UNIT-III

Fundamentals of Electrical Machines

Lecture 18

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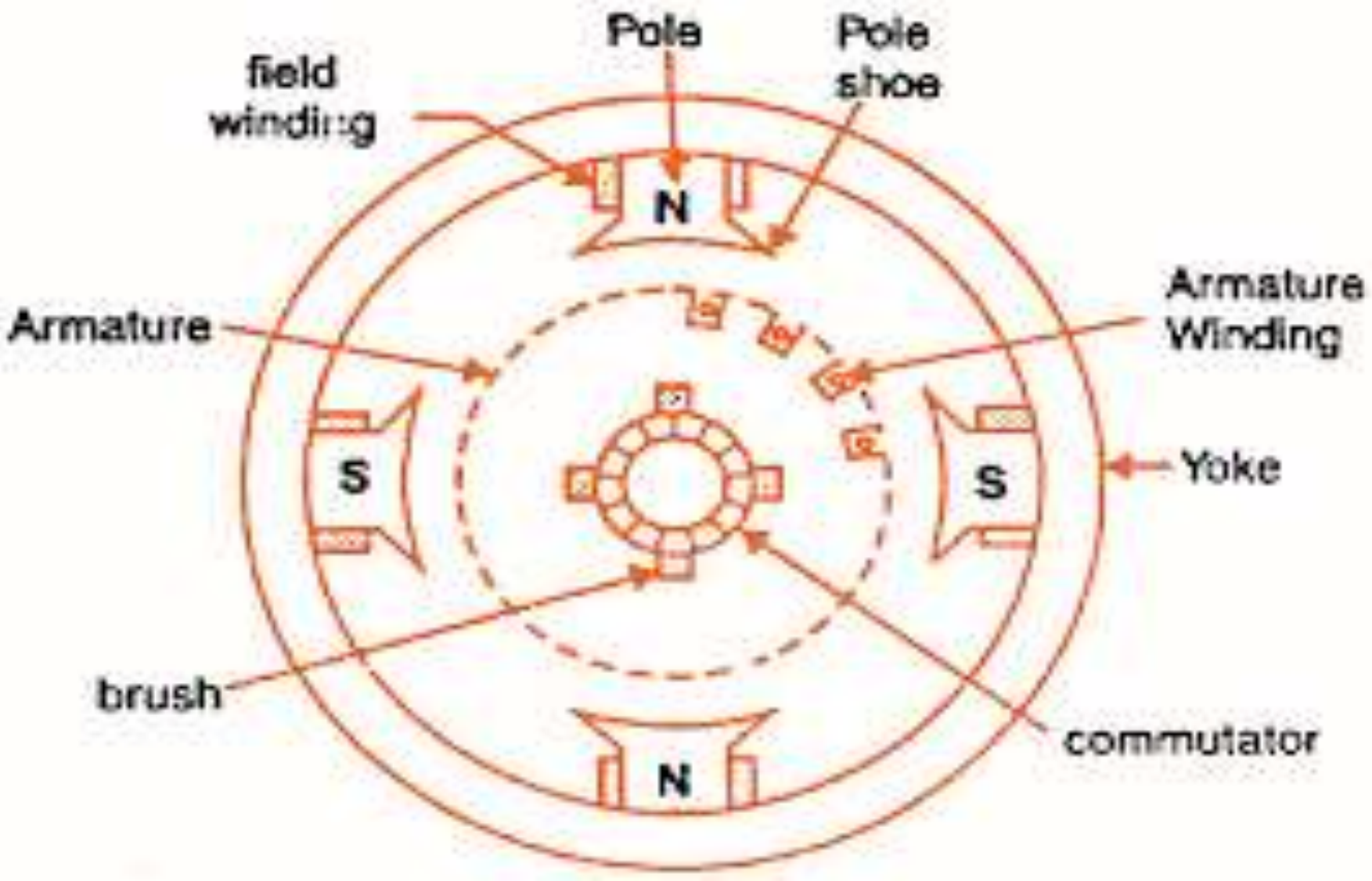
Windings in DC Machine

- In any dc machines, there are two windings:

1. Field winding 2. Armature winding

Out of these, the field winding is stationary which does not move at all and armature winding is mounted on a shaft. So it can rotate freely.

