SNS COLLEGE OF TECHNOLOGY

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Coimbatore-35

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

IIYEAR/ III SEMESTER

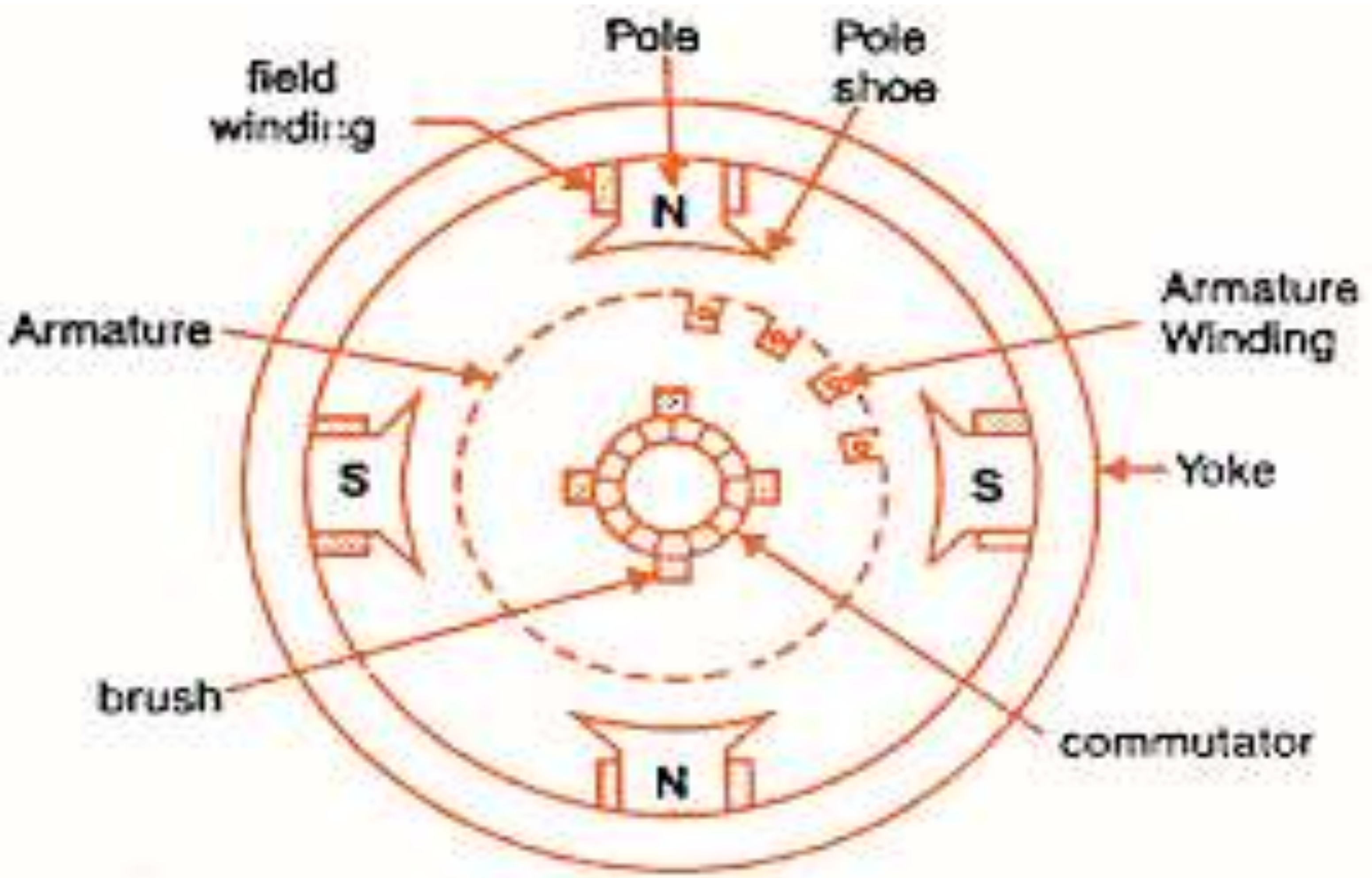
19ECT201 Electrical Engineering and Instrumentation

TOPIC – DC MOTOR

DC MOTOR

The DC machines are of two types namely DC generators and DC motors.
A DC generators converts mechanical energy into electrical energy whereas a DC motor converts the electrical energy into mechanical energy.

