



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Electric Motors



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Introduction

Electric Motor is one of the main components in Electric Vehicles. Electric Machines can be used to drive the power train and as well as to generate power. When an input electrical energy is converted to mechanical energy to drive the vehicle, machine is known as an electric motor and when the mechanical energy is converted to electrical energy while braking the machine is known as electric generator. In braking mode, the power flow will be in opposite direction, so it is called as regenerative braking.

The electric motor is the sole propulsion unit in electric vehicles (EVs). While in hybrid electric vehicles (HEVs), the electric motor and the internal combustion (IC) engine together in a series or parallel combination provide the propulsion power. In both EV and an HEV, the electric motor converts electrical energy from the energy storage unit to mechanical energy that drives the wheels of the vehicle. The major advantages of an electric motor over an IC engine are that the motor provides full torque at low speeds and the instantaneous power rating can be two or three times the rated power of the motor.

Big question comes into our mind that, which electrical motors can be used for traction of EV and selection of motors are important.

Cont....



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

There are several choices for electric drive motors selection based on different parameters:

- **Electrical Supply:** Electric motors can be operated with two types of supply, DC and AC.
- **Efficiency:** AC machines are more efficient than DC machines.
- **Ease of Control:** AC machines can be controlled easily than DC machines
- **Converters:** AC machines requires the converters to convert the DC storage power to AC to run the AC machines.

Construction of Electric Machines

Both DC and AC machines mainly consists of two main parts: stator and rotor. By the name itself stator is a static part used to create magnetic field and rotor is a rotating part in electrical machines. The other parts of the electric machines are given as below:

➤ **Armature**

The main component of an electric machines is called an armature. This part carries the current flowing in a motor and rotates normally during operation to produce torque via the action of current flow in its windings. It can be used to hold the windings in slots, and to provide a low reluctance path to the magnetic field. The laminated steel pieces are used in armature core to reduce the eddy current losses.

Cont....



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

➤ **Commutator**

This is also called as mechanical switch to convert the produced alternating current into unidirectional current. The commutator is an important part in an electric motor that allows constant rotation by changing the direction of current in the windings each time they reach the minimum flux point. The alternating magnetic poles continue to provide the push to overcome losses to reach a terminal speed. Under loaded conditions, the motor withdraws more current.

➤ **DC Motor Types**

There are so many applications are to be run through the electric motors in the world. Each application has its own specific requirements. Electric motors are classified into several types based on the application type. DC motors are divided into the following forms:

- Shunt
- Series
- Compound
- Brushless
- Permanent magnet
- Universal

Cont....

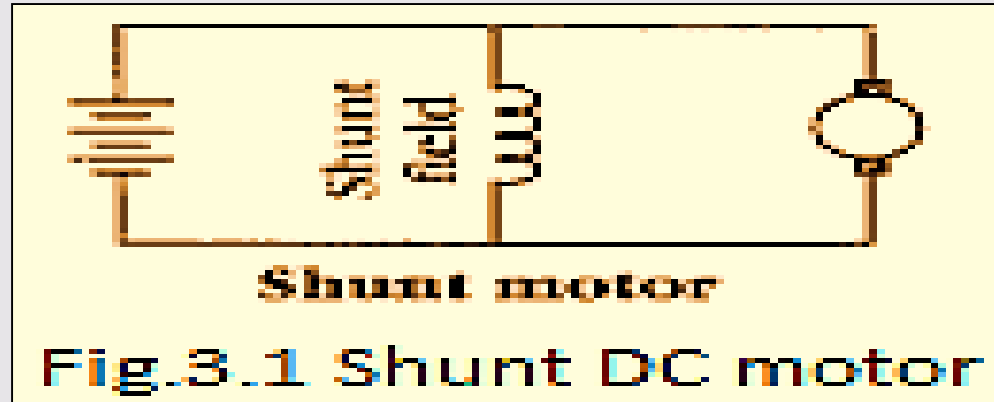


Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Shunt DC Motors

The simple construction of DC motors is the shunt DC motor. In this type, the field winding and armature are connected in parallel. The field winding is wound on stator and armature winding is wound on rotor. Usually, field winding carries a little current as compared to the armature current. The connection diagram of shunt DC motor is shown in the figure 3.1



