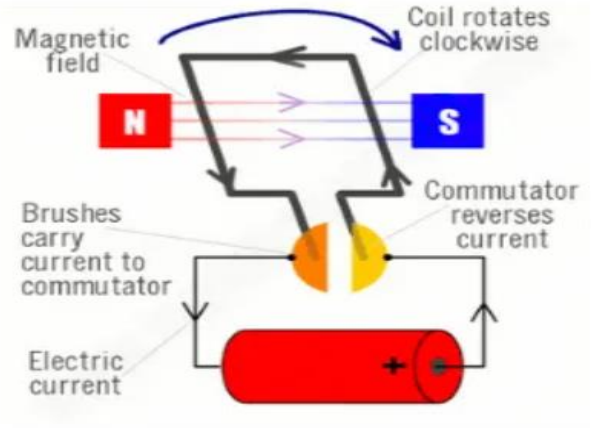
# Rugved Task-4

## 1. Motors

### I) Definition

An electric motor (or electrical motor) is an electric machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding. This interaction generates a force (as per Faraday's Law) in the form of torque which is applied to the motor's shaft.
Electric motors can be powered by direct current (DC) sources, such as batteries or rectifiers. Or by alternating current (AC) sources, such as inverters, electric generators, or a power grid.




### II) Types of Motors

There are three types of motors: -

- DC Motors
- AC Motors
- Other Motors

## a. DC Motors

The DC motor is another main type of electrical motor that only runs on DC or Direct Current. There are no phases in direct current that is why DC electric motors only uses 2 wires to run. They are the first motors to be invented. It is easier to control its speed by only varying the supply voltage. It offers simple starting, stopping, accelerating & reversing mechanisms. The installation cost of DC motor is very cheap but they do require maintenance whose cost increases significantly with increasing the size & power of the motor.

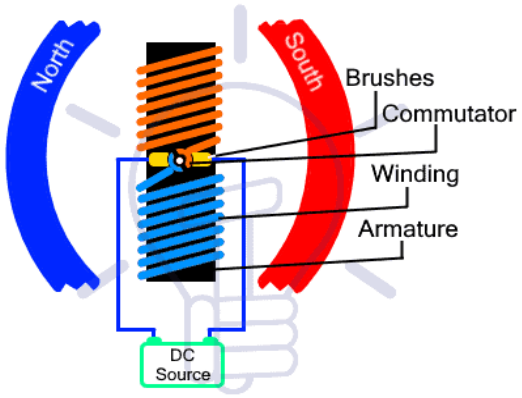
The basic working principle of DC motors is the Fleming's left hand rule. A current carrying conductor inside a magnetic field experience a force of thrust mutually perpendicular to each other.

The DC motors can be briefly classified into following types:-

- Brushed DC Motor
- Brushless DC Motor
- Coreless or Ironless DC Motors

### (i) Brushed DC Motor

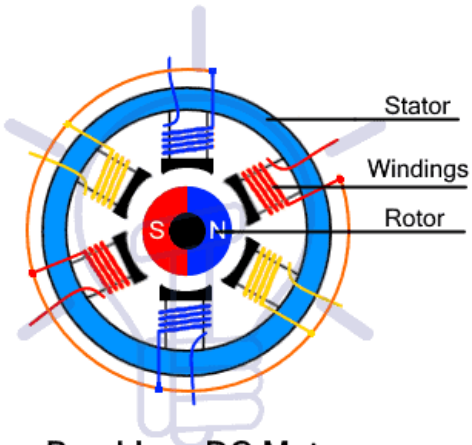
As the name suggests, such DC electric motors have brushes & commutators. They are used for connecting a stationary circuit with a rotating circuit. In such case, the rotor winding of the motor is energized through conductive brushes. The disadvantage of any brushed motor is that they require frequent maintenance due to continuous sliding of brushes & the sparks generated between them. However, they are quite simple in design & are in expensive.




Brushed Motor

## (ii) Brushless DC Motor

As the name suggests, Brushless or BLDC Motor is another main type of DC motor that does not have any carbon brushes & commutators assembly. It means the input power is not supplied to the rotating part of the motor but to the stator of the motor which in this case is made of multiple windings & the rotor is made of a permanent magnet.