Construction of DC Motor



Important parts of DC motor:

1. Yoke
2. Field winding
3. poles
4. Armature
5. Commutator, brushes & gear

1. Yoke:

- It acts as the outer support of a DC motor.
- It provides mechanical support for the poles.

2. Poles:

- pole of a dc motor is an electromagnet.
- The field winding is wound over the poles.
- Poles produces magnetic flux when the filed winding is excited.

3. Field winding:

- The coils wound around the pole are called field coils and they are connected in series with each other to form field winding.
- When current passing through the field winding, magnetic flux produced in the air gap between pole and armature.

Armature:

- Armature is a cylindrical drum mounted on shaft in which number of slots are provided.
- Armature conductors are placed in these slots.
- Theses armature conductors are interconnected to form the armature winding.

5. Commutator:

- A commutator is a cylindrical drum mounted on the shaft along with the armature core.
- It collects the current from the armature conductors and passed it to the external load via brushes

6. Brushes:

- Commutator is rotating. So it is not possible to connect the load directly to it.
- Hence current is conducted from the armature to the external load by the carbon brushes which are held against the surface of commutator by springs

Working Principle

The basic working principle of the DC motor is that whenever a current carrying conductor places in the magnetic field, it experiences a mechanical force.
Fleming's left-hand rule and its magnitude decide the direction of this force.

Fleming's Left Hand Rule:
If we stretch the first finger, second finger and thumb of our left hand to be perpendicular to each other
first finger represents the direction of the magnetic field, the second finger represents the direction of the current, then the thumb represents the direction of the force experienced by the current carrying

F = BIL Newtons

Where,

B = magnetic flux density,

I = current and

L = length of the conductor within the magnetic field.

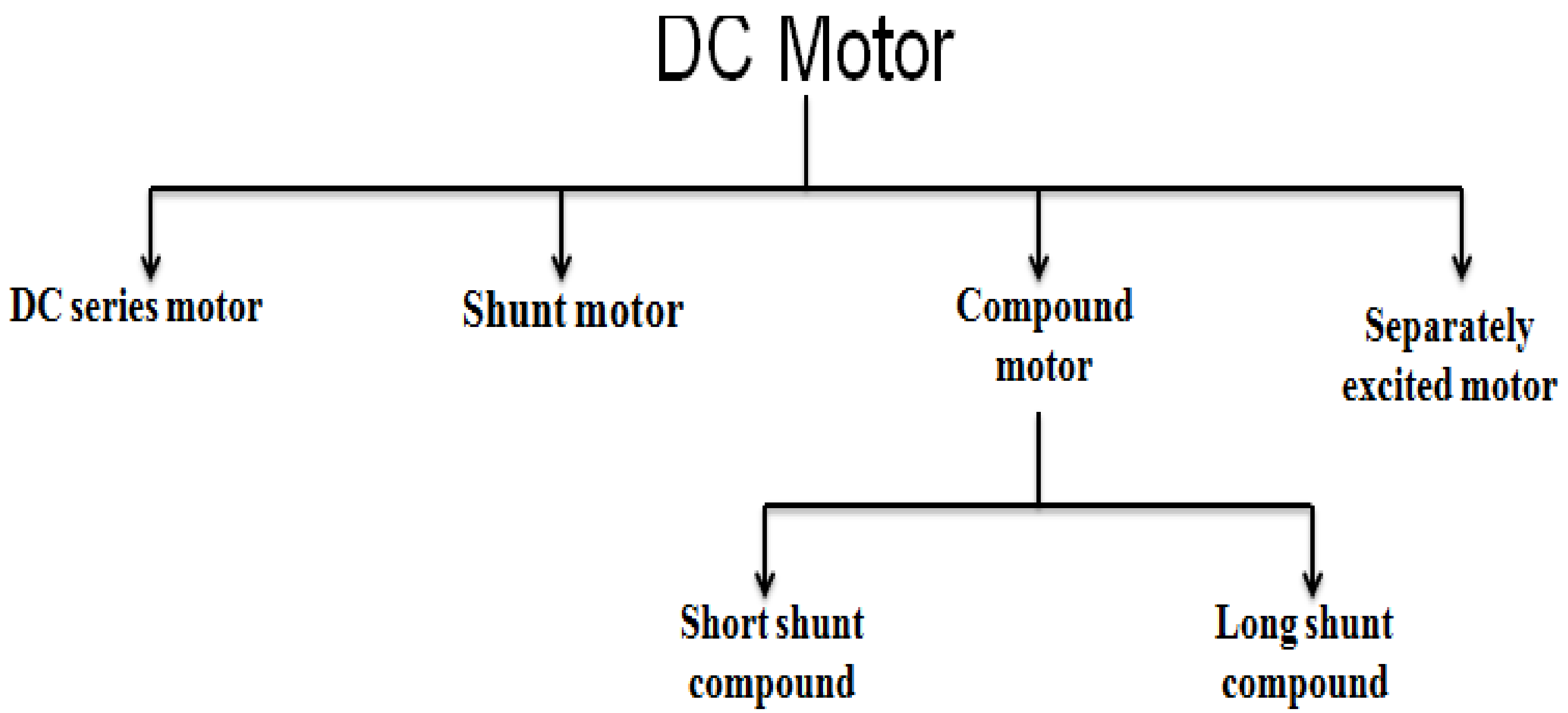
When armature winding is connected to a DC supply, an electric current sets up in the winding. Permanent magnets or field winding (electromagnetism) provides the magnetic field.