Series DC Motors

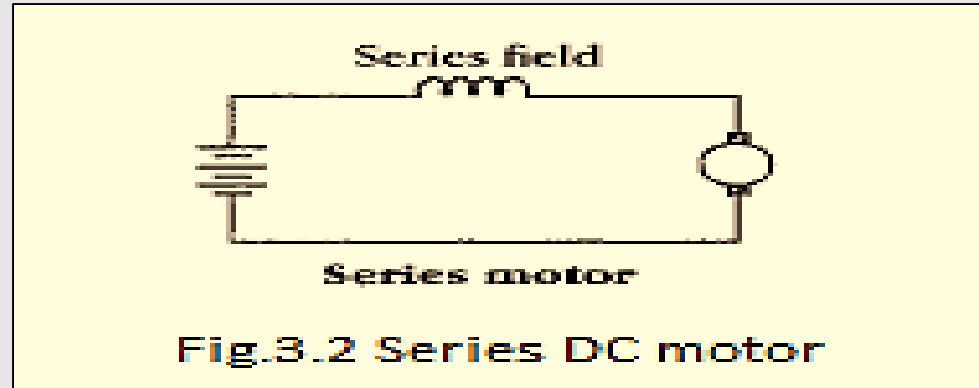
In series DC motors, the field winding and armature are connected in series. Like, DC shunt motor, the field winding is wound on stator and armature winding is wound on rotor. As both field and armature windings are connected in series, both windings carry same current. This series DC motors are mostly used for traction applications due to high starting torque. The connection diagram of shunt DC motor is shown in the figure 3.2

Cont....



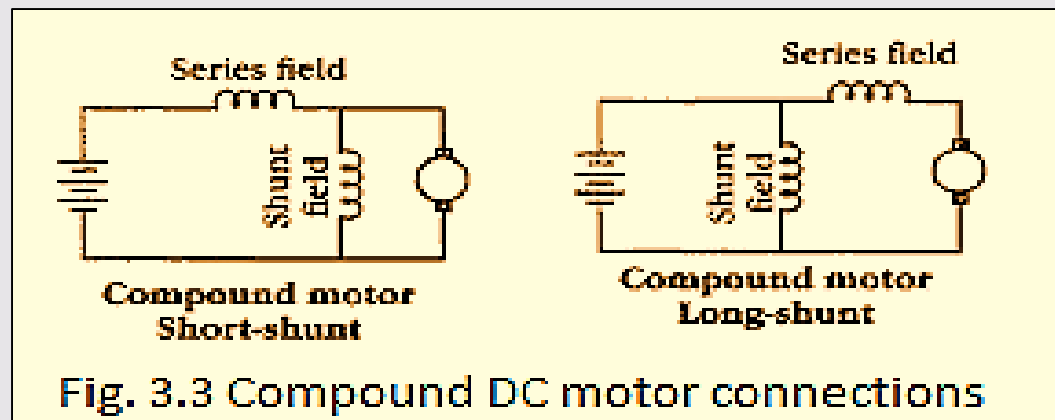
Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*



Compound DC Motors

Compound DC motors are combination of the series and shunt DC motors. Compound DC motors can be further classified based on the way its windings are connected. Two different connections are shown in the figure 3.3.