Construction of DC Motor



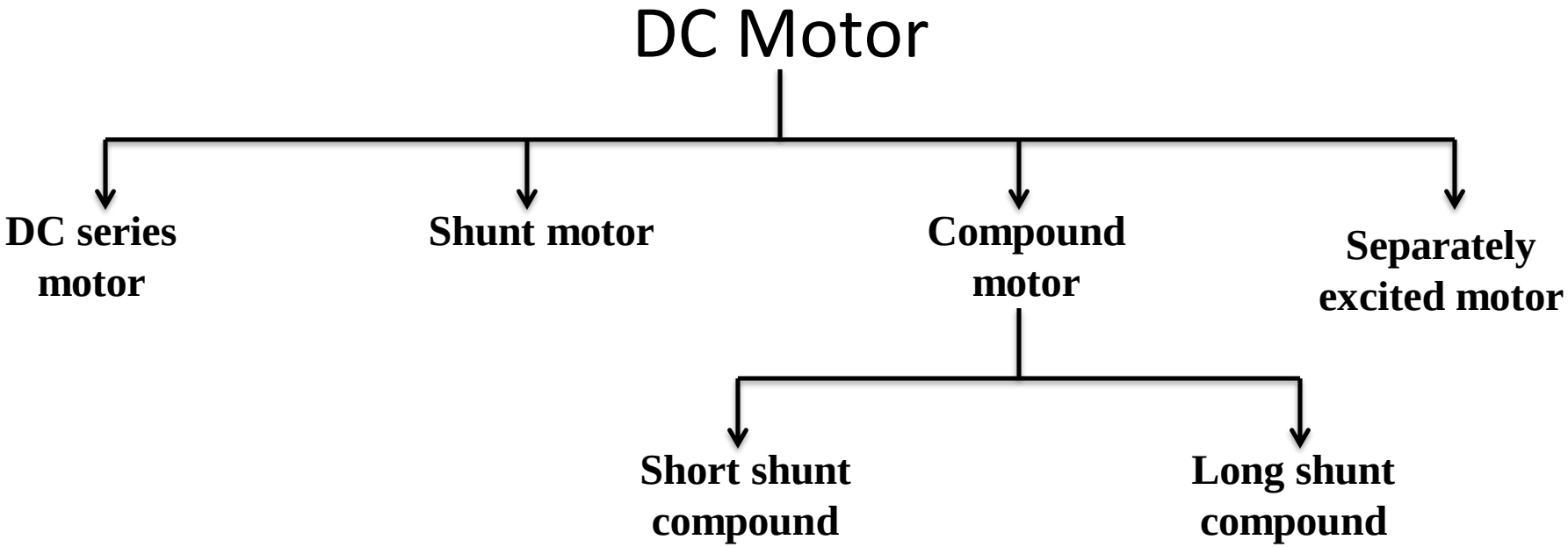
Revision Quiz (Poll 1)

According to Fleming's left-hand rule if the index finger points in the direction of the field than the middle finger will point in the direction of

a) Current in the conductor
b) Resultant force on the conductor
c) Movement of the conductor
d) None of the above