current carrying armature conductors experience a force due to the magnetic field

The Commutator is made segmented to achieve unidirectional torque. Otherwise, the direction of force would have reversed every time when the direction of movement of the conductor is reversed in the magnetic field.

Types of DC Motors

Depending on the way of connecting the armature and field windings of a d.c. motors are classified as follows:



DC Shunt Motor

In DC shunt type motor, field and armature winding are connected in parallel as shown in fig.(1), and this combination is connected across a common dc power supply.

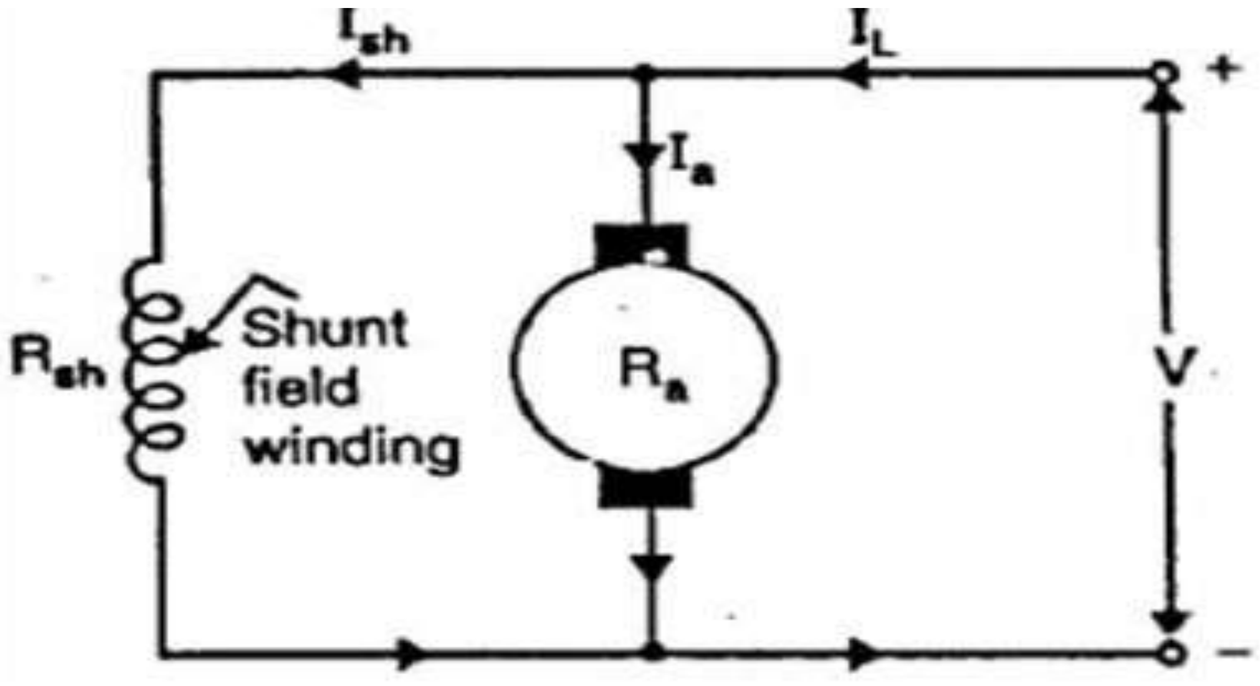
The resistance of shunt field winding (R_{sh}) is always much higher than that of armature winding (R_a).