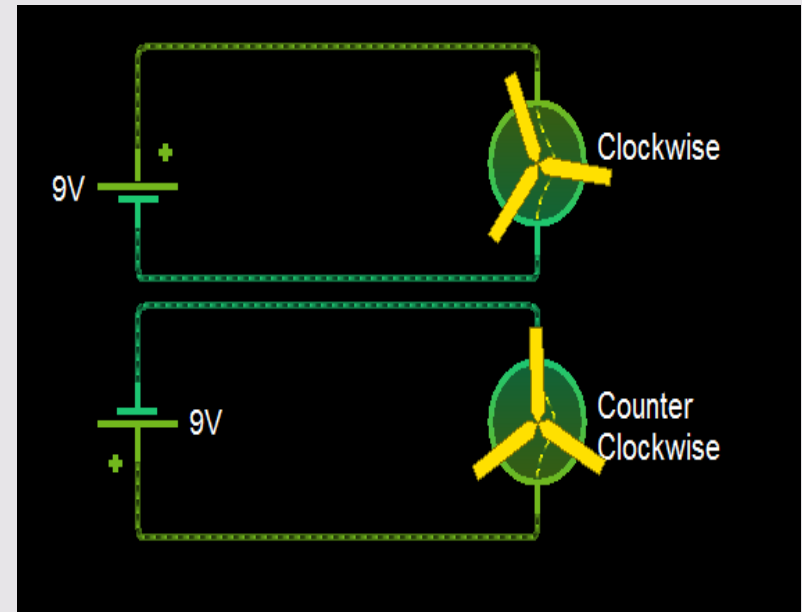
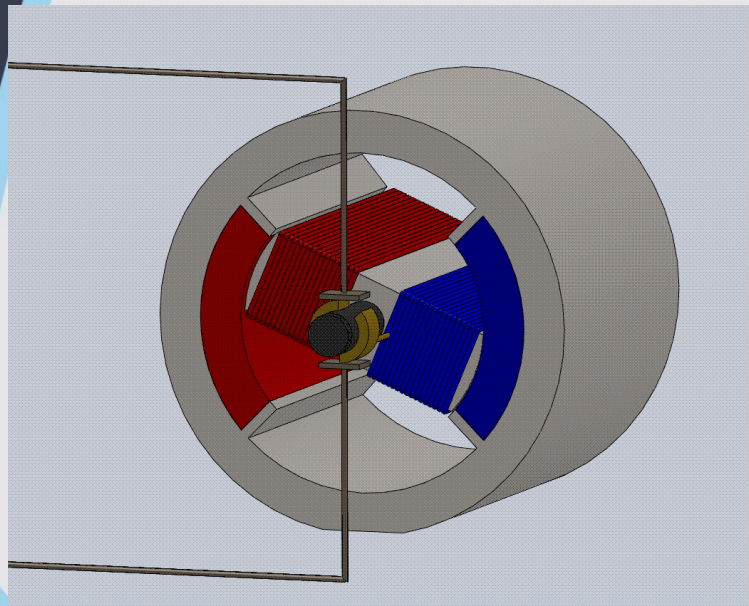
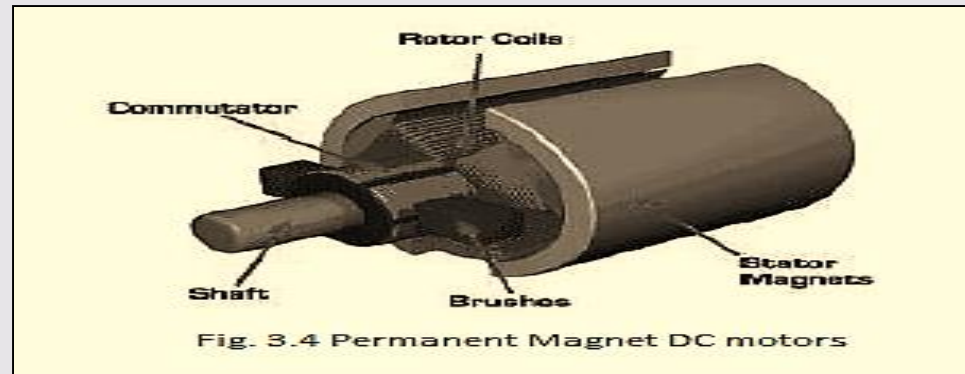
Cont....



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Because of their simplicity, permanent magnets were used as field coils to create the magnetic flux. Permanent magnet motors are being increasingly used today because of smaller and lighter in weight than equivalent wound field coil motors of the same horsepower rating. The permanent magnet DC motors are shown in figure 3.4.



Cont....

