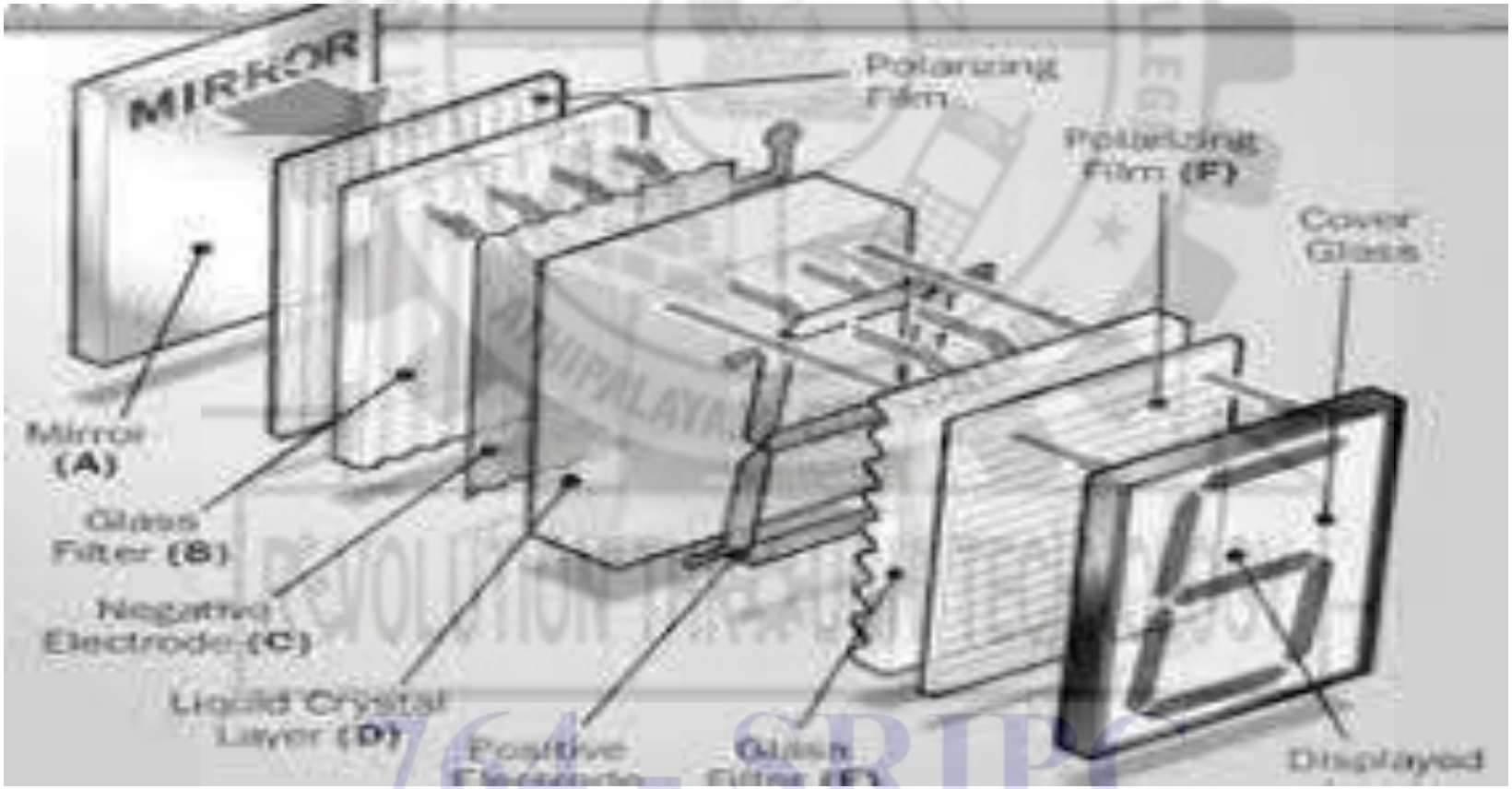






LCD, APPLICATIONS

LCDs are commonly used for **portable electronic games, as viewfinders for digital cameras and camcorders, in video projection systems, for electronic billboards, as monitors for computers, and in flat-panel televisions**.



LOGIC GATES: POSITIVE AND NEGATIVE LOGIC

- **Symbol and truth table.Boolean expression OR**

Positive logic is defined as a high voltage level representing a logic 1 and a low voltage level representing a logic 0. Negative logic is the reverse, i.e., a low voltage level represents a logic 1 and a high voltage level represents a logic 0.
GANTE