This is because the number of turns for the field winding is more than that of armature winding

The field current I_{sh} always remains constant. Since V and R_{sh} both are constant. Hence flux produced also remains constant. Because field current is responsible for generation of flux.

$$\therefore \phi \propto I_{sh}$$

This is why the shunt motor is also called as the constant flux motors.

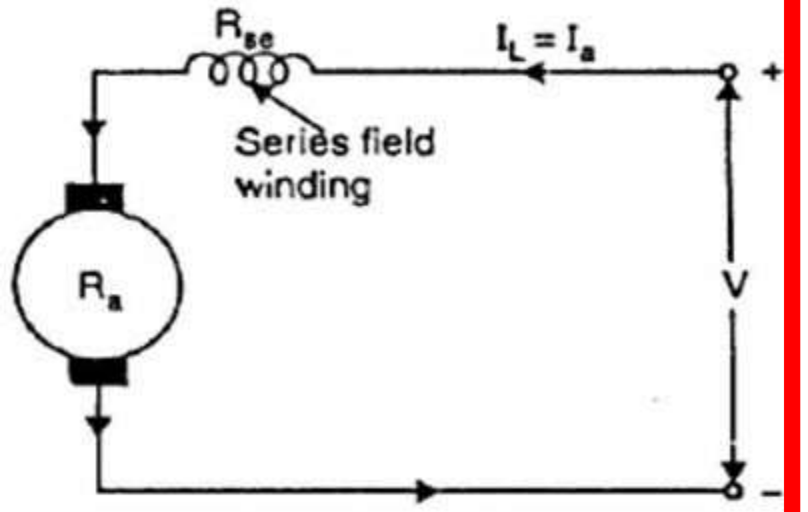


DC Series Motor

In DC series motor, the armature and field windings are connected in series with each other as shown in fig.(2).
The resistance of the series field winding (R_s) is much smaller as compared to that of the armature resistance (R_a).
The flux produced is proportional to the field current. But in series motor, the field current is same as armature current.

$$\therefore \phi \propto I_a \quad \text{or}$$
$$\therefore \phi \propto I_s$$

The armature current I_a and hence field current Is will be dependent on the load.
Hence in DC series motor the flux does not remains constant.



DC Compound Motor

1. **Long Shunt Compound Motor:**

As shown in fig.(3), in long shunt dc motor, shunt field winding is connected across the series combination of the armature and series field winding.

2. Short Shunt Compound Motor:

In short shunt compound motor, armature and field windings are connected in parallel with each other and this combination is connected in series with the series field winding.

