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Department of Electrical & Electronics Engineering

24EE202

Fundamentals of Electrical and Electronics Engineering

UNIT III

DC Machines and Transformers

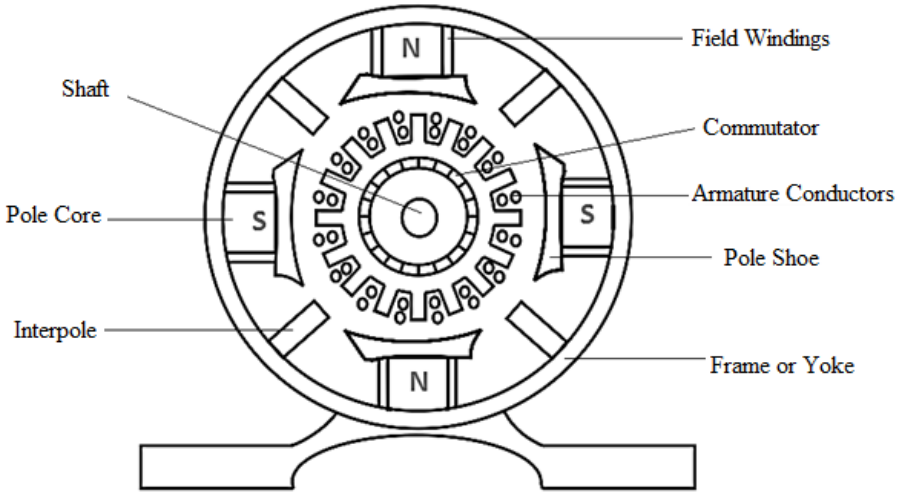
- **Construction, principle of operation, characteristic and application – DC Motor**
- **Construction, principle of operation, characteristic and application – DC Generator**
- **Types of DC motors**
- **Types of DC generators**
- **Application: Electric Vehicle**
- **Structure of electric power system**
- **Introduction to single phase transformers**
- **Construction, principle of operation, characteristics and application of single phase transformers**

Construction, principle of operation, characteristic and application of DC motor

DC Motor

DC motor is an electrical machine that converts electrical energy into mechanical energy. In a DC motor, the input electrical energy is the direct current which is transformed into the mechanical rotation.

Construction of DC Motor



Different Parts of a DC Motor

A DC motor is composed of the following main parts:

1. Shaft
2. Bearings
3. Commutator and brushes
4. Armature Core
5. Armature Windings
6. Pole Core and Pole Shoes
7. Field Winding
8. Interpole
9. Magnetic Frame and Yoke

Shaft

Shaft is the inner most part of DC motor. It is made of mild steel with a maximum breaking strength. The shaft is used to transfer mechanical power from or to the machine. The rotating parts like armature core, commutator, etc. are keyed to the shaft.

Bearings

The ball or roller bearings are fitted in the end housings. The function of the bearings is to reduce friction between the rotating and stationary parts of the machine. Mostly high carbon steel is used for the construction of bearings as it is very hard material.

Commutator and brushes

Commutator

The commutator of a DC motor is a cylindrical structure that is made of copper segments stacked together but insulated from each other using mica. The primary function of a commutator is to supply electrical current to the armature winding.

Brushes

The brushes of a DC motor are made with graphite and carbon structure. These brushes conduct electric current from the external circuit to the rotating commutator. Hence, we come to understand that the commutator and the brush unit are concerned with transmitting the power from the static electrical circuit to the mechanically rotating region or the rotor.

Armature Core

The armature core of DC motor is cylindrical in shape and keyed to the rotating shaft. At the outer periphery of the armature have grooves or slots which accommodate the armature winding.

The armature core of a DC motor or machine serves the following purposes.

It houses the conductors in the slots.

It provides an easy path for the magnetic flux

Armature Windings

The insulated conductors are placed in the slots of the armature core. The conductors are wedged, and bands of steel wire wound around the core and are suitably connected. This arrangement of conductors is called Armature Winding. The armature winding is the heart of the DC Machine.

Armature winding is a place where conversion of power takes place. In the case of a DC Generator here, mechanical power is converted into electrical power.

Pole Core and Pole Shoes

The Pole Core and Pole Shoes are fixed to the magnetic frame or yoke by bolts. Since the poles, project inwards they are called salient poles. Each pole core has a curved surface. Usually, the pole core and shoes are made of thin cast steel or wrought iron laminations which are riveted together under hydraulic pressure. The poles are laminated to reduce the Eddy Current loss.