Fig OR gate

Table Truth table of OR gate

Inputs		Output
A	B	Y = A + B
0	0	0
0	1	1
1	0	1
1	1	1

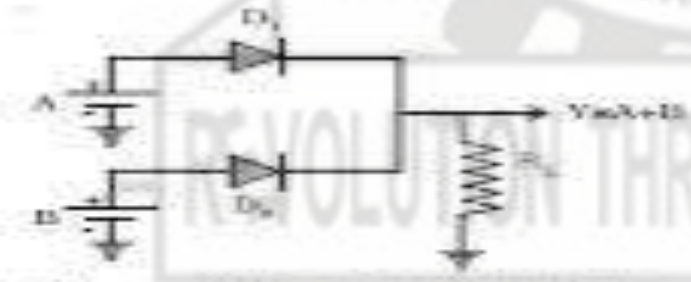
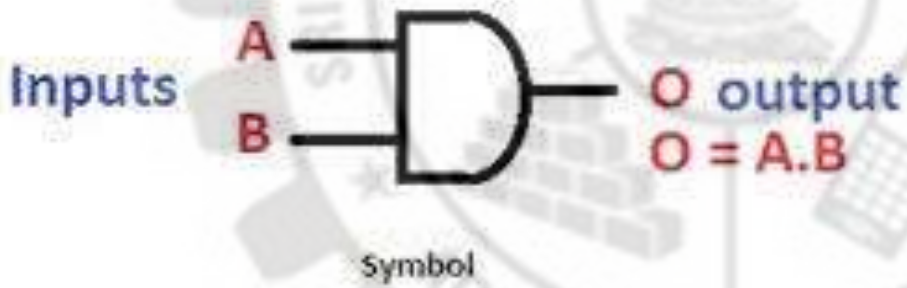


Fig OR gate using diodes

AND GATE & NOT GATE

As well as a standard Boolean Expression, the input and output information of any **Logic Gate** or circuit can be plotted into a standard table to give a visual representation of the switching function of the system.



Symbol

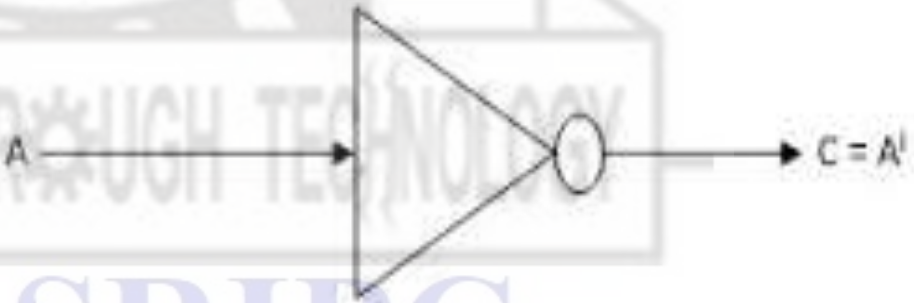
Inputs		Output
A	B	O
0	0	0
0	1	0
1	0	0
1	1	1

Truth table

Truth table:

A	A'
0	1
1	0

Graphical Symbol:



Algebraic Expression is, C = A'

NOR GATE & NAND GATE

The logic or Boolean expression given for a logic NOR gate is that for *Logical Multiplication* which it performs on the *complements* of the inputs. The Boolean expression for a logic NOR gate is denoted by a plus sign, (+) with a line or *Overline*, ($\overline{\ }$) over the expression to signify the NOT or logical negation of the NOR gate giving us the Boolean expression of: A+B = Q.

2 Input OR Gate

TRUTH TABLE

INPUTS		OUTPUT
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

Truth teble

Input		Output
A	B	C=(A . B)'
0	0	1
0	1	1
1	0	1
1	1	0

Graphical Symbol:

Algebraic Expression is, C = (A . B)'

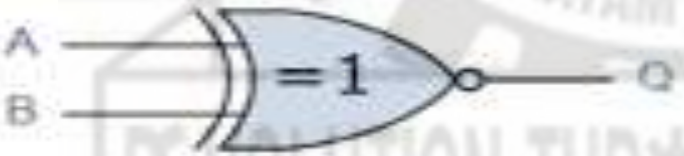
EXOR GATE AND EXNOR GATE

The XOR operation of inputs A and B is A ⊕ B; therefore, XNOR operation those inputs will be (A + B)‾. That means the output of the XOR gate is inverted in the XNOR gate. In the XOR gate operation, the output is only 1 when only one input is 1.