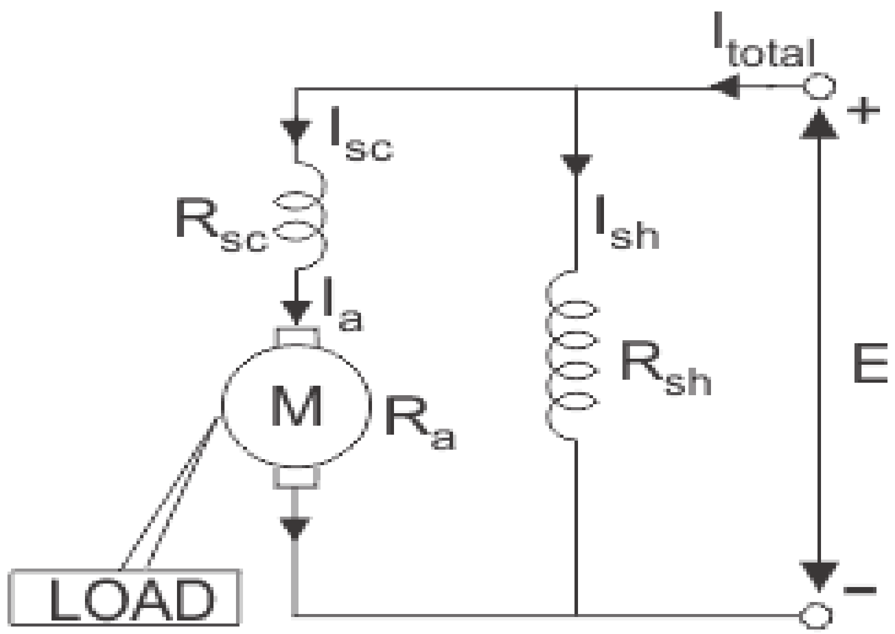


Fig.(1): Long shunt compound dc motor

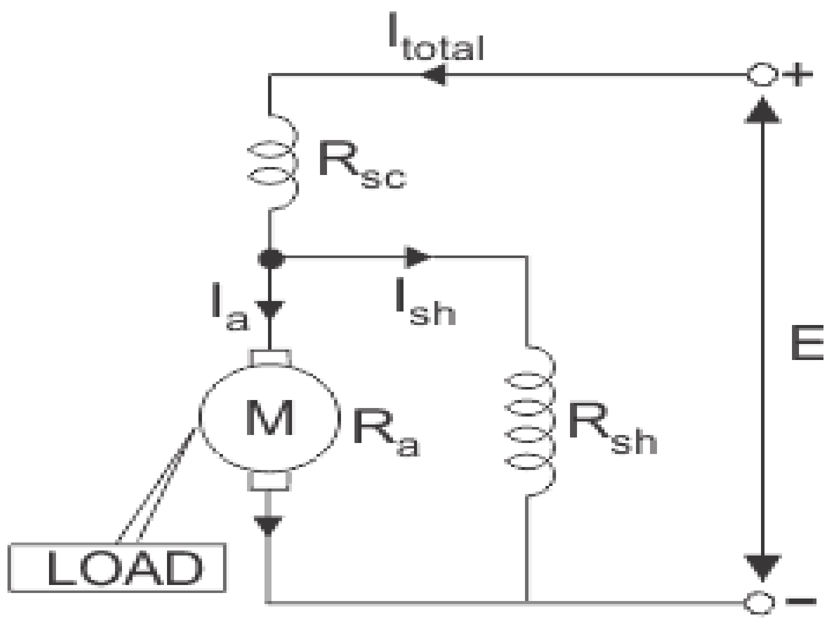


fig.(2):Short shunt compound dc motor

Torque Equations

Torque equations:

- Torque produced by a motor will always be proportional to the air gap flux ø and the current flowing through the armature winding (I_a).
- That means $T \propto ø I_a$
- The flux is produced by the field current hence ø will be proportional to field current. That means,

$$ø \propto I_{field}$$

- hence torque produced by a dc motor is proportional to the product of I_a and I_{field}. That means,

$$T \propto I_a I_{field} \qquad ………..(1)$$

- For various types of dc motors the expression for field current will be different. We will substitute them into eq.(1) to get the torque equations.

1. **Torque equation of DC shunt motor:**

- For DC shunt motor $I_{field} = V/R_{sh}$ = constant
- Hence the flux ø is constant.

$$\therefore T \propto I_a \qquad \text{……..(2)}$$

- Hence in dc shunt motor, torque is proportional to only to the armature current.

2. Torque equation DC series motor:

- For DC series motor, the field current is equal to the armature current i.e. $I_{field} = I_a$.
- Hence $T \propto I_a I_a$

$$\therefore T \propto I_a^2 \qquad \text{………(3)}$$

- Hence in dc series motor, torque is proportional to the square of armature current

Applications of DC Motor

1. Shunt motor applications:

i. Various machine tools such as lathe machines, drilling machines, milling machines etc.
ii. Printing machines
iii. Paper machines
iv. Centrifugal and reciprocating pumps
v. Blowers and fans etc

2. Series motor applications:

i. Electric trains
ii. Diesel-electric locomotives
iii. Cranes
iv. Hoists
v. Trolley cars and trolley buses
vi. Rapid transit systems
vii. Conveyers etc.

. Cumulative compound motor applications:

i. Elevators
ii. Rolling mills
iii. Planers
iv. Punches
v. Shears

4. Differentials compound motors applications:

- The speed of these motors will increase with increase in the load, which leads to an unstable operation.
- Therefore we can not use this motor for any practical applications