Field Winding

Each pole core has one or more field coils (windings) placed over it to produce a magnetic field. The enameled copper wire is used for the construction of field or exciting coils. The coils are wound on the former and then placed around the pole core.

When direct current passes through the field winding, it magnetizes the poles, which in turns produces the flux. The field coils of all the poles are connected in series in such a way that when current flows through them, the adjacent poles attain opposite polarity.

Interpoles

Interpoles, also known as commutating poles, are small poles placed in between the main poles of a DC generator. The effect of armature mmf on the main field flux is to distort the main field flux and to reduce the net main field flux. Interpoles are designed in DC generator to overcome the effects of the armature reactance and the self-induction of the machine.

Magnetic Frame and Yoke

The outer hollow cylindrical frame to which main poles and inter-poles are fixed and by means of which the machine is fixed to the foundation is known as Yoke. It is made of cast steel or rolled steel for the large machines and for the smaller size machine the yoke is generally made of cast iron.

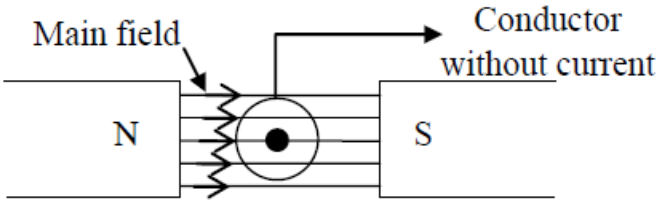
The two main purposes of the yoke are as follows:-

It supports the pole cores and provides mechanical protection to the inner parts of the machines.

It provides a low reluctance path for the magnetic flux.

Working principle of DC Motor

Whenever a current carrying conductor is placed in a magnetic field, it gains torque and develops a tendency to move. In short, when electric fields and magnetic fields interact, a mechanical force arises. This is the principle on which the DC motors work.



The magnitude of the force experienced by the conductor in a motor is given y,

$$F = BI\ell \text{ Newtons}$$

Where, B = Magnetic field density in Wb/m^2

I = Current in amperes

ℓ = length of the conductor in metres.

Applications of DC Motor

- Automotive applications (including electric vehicles)
- Power tools
- Appliances
- Electronics
- Robotics
- Industrial machinery
- Medical equipment
- Household devices
- Audio and video equipment
- Computer equipment
- Lathe
- Electrical Traction

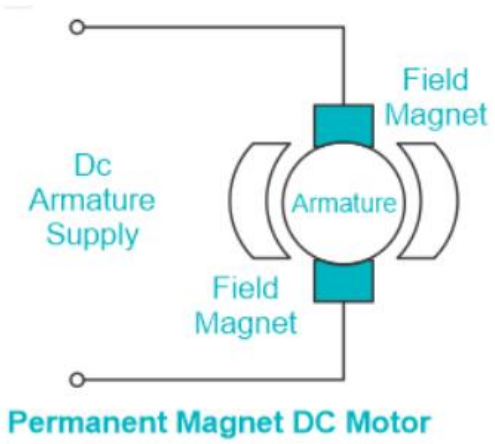
Types of DC motor

DC motors have a wide range of applications ranging from electric shavers to automobiles. To cater to this wide range of applications, they are classified into different types based on the field winding connections to the armature as:

- Permanent magnet DC Motor
- Separately Excited DC Motor
- Self Excited DC Motor

Permanent magnet DC Motor

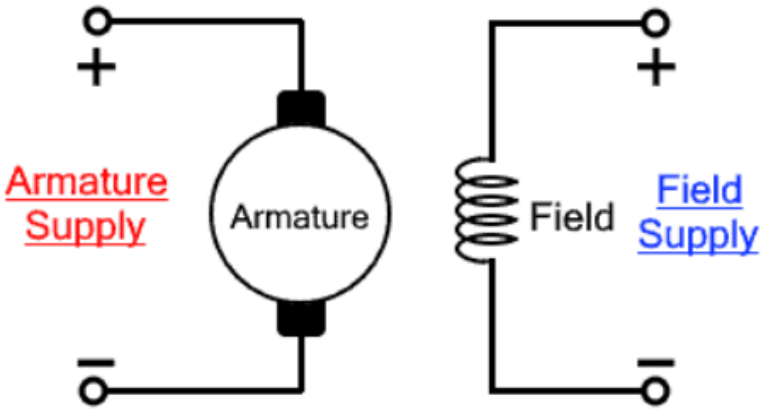
If the file of the DC motor is generated by permanent magnet then the motor is called permanent magnet DC Motor.