Symbol

Inputs		Output
A	B	O
0	0	0
0	1	1
1	0	1
1	1	0

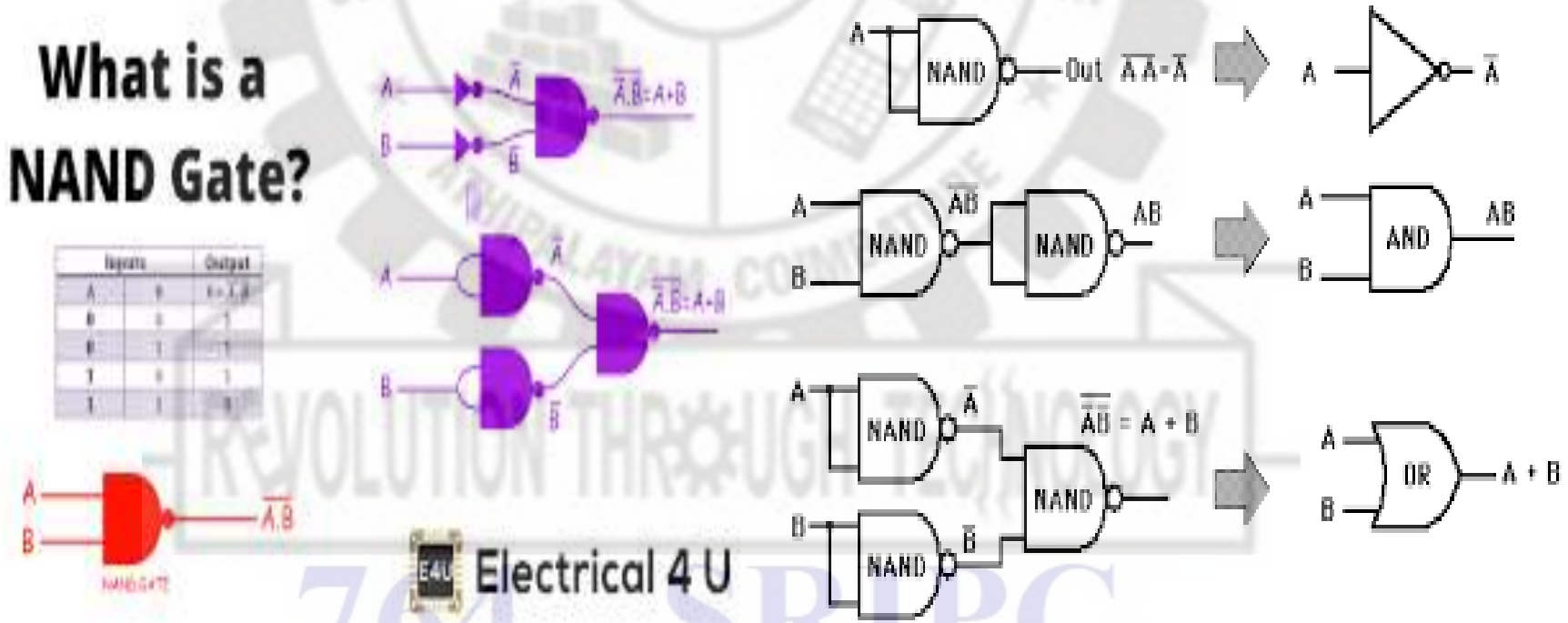
Truth table

Symbol	Truth Table		
	A	B	Q
	0	0	1
	0	1	0
	1	0	0
	1	1	1
Boolean Expression Q = A XNOR B			

2-Input Ex-NOR Gate

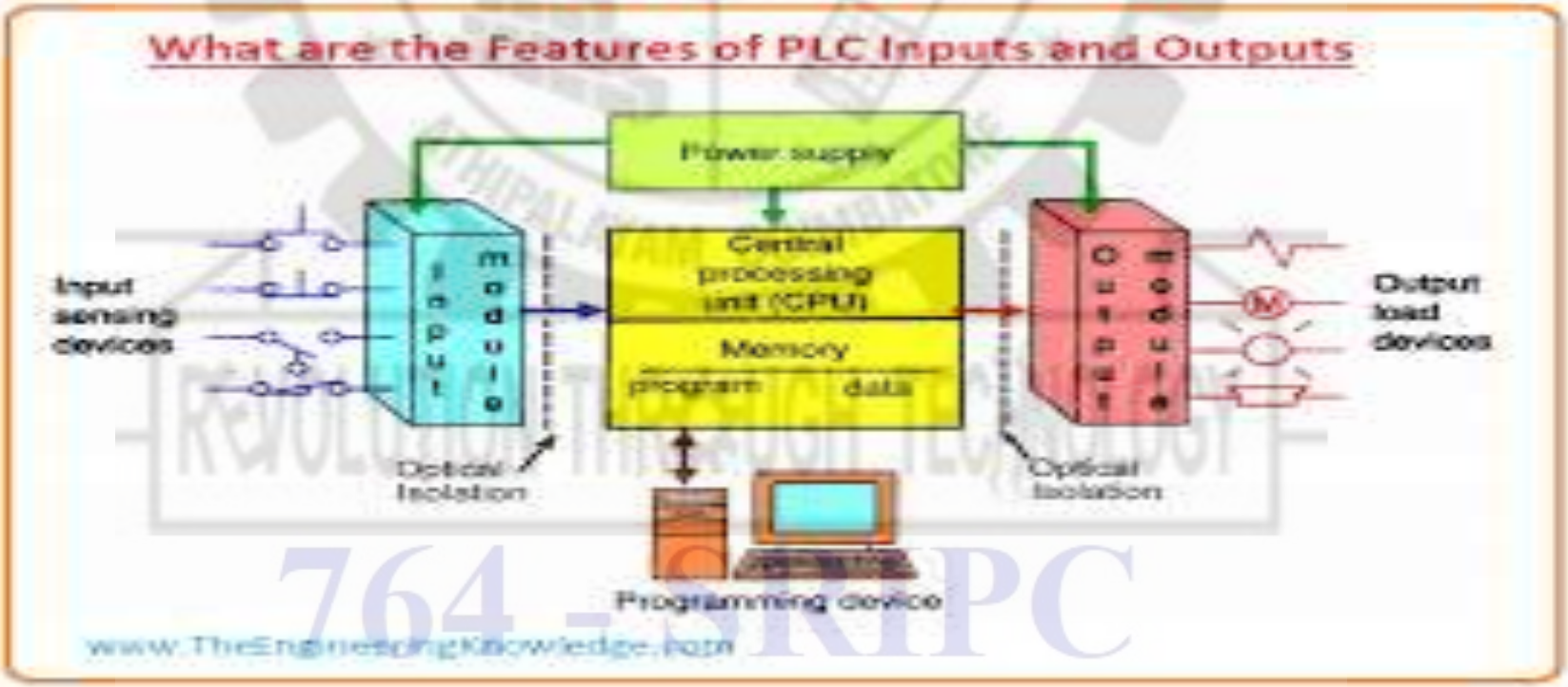
UNIVERSAL LOGIC GATES: NAND, AND NOR.