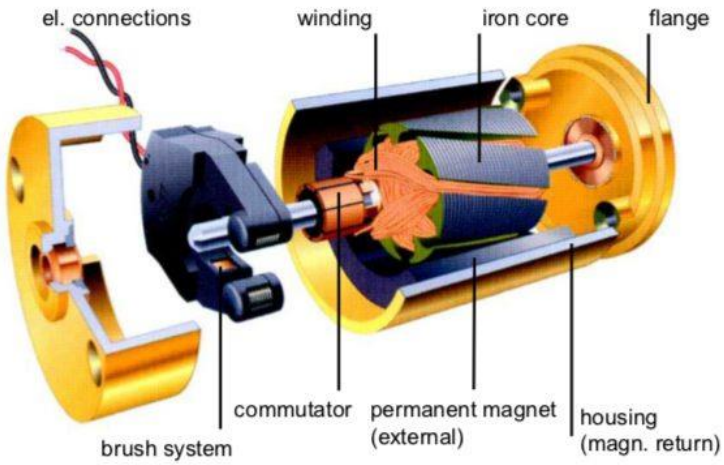


Brushless DC Motor

## (iii) Coreless/Ironless DC Motors

These are DC motors which have no laminated iron core. The rotor winding is wound in skewed or honeycomb shape to form a self-supporting hollow cage often made with using epoxy. The rotor made of permanent magnet sets in the hollow rotor.

The coreless design eliminates the issues & losses associated with the iron cores of the traditional motors. For example, such electric motors have no iron losses which increases the efficiency of the motor up to 90%. The design also reduces the winding inductance which reduces the sparks generated between the brushes & commutator thus increasing the lifetime of the motor. It also reduces the mass & inertia of the rotor which also increases the acceleration & deceleration rate of the motor.




## b. AC Motors

The AC electric motor converts AC (Alternating Current) electrical energy into mechanical energy. These electric motors are powered using a single-phase or three-phase alternating current. The basic working principle of AC motor is the rotating magnetic field (RMF) generated by the stator winding when an alternating current is passed through it. The rotor (having its own magnetic field) follows the RMF & starts rotation.

There are two types of AC Motors :-

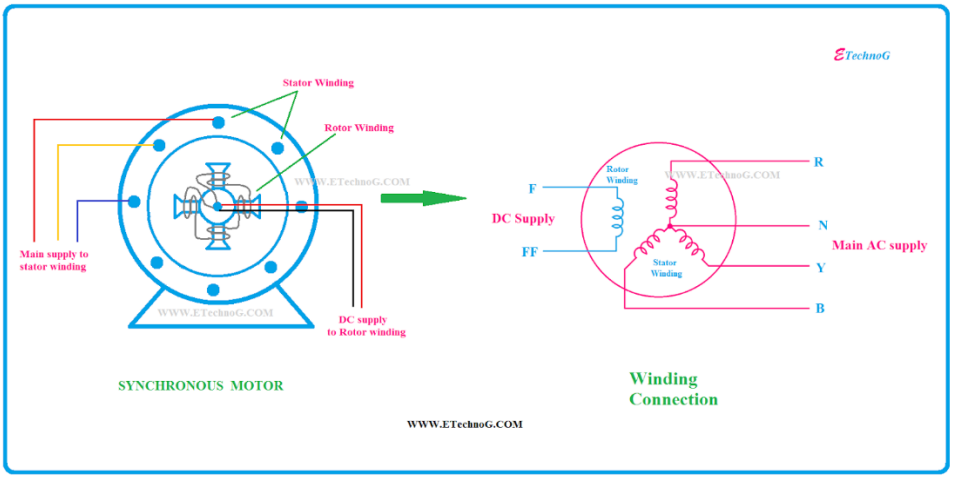
- Synchronous AC Motors
- Asynchronous AC Motors

### (i) Synchronous AC Motors

These are AC motor which have a constant speed called synchronous speed that only depends on the frequency of the supply current. The speed of such electric motors only varies with variation in supply frequency & remains constant upon varying loads. It is used for constant speed application & precision control.