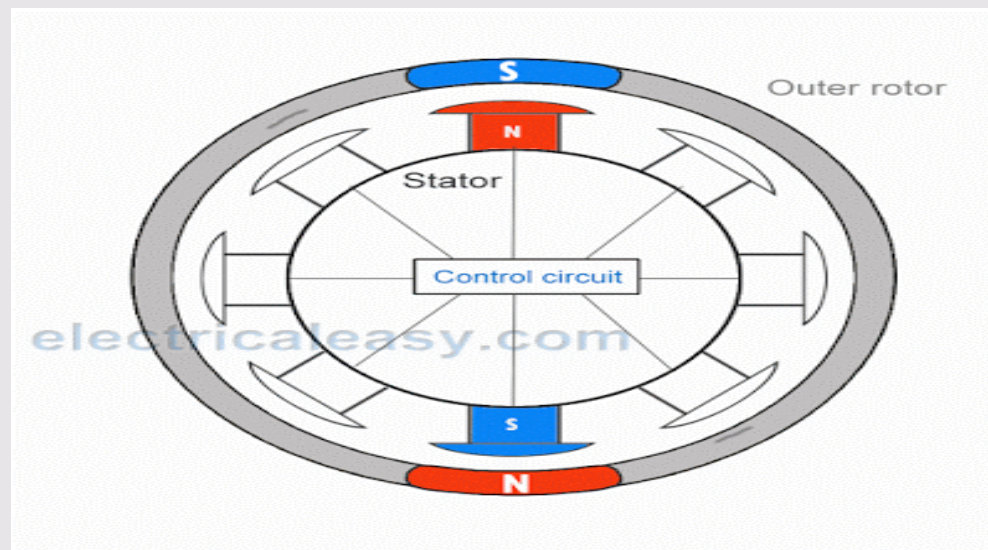
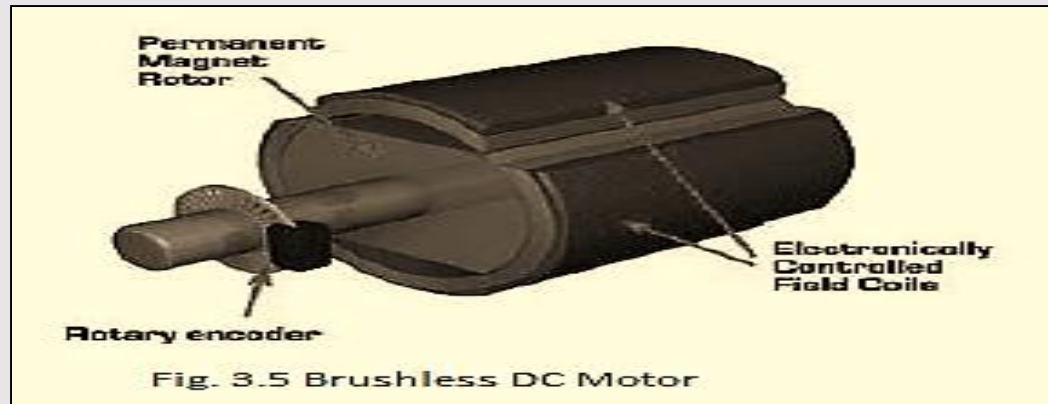


Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Brushless DC Motors

Because of the losses in brushes in the DC motors, brushless motors are used to prevent the losses occurred due to brushes there by increase the efficiency of the motors. The brushless DC motor is shown in the figure 3.5.