The NOR gate and NAND gate are universal gates. This means that **you can create any logical Boolean expression using only NOR gates or only NAND gates**. In practice, this is advantageous since NOR and NAND gates are economical and easier to fabricate than other logic gates.



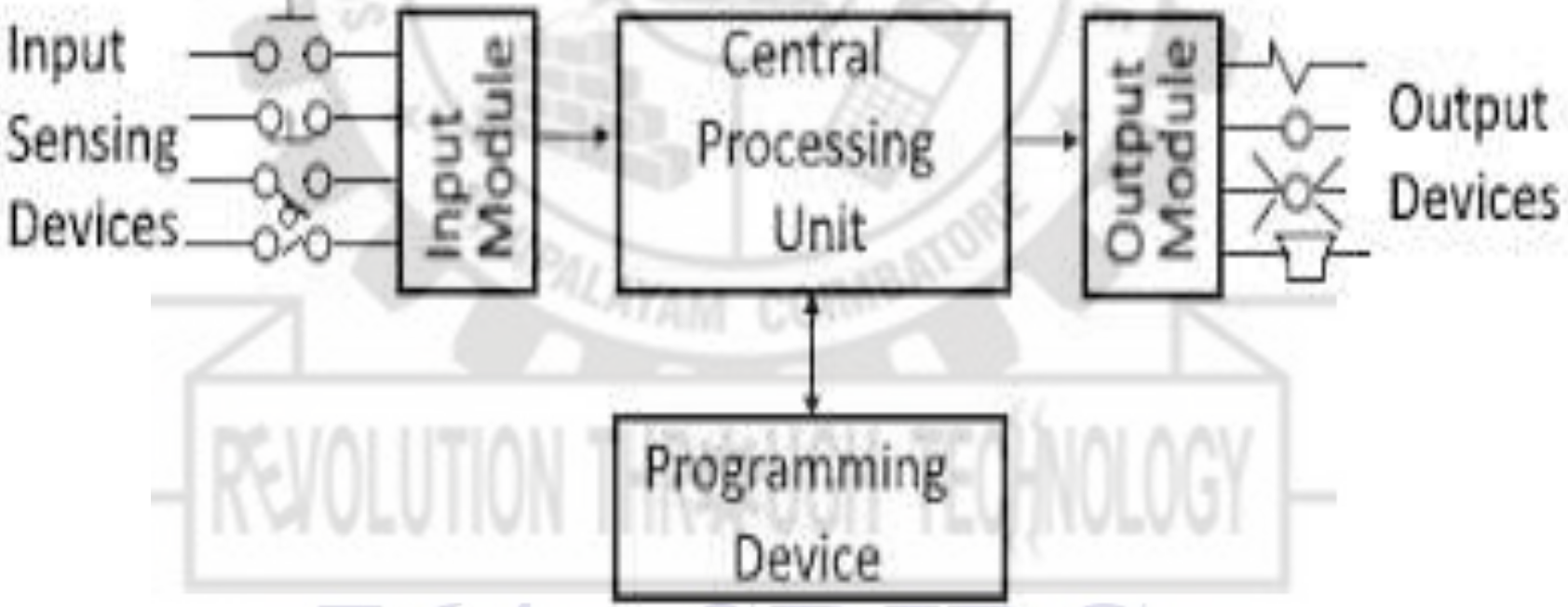
FEATURES OF PLC

- **Main Feature of PLC**
- High Reliability. Strong anti-interference quality and very high reliability are the most important features of PLC. ...
- Good Flexibility. There are several programming languages for PLC including ladder diagram, SFC, STL, ST and so on. ...
- Quality of Strong Easy-Operating.