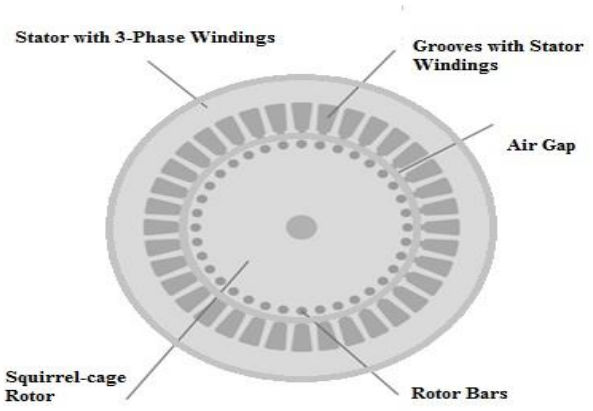
A synchronous motor has the same stator design as asynchronous motor & it generates a rotating magnetic field when supplied with input alternating current. While the rotor

design may vary i.e., it uses a separate DC excitation to generate its own magnetic field.




## (ii) Asynchronous AC Motor

An electric motor that works with alternating current is known as the asynchronous motor. These type of AC motors never run at synchronous speed and is called asynchronous speed. Its rotor speed is always less than the synchronous speed. It does not require separate rotor excitation.This motor mainly works on the induced current within the rotor from the rotary magnetic field of the stator. In this motor design, the movement of the rotor cannot be synchronized through the moving stator field. The rotating stator field of this motor can induce a current within the windings of the rotor. In turn, this current will generate a force to push the rotor in the direction of the stator. In this motor, as the rotor is not in phase with the stator, then the torque will be generated.



## c. Special Motors

There are several types of special electric motors that are the modified versions of other motor designed for special purposes. Some of these electric motors are given below.

- Servo Motor
- Direct Drive
- Linear Motor
- Stepper Motor
- Universal Motor

### (i) Servo Motor

Servo motor is a special type of motor used for pushing/Pulling or lifting or rotating an object at some specific angle. Servo motor can be designed to run on AC as well as DC power supply. Servo motor that runs on DC supply is called DC servo motor While those that runs on AC is called AC servo motor. It is a simple motor with a controller & multiple gears to increase its torque.

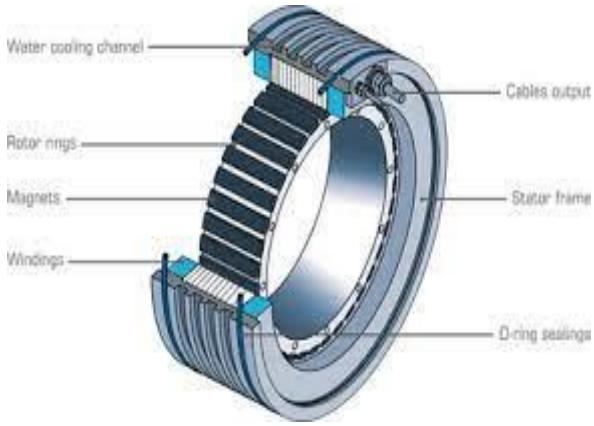
These motors are rated in kg/cm (kilogram per centimetre). It specifies much weight the servo can lift at a specific distance

The servo motor has a gear assembly, controller, a sensor, and a feedback system. The gear assembly is used to decrease the speed & increase its torque significantly. The controller is used for comparing the input signal (desired position) & signal from the sensor (actual position of the servo) which is acquired through the feedback system. The controller compares these two signals & eliminated the error between them by rotating the motor shaft.

Servo Motor

## (ii) Direct Drive

Direct drive motor or also known as torque motor is another type of motor that produces high torque at low speed even when it is stalling. The payload is directly connected to the rotor thus eliminating the use of gearbox, belts, speed reducers etc. It is a brushless permanent magnet synchronous motor with no commutators & brushes. Since there is no mechanical wear & tear, it reliable & has a long lifetime. The fact that it has fewer mechanical parts means it require less maintenance and low cost.