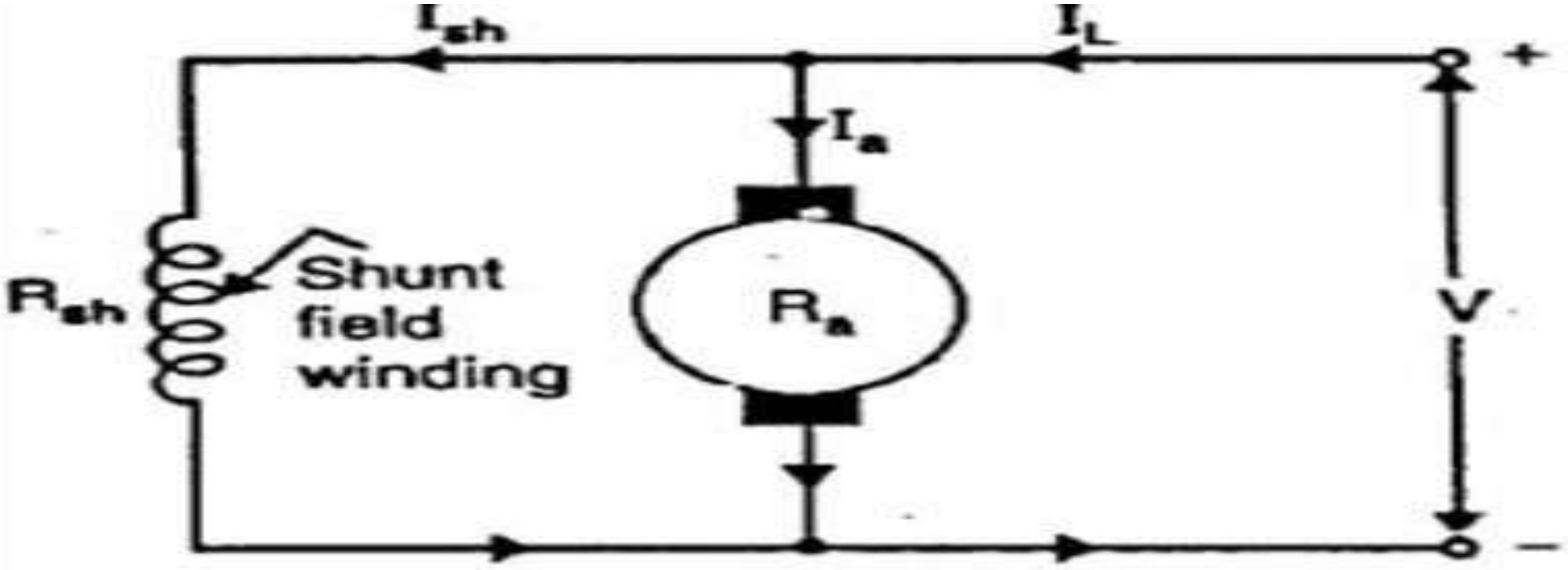
Types of DC Motors

- 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, 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.(1).
- 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.