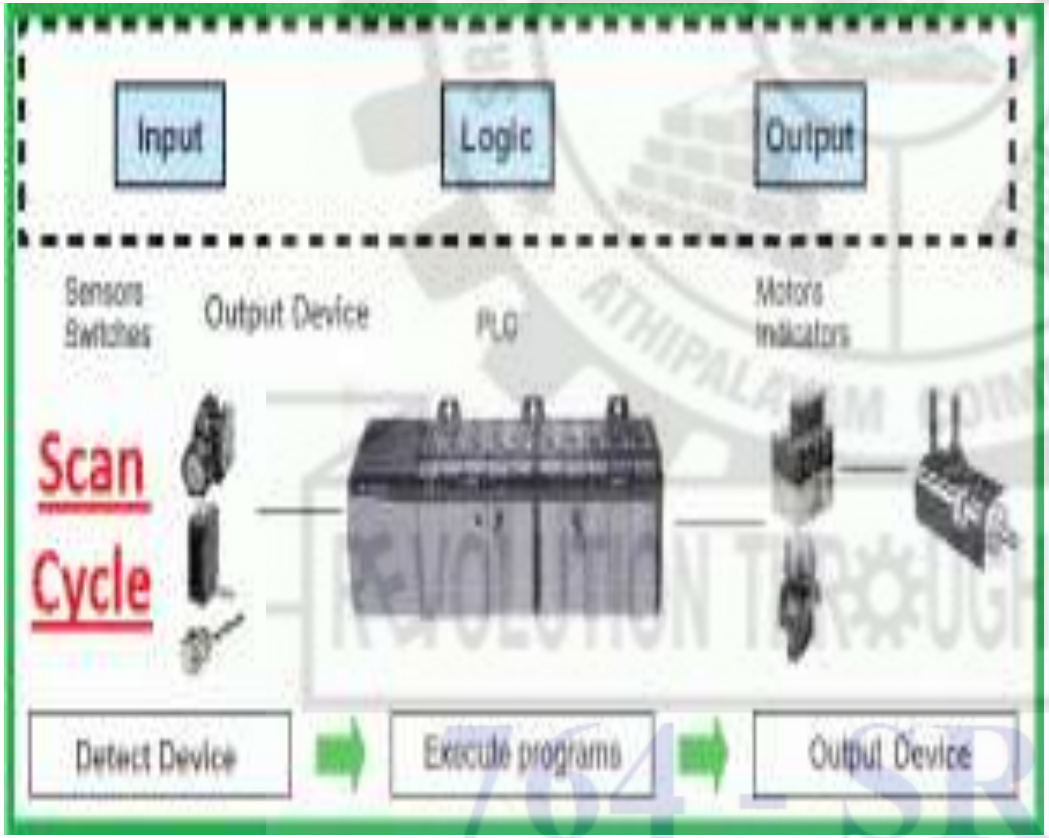
PLC Block diagram

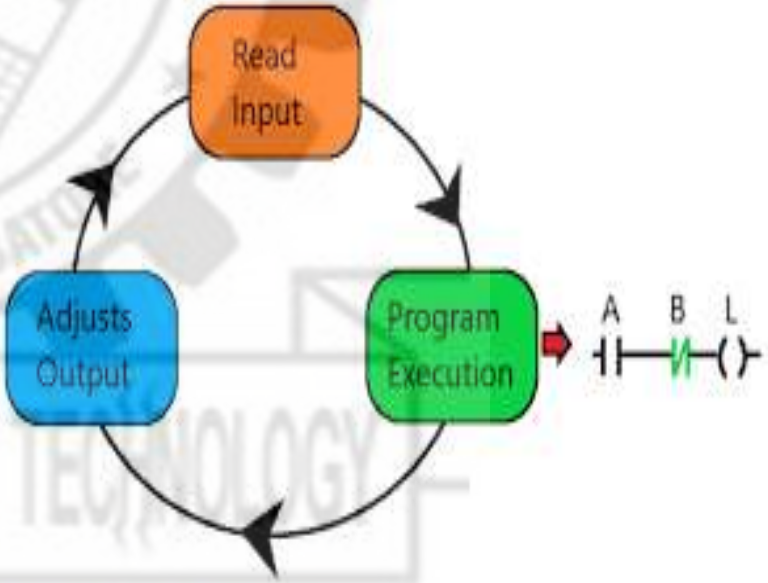
- Programmable Logic Controller is a short abbreviation of PLC. PLC is basically known as **'Primary Controller'** or **'Programmable Controller'**.
- In the enhancing mode and development of new technologies, the trend of PLC is evolving. It has become an integral part of the control system in an industrial environment.