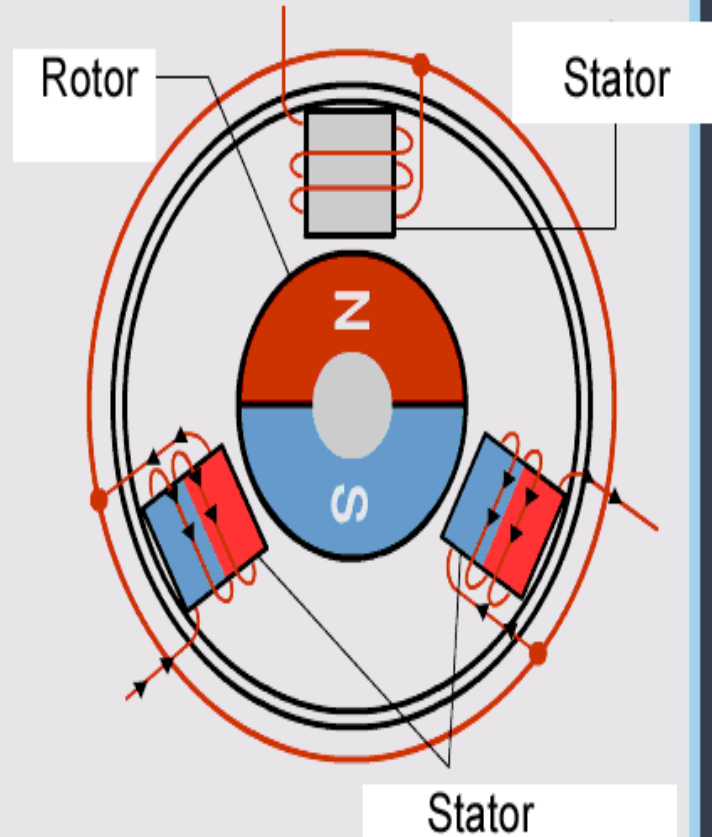
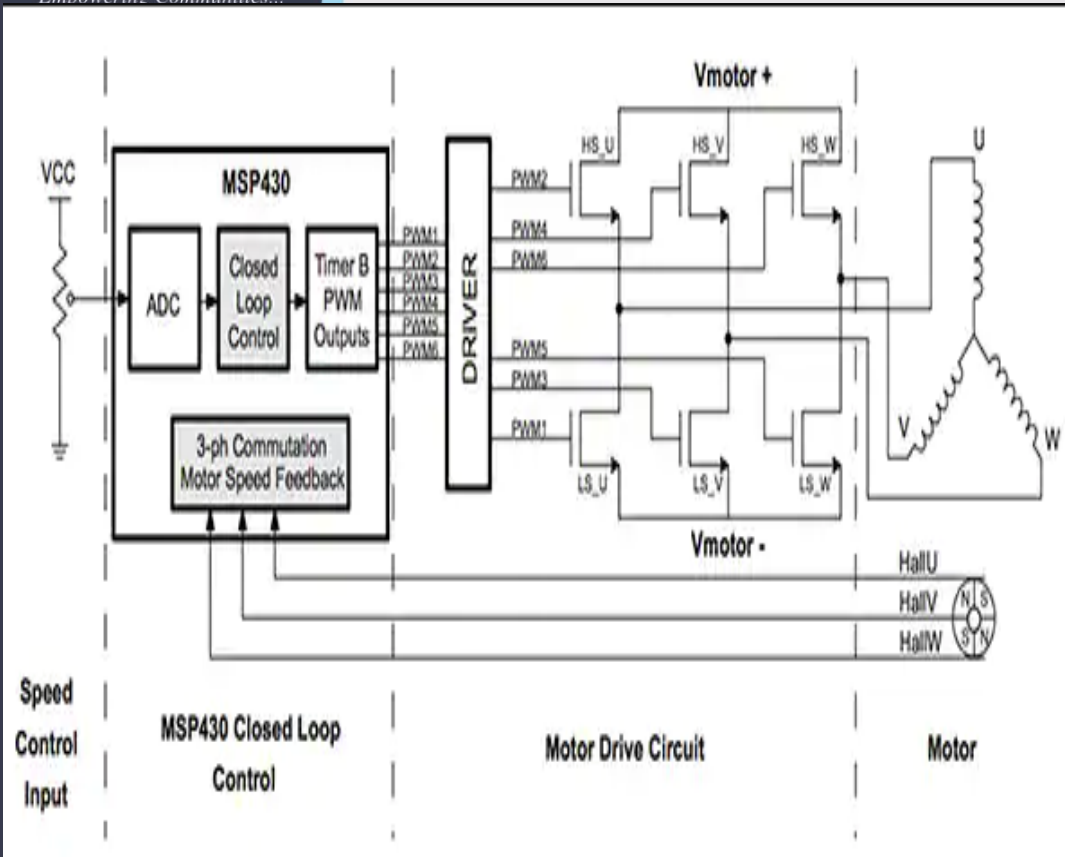


BLDC



Centurion
UNIVERSITY

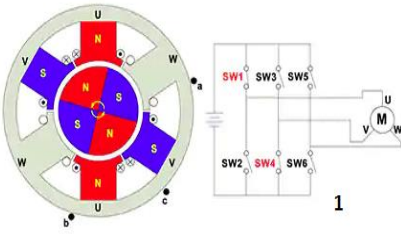
Shaping Lives...
Empowering Communities...