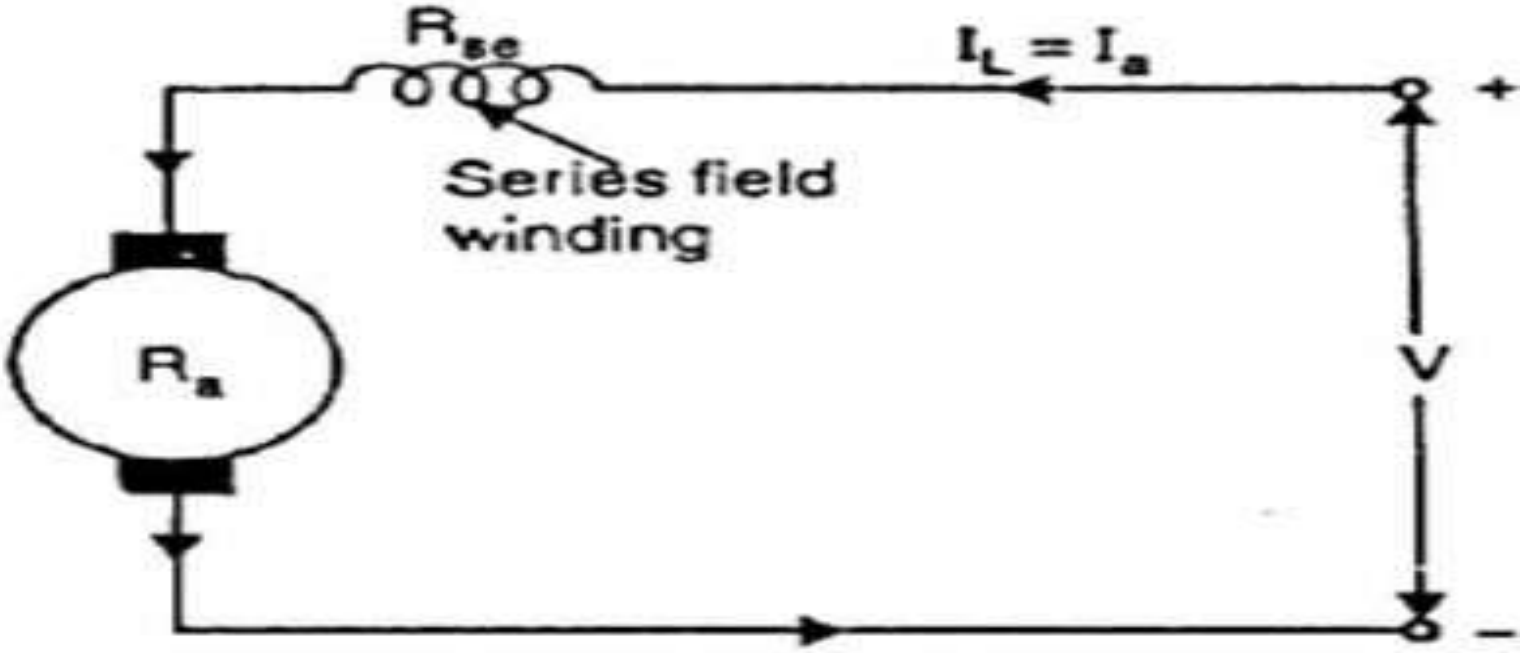


Fig.(1):DC series motor schematic diagram

DC Compound Motor

1. **Long Shunt Compound Motor:**

- As shown in fig.(1), 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. This is shown in fig.(2).

➢ The long shunt and short shunt compound motors are further classified as **cumulative and differential compound motors**