PLC SCAN

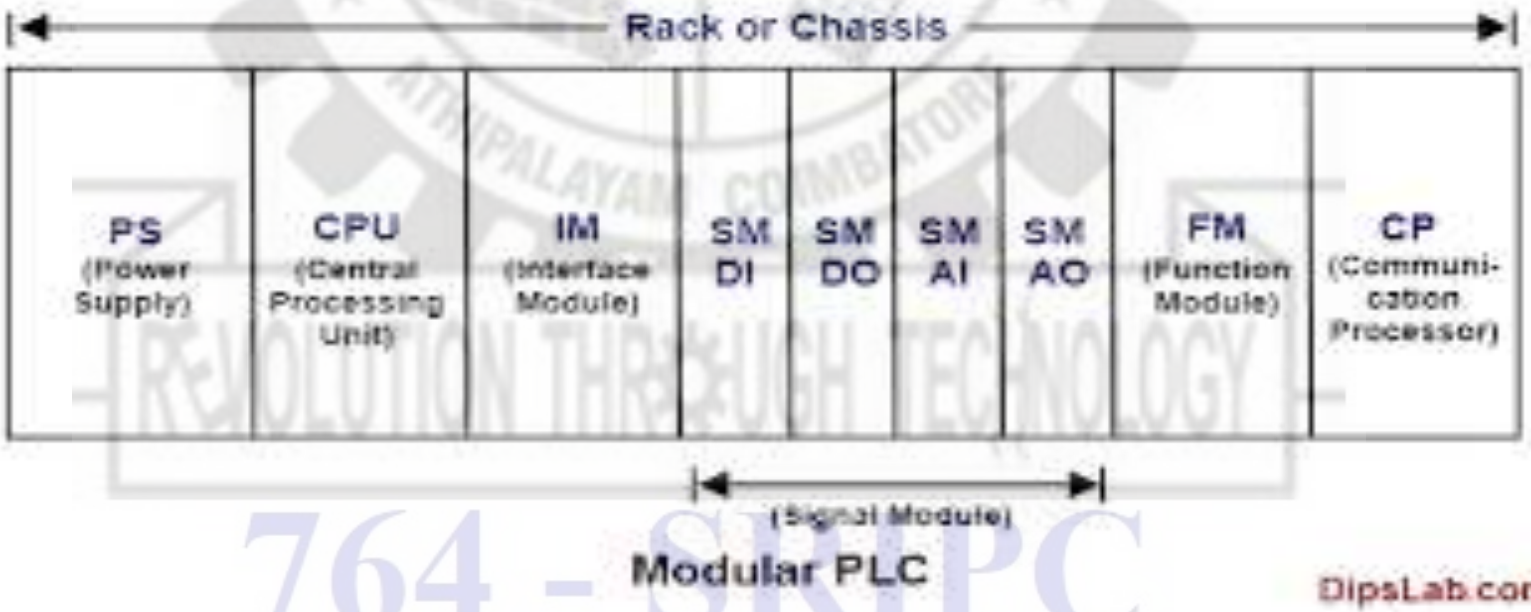
- Definition of PLC Scan Time
- **Time taken by the PLC to read the inputs, solve the Logic, and to write the output** is called a PLC Scan Time. These functions work in the loop it may vary its time taken for execution from 0ms to 150ms to a large till 1000ms.





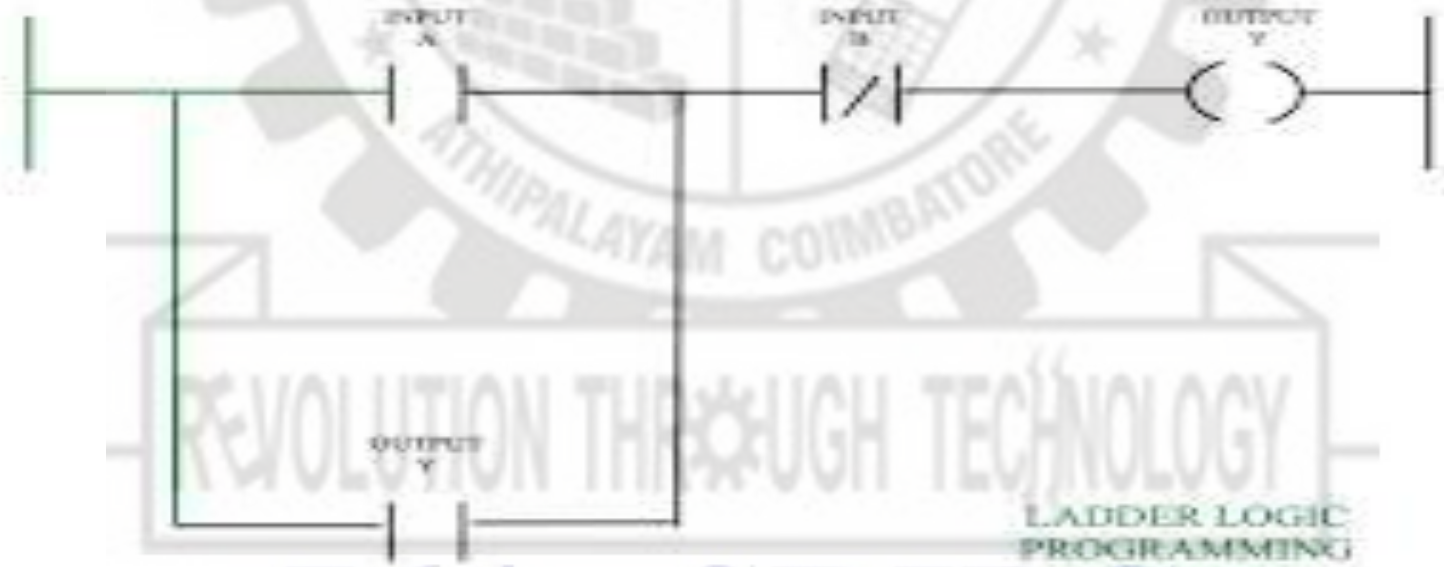
FIXED AND MODULAR PLC

As mentioned, PLCs have two main categories: modular or fixed. Both have the same basic functions. A PLC is much like a personal computer. It consists of a central processing unit (CPU) and an input/output (I/O) interface system. The difference between a PC and PLC is that PLCs handle multiple configurations and carry out control functions. All I/O systems consist of message or information carriers - inputs - and controllable devices - outputs. Any switches, sensors, or other similar devices are physically linked to the main I/O system and all of the activity throughout the entire system is controlled by the CPU.