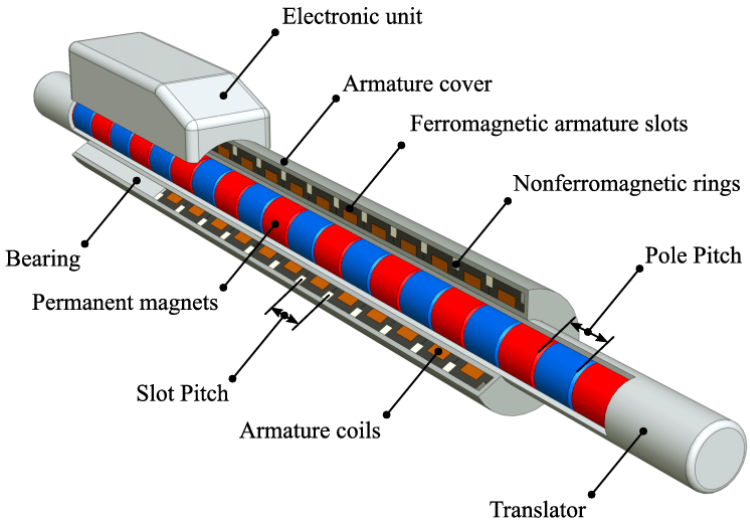

## (iii) Linear Motor

The linear motor has an unrolled stator & rotor that offers a linear force instead of rotational force. If you slice any motor & lay it flat on a surface, you will get a linear motor.

The armature windings are designed in a linear fashion which carries 3 phase current to generate a magnetic field. the magnetic field does not rotate instead moves in a straight line. The magnetic field interacts with the magnetic field generated by the flat permanent magnet lying below it. The interaction between them generates a linear force upon each other thus the armature moves forward or backward.

It is an AC powered motor with a controller such as in servo motor. The power is supplied to the primary part of the motor that contains windings. It generates its own magnetic field whose polarity depends on the phase of the AC supply. The secondary part of the motor is

permanent magnet whose magnetic field interacts with the magnetic field of the primary part & as a result attracts & repels it by generating a linear force. The amount of current determines the force while the rate of change of current determines the speed of the primary part.




## (iv) Stepper Motor

A stepper motor or a stepping motor is a brushless DC motor whose full rotation is divided into a few equal steps. Such motor rotates in steps (fixed degrees) instead of rotating continuously. Such stepping movement offers great precision which is utilized is robotics.

The stepper motor operates on pulses. Each pulse moves the motor by one step. The precision of the motor depends on the number of steps per revolution. The steps size is determined during its design. However, the speed of the motor can be controlled by applying the pulse train of variable frequency. The controller inside the servo motor moves forward or backward the rotor by one step upon each pulse.

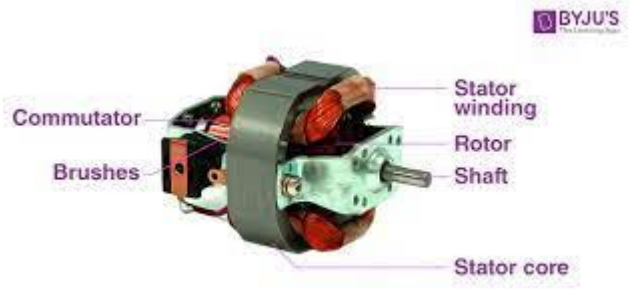
It is used for its accurate & precise positioning. It offers full torque at standstill. It has less maintenance requirement due to brushless design. Thus, they are very reliable & has long lifetime.

Stepper Motor

### (v) Universal Motor

The Universal motor is a special type of motor that can run on AC as well DC power supply. it is a brushed series-wound motor where the field windings is connected in series with the armature windings. They offer maximum starting torque with a high operating speed.

Since the windings are connected in series, the direction of the current through both windings remains the same even if the current direction reverses multiple times in a second. Although, the motor may run slower on AC due to the reactance of the windings.




## III) Applications

The applications of electric motors primarily include fans, blowers, machine tools, turbines, pumps, power tools, compressors, alternators, rolling mills, movers, ships, and paper mills. The electric motor is an important device in various applications like high voltage AC heating, cooling & ventilating equipment, motor vehicles, and home appliances.

# 2. Motor-Drives

## I) Definition

Motor drives are electronic devices that control torque, position outputs and motor speed. As power goes into the motor, the drive modifies it so that your motor has the needed output. The terms “motor controllers” and “motor drives” are often used interchangeably since controller circuits are usually combined with drive circuits to produce a single unit.