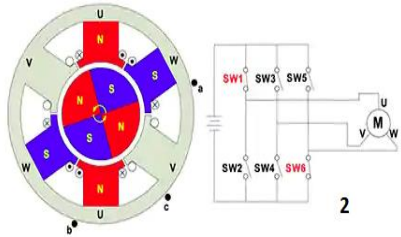
BRUSH LESS DIRECT CURRENT (BLDC) MOTOR



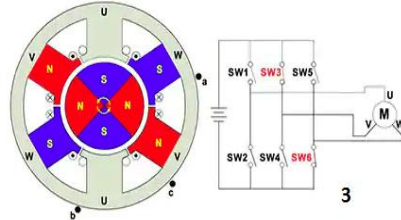
Centurion



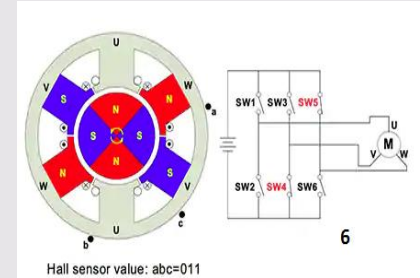
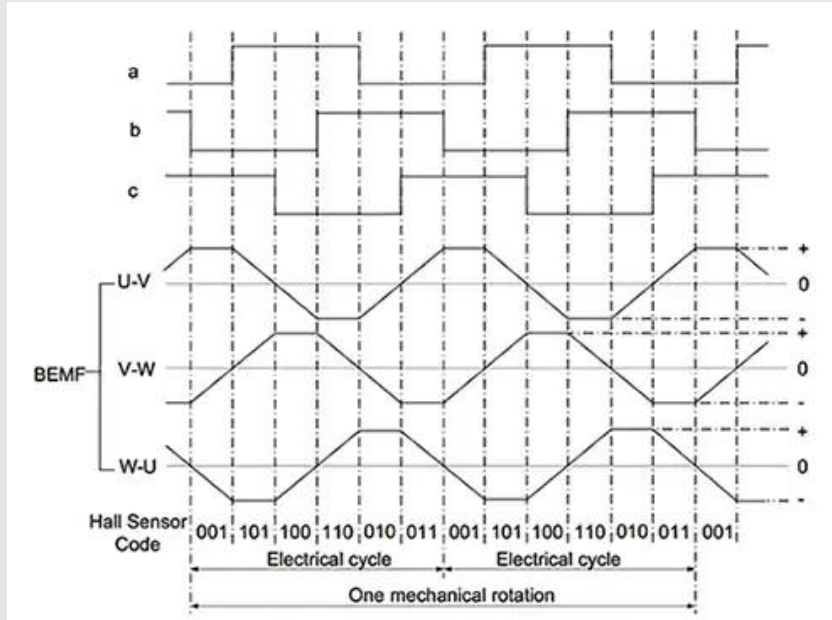
Hall sensor value: abc=001



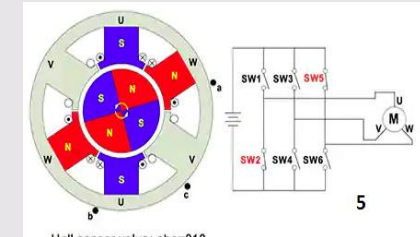
Hall sensor value: abc=101



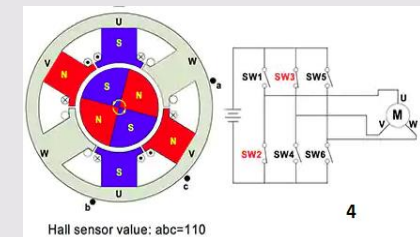
Hall sensor value: abc=100



Hall sensor value: abc=011



Hall sensor value: abc=010



Hall sensor value: abc=110

BRUSH LESS DIRECT CURRENT (BLDC) MOTOR

Picture from google.com

Cont....

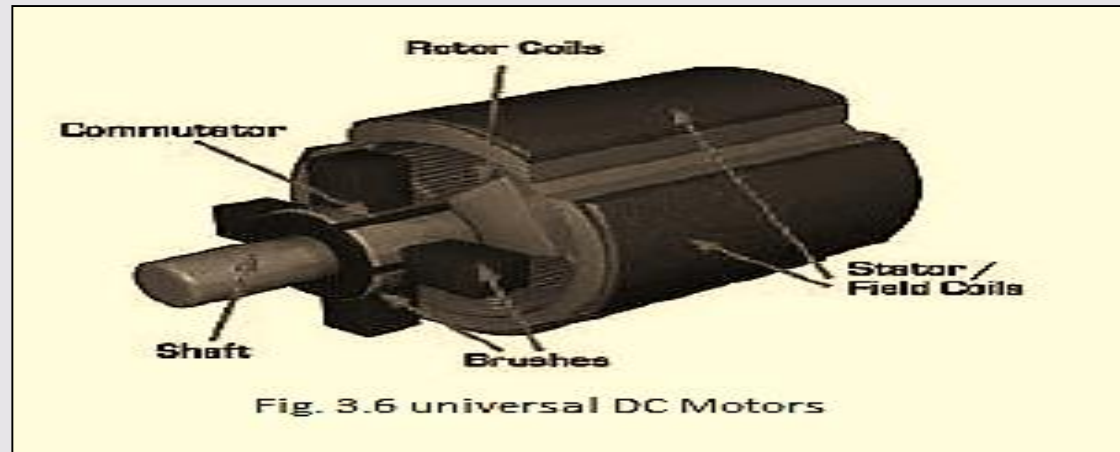


Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Universal DC Motors

Universal motors are those run on both power supplies AC and DC. Some DC motor types does run on AC and some might not start at all. Design of DC motor should be changed to make it run on AC as well. The universal DC motor is shown in figure 3.6



AC Electric Motors

AC Induction Motors

When an alternating current (AC) is applied to the primary winding which is stationary part called as stator, the varying magnetic field produces which in turn cuts the rotor windings which are in stationary initially via induction. This rotating part (rotor) has a rigid conductors s attached to the motor's shaft. There is no need for any commutator or brushes, as energy is received by the rotor

Cont....