LADDER LOGIC

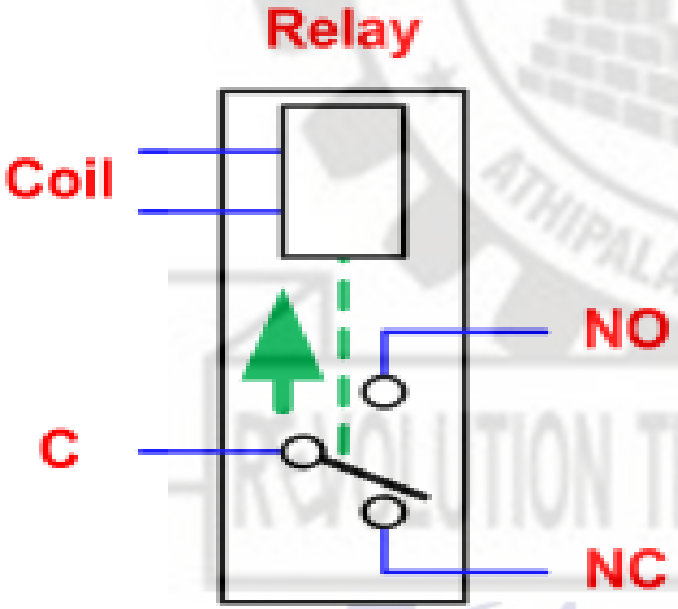
- One of the best visual programming languages is a PLC programming language called **ladder logic** or **ladder diagram (LD)**.
- The great thing about ladder logic is that it's much more visual than most programming languages, so people often find it a lot easier to learn.
- The smart thing about ladder logic is that it looks very similar to electrical relay circuits. So if you already know a little bit about relay control and electrical circuits, you can learn ladder logic even faster.