## II) Types of Motor-Drives

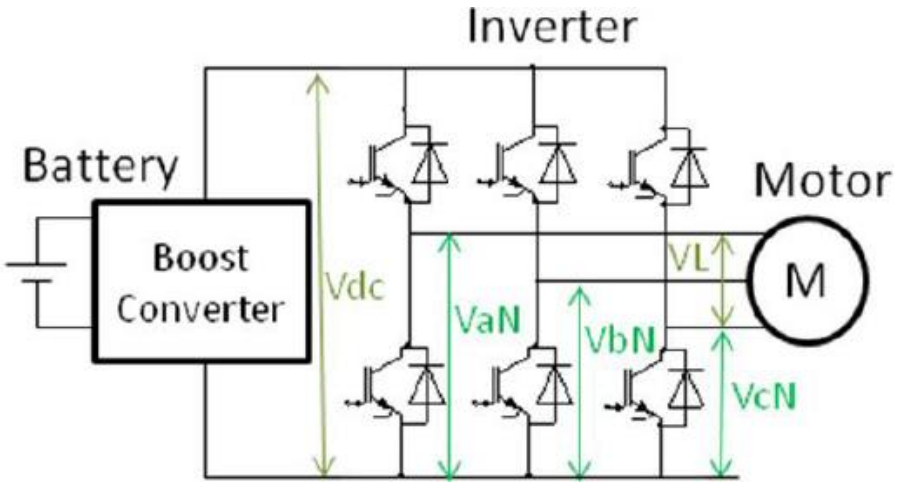
There are 4 types of Motor-Drivers:-

- AC Motor Drivers
- DC Motor Drivers
- Servo Motor Drivers
- Stepper Motor Drivers

### a. AC Motor Drivers

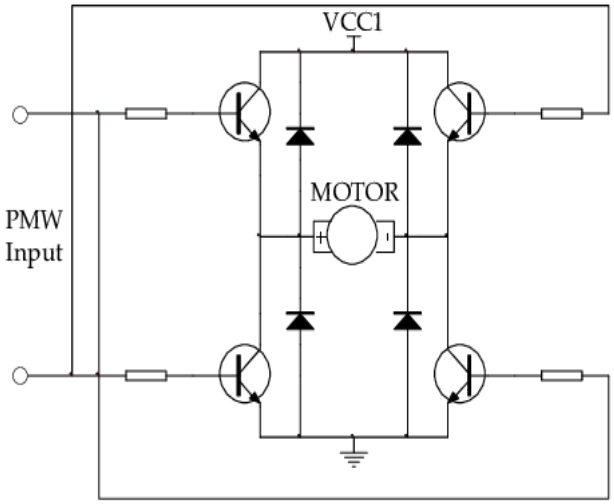
AC Motor Drives are electronic devices that modify the input power to motors by typically adjusting the frequency of the power to the motor for the purpose of regulating the output speed and torque. Key specifications include the intended application, drive operating mode, motor type, inverter type, loop system voltage classification, power rating, communication interface, as well as input and output electrical specifications.

They are used primarily in process applications to control the speed of pumps, fans, blowers, etc. They are known as variable speed drives, adjustable frequency drives, or AC inverters. The controller, commonly integrated with the drive circuits, supplies the control signals to the drive.



## b. DC Motor Driver

DC Motor Controllers and Drives are electrical devices that modify the input power by adjusting the constant or alternating current source to a pulsed, direct current output of varying pulse duration or frequency. Key specifications include the intended application, drive operating mode, motor type, loop system, voltage classification, power rating, output signal type, communication interface, as well as input and output electrical specifications. DC motor controllers and drives are used primarily to control motor speeds and torques for machine tools, electric vehicles, pumps, etc. The controller, commonly integrated with the drive circuits, supplies the control signals to the drive.




## c. Servo Motor Driver

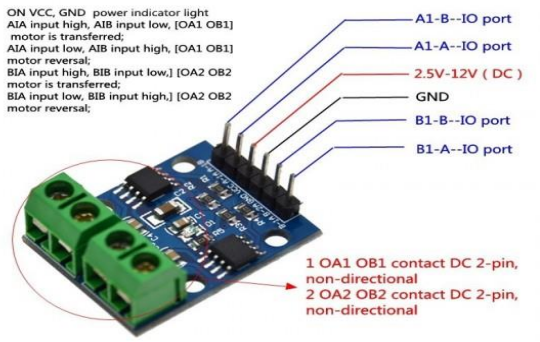
Servo Motor Drivers are electronic devices that modify the input power by adjusting the constant or alternating current source to a pulsed, current output of varying pulse duration or frequency. Key specifications include the intended application, motor type, drive operating mode, loop system, power rating, output signal type, communication interface, as well as electrical specifications. Servo motor controllers and drives are used primarily in motion control applications in manufacturing and construction environments, among others, and used to control motor speeds, torques, and positions, and may be AC or DC driven. Servo motors are used in many applications including machine tools, micro-positioning, and robotics, among many other types of machinery, such as conveyors or spindle drive systems.