Permanent Magnet DC Motor

Separately Excited DC Motor

The field winding and the armature windings are excited by separate DC supply the motor is called separately excited dc motor.



Separately Excited DC Motor

Self Excited DC Motor

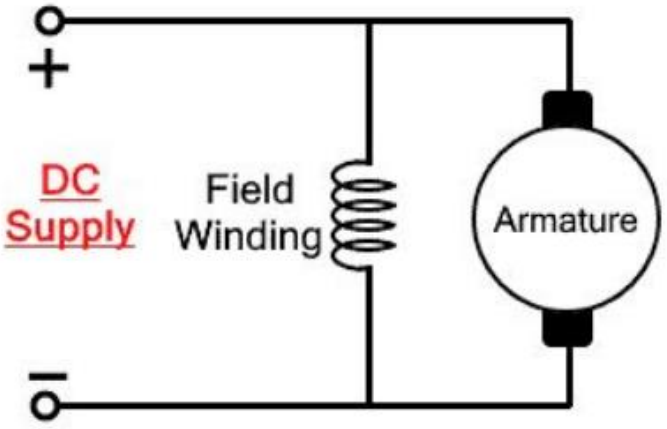
The field winding and the armature windings are excited by common DC supply then the motor is called self excited dc motor.

Types of Self Excited DC Motor

1. Shunt DC Motor
2. Series DC Motor
3. Compound DC Motor

Shunt DC Motor

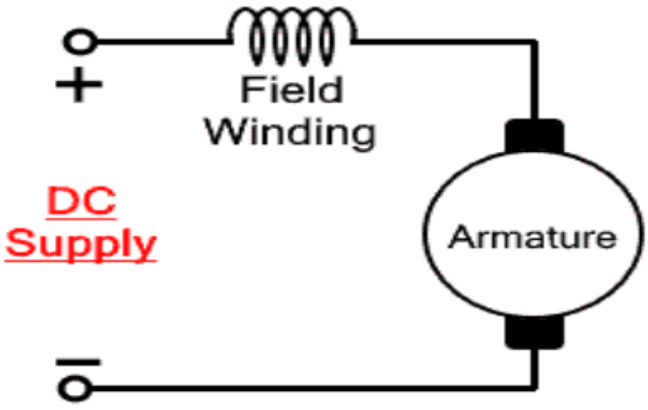
The field winding is connected parallel with the armature windings then the motor is called self excited dc motor. Shunt motor is shown in figure



Shunt Wound DC Motor

2. Series DC Motor

The field winding is connected series with the armature windings then the motor is called self excited dc motor. Shunt motor is shown in figure

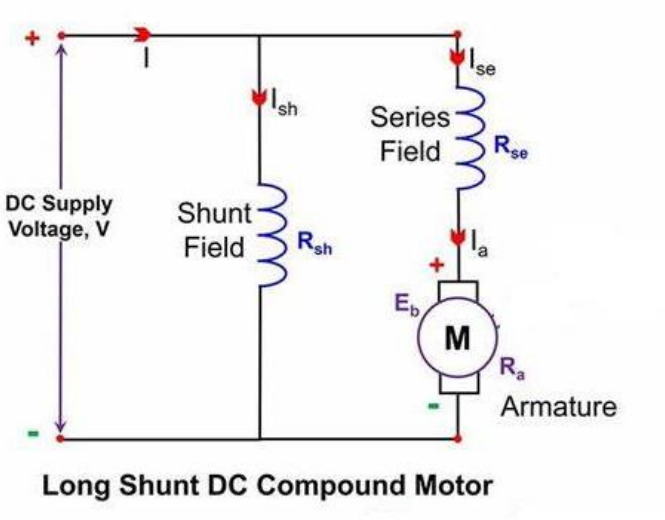


Series Wound DC Motor

Compound DC Motor

Compound wound motors have both series field winding and shunt field winding. One winding is placed in series with the armature and the other is placed in parallel with the armature. This type of DC motor may be of two types

- short shunt compound wound motor and long shunt compound wound motor.



Long Shunt DC Compound Motor

DC Generator

A DC generator is an electrical machine that converts mechanical energy in to electrical energy

Construction of a DC Generator