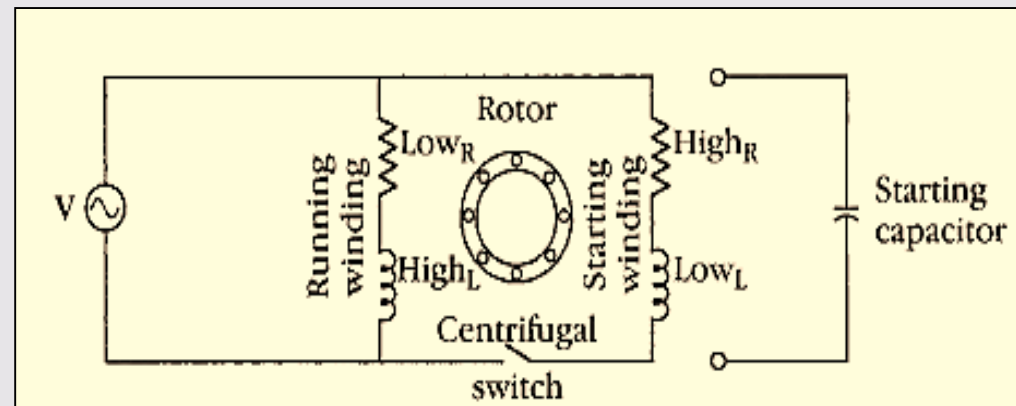
Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

via induction without any direct connection. Because of the extremely rugged in construction, induction motors are far more economical than their equally rated DC motor in both initial cost and ongoing maintenance. Because of its significant advantages over DC motors, the AC induction motors widely used and gives the greatest promise for EV consumers.

Two types of AC induction motors can be used:

1. **Single phase induction motors:** Single phase induction motors are not self-starting, because the flux created using the single-phase supply is not rotating in the space. This drawback can be overcome by introducing an extra phase which is out of phase with main winding. This is called as split phase AC induction motor. The split phase AC induction motor is shown in figure.3.7.



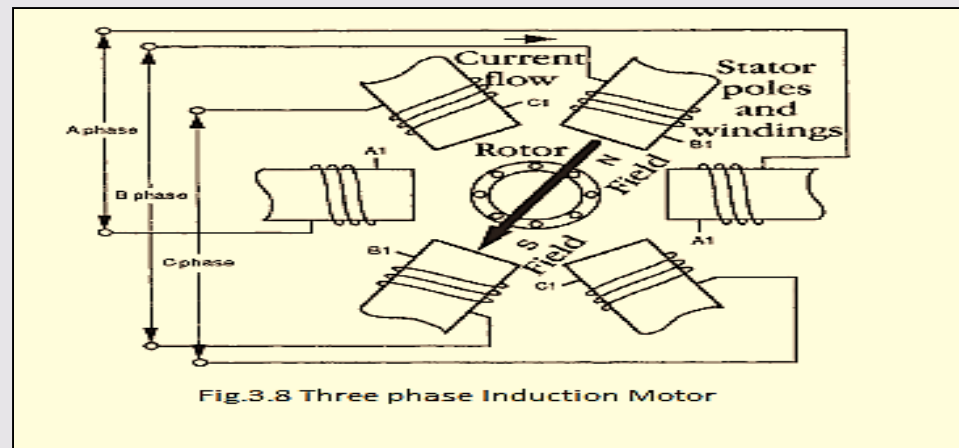
Cont....



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

2. Polyphase AC induction Motors: Poly means many. Usually poly phase induction motors come with three phases. When three phase supply is applied to three phase windings (stator), a rotating magnetic field is produced which causes a rotating field which cuts the stationary rotor conductors through induction. Three phase arrangement is shown in figure 3.8 below.