### d. Stepper Motor Driver

Stepper Motor Drivers are electronic devices that modify the input power by adjusting the constant or alternating current source to a pulsed, or "stepped," current output.

Key specifications include the intended application, motor type, drive operating mode, loop system, power rating, output signal type, communication interface, as well as electrical specifications.

Stepper motor controllers and drives are used primarily in motion control applications in manufacturing and construction environments, among others, and used to control motor speeds, torques, and position. They are used in many applications including machine tools, micro-positioning, and robotics, among many other types of machinery, such as conveyors or OEM equipment. The controller, commonly integrated with the drive circuits, supplies the control signals to the drive. Stepper drives are also known as pulse drives and step amplifiers. Stepper controllers are also known as motor indexers.




## III) Applications

AC motors drives are used to control the speeds of motors that drive pumps, fans, etc. where traditional valves or dampers might otherwise be used to throttle the flow. AC motor drives are used to increase efficiency by setting pump, fan, etc. speed to exactly match requirements.

DC motor drives are used to control permanent magnet DC motors running from AC sources. DC motors have very good low-speed torque, making them especially suited to winches, cranes, etc. where loads have to be lifted without a “running start.” Before the advent of

electronic DC controls, DC motors we often coupled as motor-generator sets to produce direct current via AC induction motors.

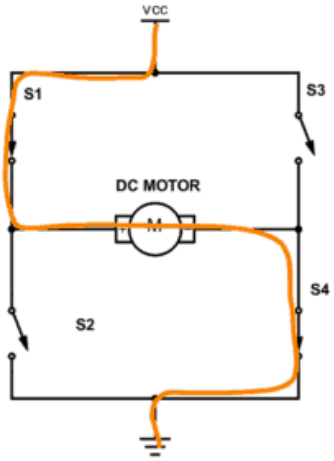
Servomotor controllers and drives rely on feedback from the servomotors to control position, velocity, acceleration, etc. Servomotor manufacturers generally supply drives that work with their motors. While steppers don't require a feedback loop, some use one. Stepper motor manufacturers also usually supply drives for their specific motors. Most servo- and stepper-motor manufacturers provide charts as guides to which motors will work with which drives.

# 3. H-Bridge

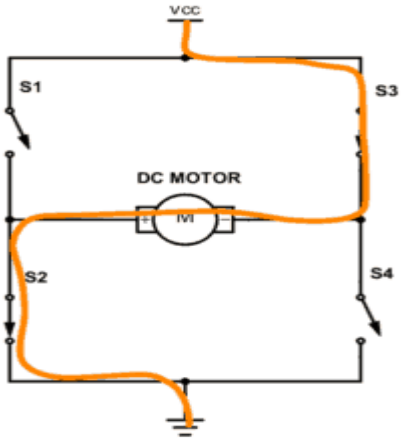
## I) Definition

An H-bridge is a simple circuit that lets you control a DC motor to go backward or forward. A DC motor spins either backward or forward, depending on how you connect the plus and the minus.

If you close switch 1 and 4, you have plus connected to the left side of the motor and minus to the other side. And the motor will start spinning in one direction.




If you instead close switch 2 and 3, you have plus connected to the right side and minus to the left side. And the motor spins in the opposite direction.