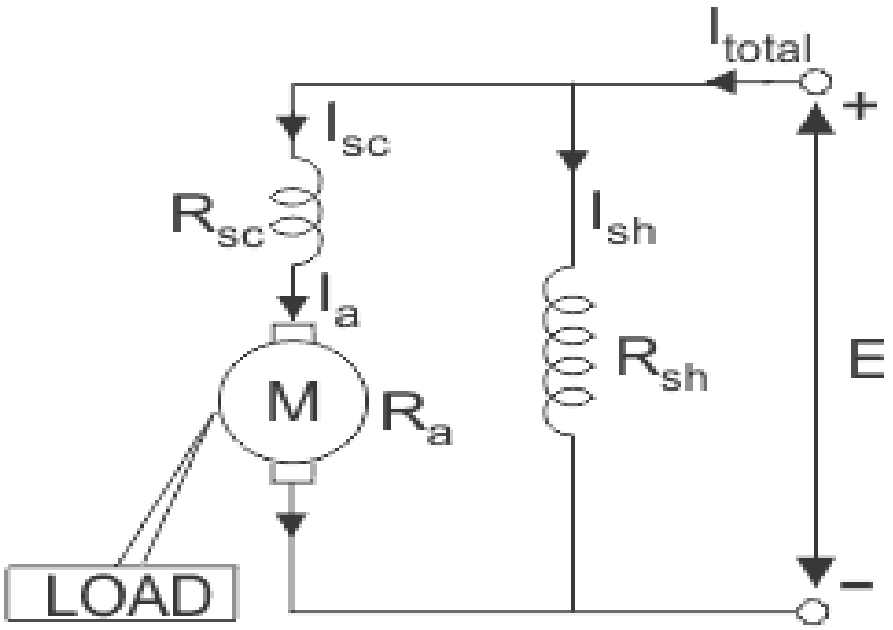


Fig.(1): Long shunt compound dc motor

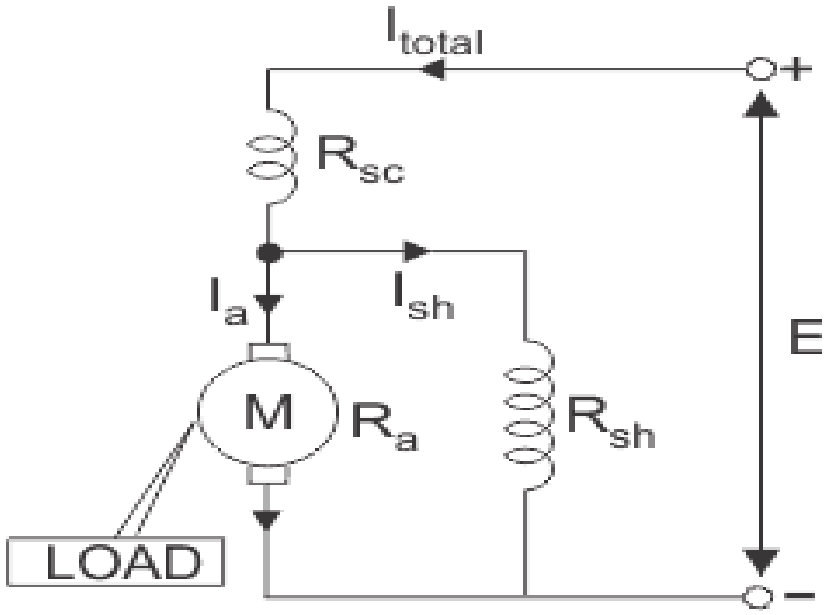


fig.(2):Short shunt compound dc motor

Voltage Equation of a DC Motor

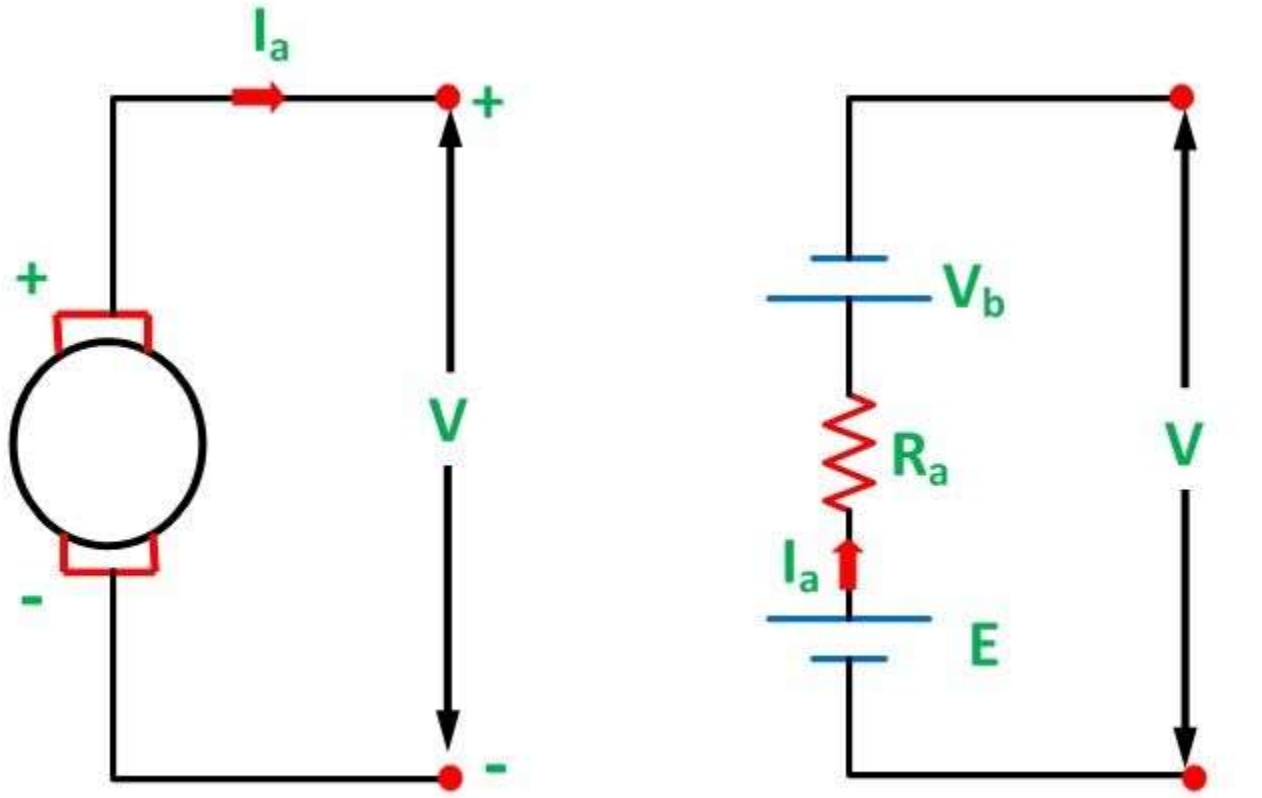


Fig.(1):Equivalent circuit of DC motor

- As shown in fig.(1), the armature supply voltage V has to overcome the opposition posed by the back emf E_b and some other voltage drops such as brush drop and the voltage drop across R_a.
- From fig.(1), we can write that,

$$V = E_b + I_a R_a + V_b \qquad \text{.....(1)}$$

- But voltage drop across brushes is negligible.

$$\therefore V = E_b + I_a R_a \qquad \text{.....(2)}$$

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 $T \propto ø\ I_a$

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

- For DC shunt motor field current = 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.

Quick Quiz (Poll 2)

- Which DC motor is preferred for constant speed?

a) Series motor
b) Compound motor
c) Shunt motor
d) Differential motor

Quick Quiz (Poll 3)

- If T_a be the armature torque and I_a be the armature current then which of the following relation is valid for DC series motor before saturation?
- $T_a \propto I_a$
- $T_a \propto I_a^2$
- $T_a \propto 1/I_a$
- $T_a \propto 1/I_a^2$