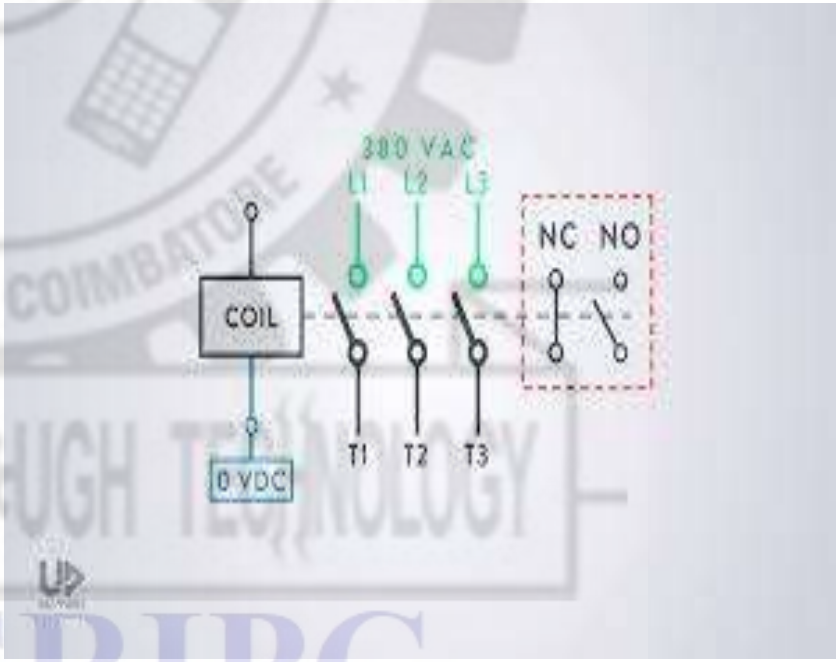


LADDER LOGIC PROGRAMMING EXAMPLE

NO, NC contacts

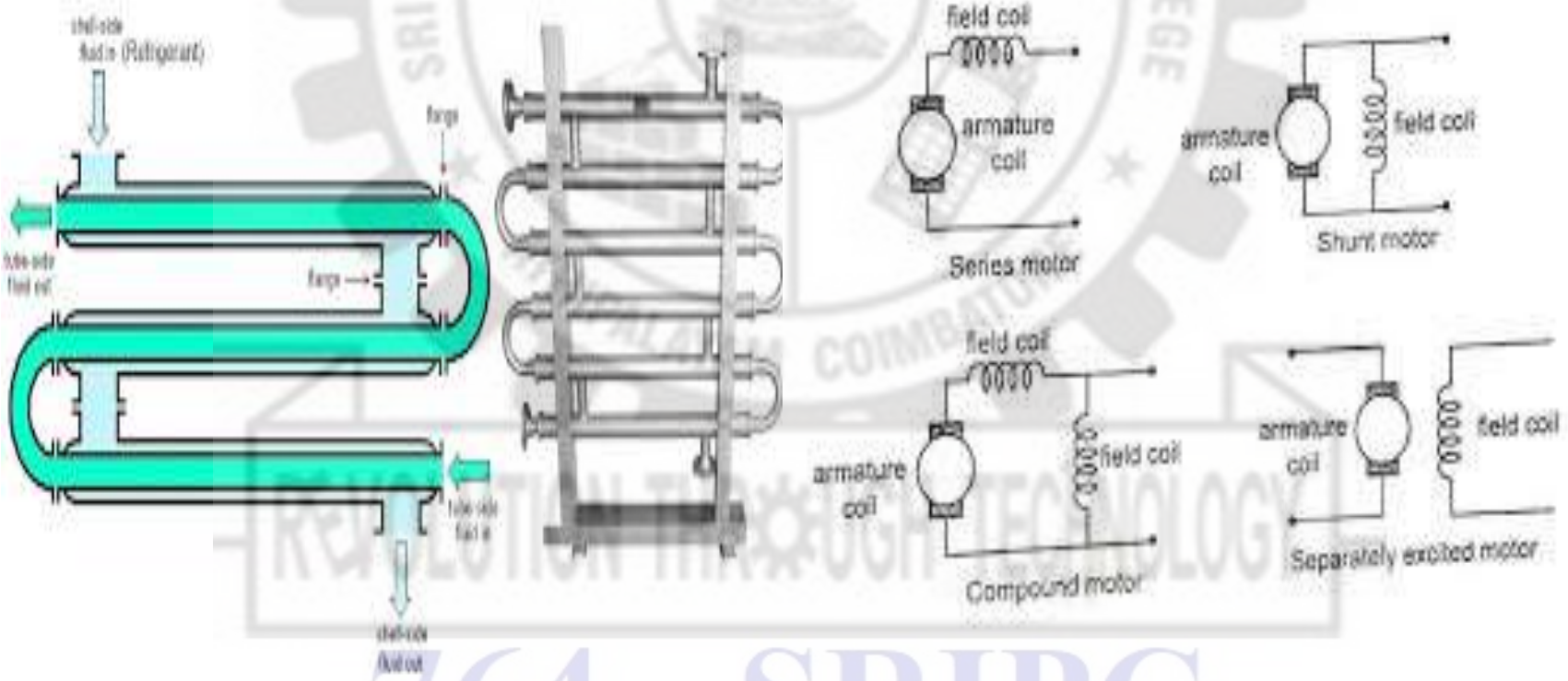
- We all know how normally closed and normally open sensors and contacts work and how they differ from each other.
- But have you ever noticed that why in emergency push buttons and stop push buttons we always use Normally Closed contacts? Or do you know what is the best solution for being aware of damage in a level switch cable?
- In this article, you'll find out the answer to these questions by some real-world examples and much more about NO and NC contacts.





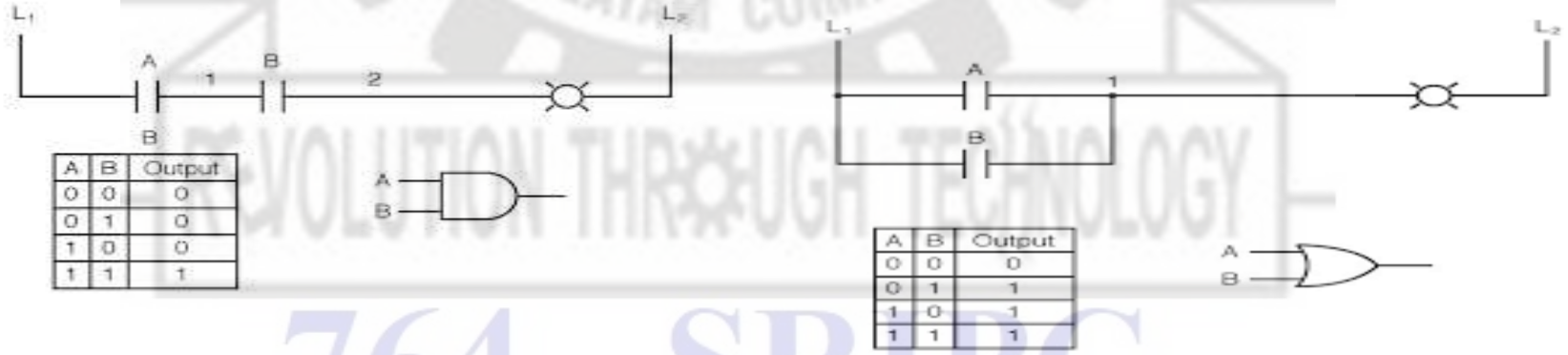
COILS

coil, in an electric circuit, **one or more turns, usually roughly circular or cylindrical, of current-carrying wire designed to produce a magnetic field or to provide electrical resistance or inductance**; in the latter case, a coil is also called a choke coil (see also inductance).



AND logic & OR logic.

1. The *AND gate* is so named because, if 0 is called "false" and 1 is called "true," the gate acts in the same way as the logical "and" operator. The following illustration and table show the circuit symbol and logic combinations for an AND gate. (In the symbol, the input terminals are at left and the output terminal is at right.) The output is "true" when both inputs are "true." Otherwise, the output is "false." In other words, the output is 1 only when both inputs one AND two are 1.
2. The *OR gate* gets its name from the fact that it behaves after the fashion of the logical inclusive "or." The output is "true" if either or both of the inputs are "true." If both inputs are "false," then the output is "false." In other words, for the output to be 1, at least input one OR two must be 1.




THANK YOU
SRI RANGANATHAR INSTITUTE OF POLYTECHNIC COLLEGE
ATHIPALAYAM COIMBATORE
REVOLUTION THROUGH TECHNOLOGY
764 - SRIPC