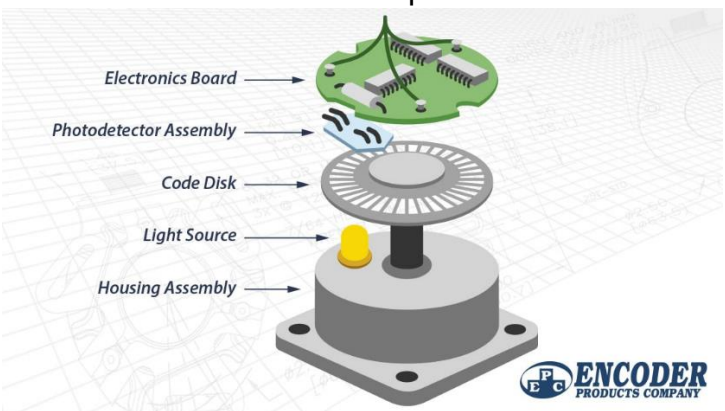

### II) Applications

1. The most important application of the H-Bridge circuit as the motor driver circuit.
2. In Robotics Technology, H-bridge circuits are used.
3. H-Bridge circuit is also used as Inverter circuit.
4. In modern battery charger for electrical vehicles, H-bridge circuits are used.

## 4. Encoders

### I) Definition

An encoder is a sensing device that provides feedback. Encoders convert motion to an electrical signal that can be read by some type of control device in a motion control system, such as a counter or PLC. The encoder sends a feedback signal that can be used to determine position, count, speed, or direction. A control device can use this information to send a command for a particular function.



## II) Types of Encoders

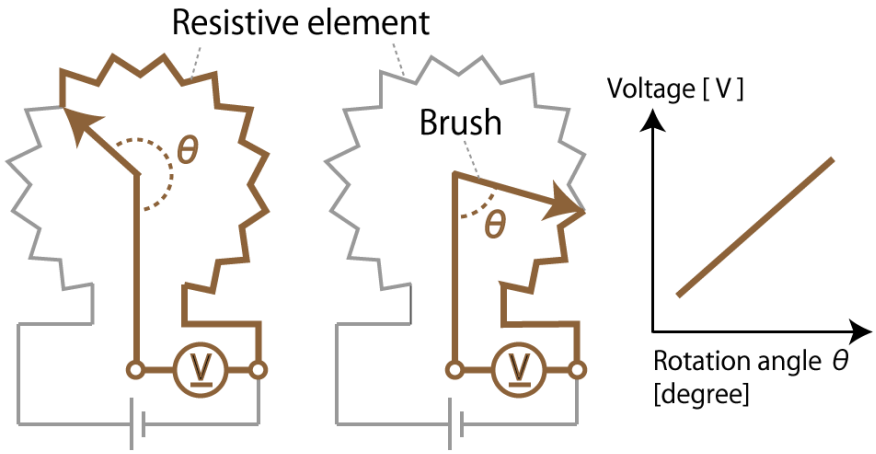
An encoder is divided into four types

- Mechanical Induction
- Optical Induction
- Magnetic Induction
- Electromagnetic Induction

### a. Mechanical Induction Encoder

This method detects the rotational position with a variable resistor whose electrical resistance change in proportion to the rotation angle. Such a mechanical encoder is generally called a potentiometer.

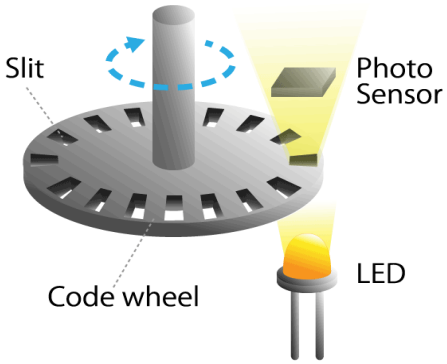
When the slider moves on resistors, the resistance value of the potentiometer changes in proportion to the moving distance of the slider.




### b. Optical Induction Encoder

This is a method that uses a light sensor to detect whether light passes through a slit in the radial direction of a rotating disk called a code wheel attached to the motor shaft.