Synchronous Motor

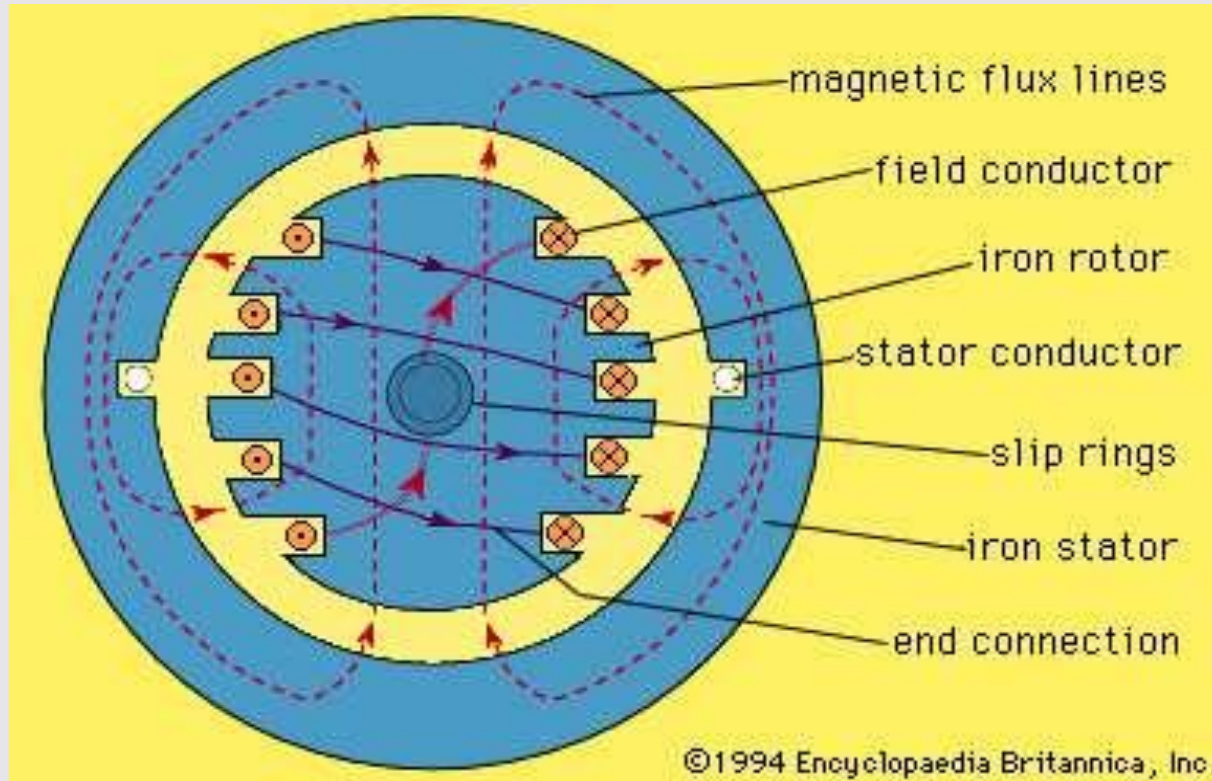
A [synchronous motor](#) is one in which the rotor normally rotates at the same speed as the revolving field in the [machine](#). The stator is similar to that of an [induction](#) machine consisting of a cylindrical iron frame with windings, usually three-phase, located in slots around the inner [periphery](#). The difference is in the rotor, which normally contains an insulated winding connected through slip rings or other means to a source of [direct current](#)

Cont....



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*



Cont....



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Regenerative Braking.

Regenerative braking systems (RBSs) are a type of kinetic energy recovery system that transfers the kinetic energy of an object in motion into potential or stored energy to slow the vehicle down, and as a result increases fuel efficiency . These systems are also called kinetic energy recovery systems. There are multiple methods of energy conversion in RBSs including spring, flywheel, electromagnetic and hydraulic. More recently, an electromagnetic-flywheel hybrid RBS has emerged as well. Each type of RBS utilizes a different energy conversion or storage method, giving varying efficiency and applications for each type.

RBSs are installed along the drive train or fitted to the drive wheels of a vehicle where they inhibit the motion of the wheels using magnetic fields or mechanical torque. These methods of motion inhibition allow energy to be generated under braking, as opposed to friction brakes which simply waste away energy to slow the vehicle by turning the kinetic energy into thermal energy. Due to the maximum charging rate of the energy storage mechanisms, the braking force from a RBS is limited. Therefore, a traditional friction brake system is required to maintain the safe operation of a vehicle when heavy braking is necessary. RBS can improve fuel consumption and reduce the overall braking load taken on by the vehicles friction brakes, reducing the wear on the brake pads.