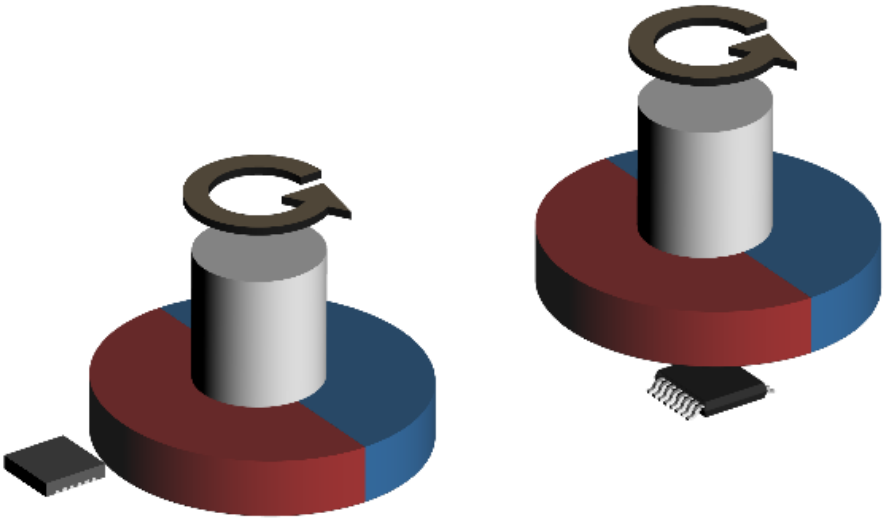
The light pulse signal changes as it passes through the slit, and the amount of rotation of the motor shaft can be detected by counting the number of pulses.




## c. Magnetic Induction Encoder

This method uses a magnetic sensor to measure changes in the magnetic field distribution created by a permanent magnet attached to the motor shaft.

When the motor rotates, the magnetic field distribution of the permanent magnet also changes, so if you detect it with a magnetic sensor, you can determine the rotational position of the motor shaft.

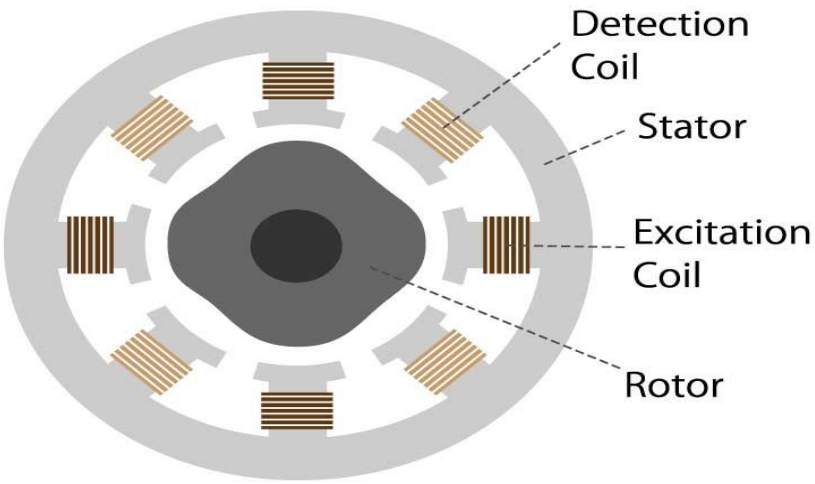


## d. Electromagnetic Induction Encoder

This method reads changes in the magnetic field generated between the induction coil (excitation coil) and fixed coil (detection coil) attached to the motor shaft.

The basic principle is the same as a transformer using electromagnetic induction, and such an encoder is called a resolver.

The power supply to the rotating induction coil of the resolver has a risk of wear due to the contact method using a brush. However, there is a VR (Variable Reactance) resolver that improves this risk.




## III) Applications of Encoders

1. Industrial processes
   Most of the processes in the latest industries are automatic, non-stop, and redundant. Such a process can be controllable with a computer. These processes could be simple and complex like, PCB board fabrication, hole drilling, component placement, and testing a PCB board. Each motion of the machine in such industries is measured by encoders.

2. Robots
   Robotic arms have increased the productivity of industries and increased the precision of products. A robotic arm is like a human arm that contains multiple joints like the shoulder, elbow, and wrist. The motion of the robotic arm is measured by encoders.

3. Actuators
   Motors are commonly used actuators with gear assembly to increase or decrease the output torque. A simple 3D printer is also using a motor as an actuator in a linear slide by controlling the motion of the electric motor. The motion of the slide is monitored with encoders.

4. Servomotors
   A servomotor is a closed loop motor. Where the motor is commanded to a certain target angle and speed. With the help of

an encoder, it detects if the motor has achieved the target or not. The motor will try unless and until achieve the targeted speed and angle. A servo motor is an assembly of an AC or DC brushless motor, a Servo amplifier or driver, and an encoder.