4 Types of DC Machines

There are two main types of DC machines first one is a generator and the second one is a DC motor, DC motor uses DC current and provides mechanical power and DC generator generates DC voltage. As we discuss when current-carrying conductor when placed in field emf induced forces apply on it. There are two main categories by which the DC machine gets excited first one is self-excited and the second one is separately excited.

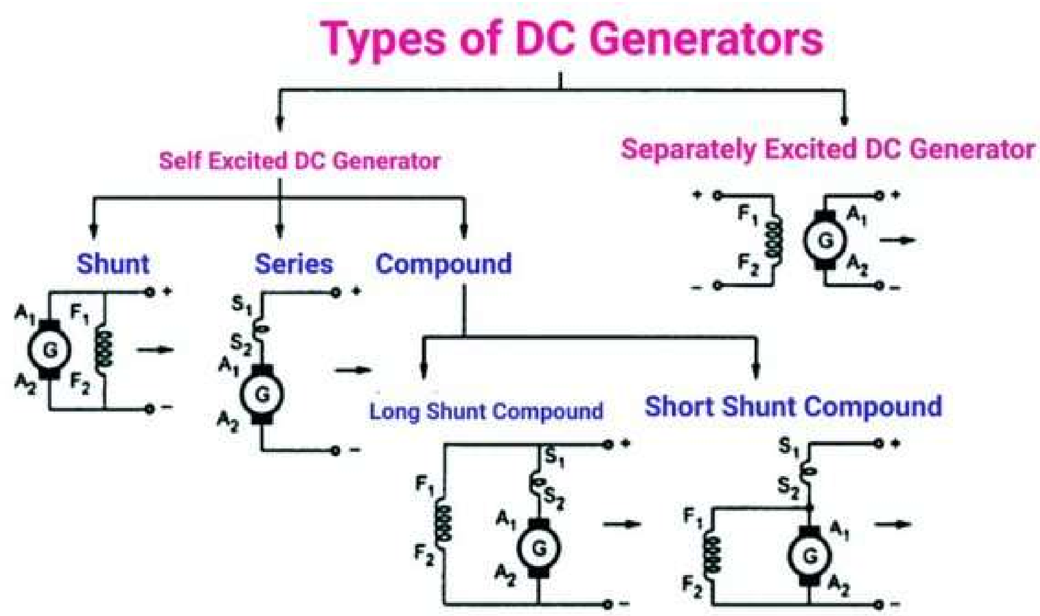

Fig 11. Classification of DC machine.

In self-excited machines field current produced by the machines itself while in separately excited machines the field current is provided by the separated source. Due to these two excitations methods, the DC machines are further divided into different types that are described here.

- Compound DC machine.
- Shunt DC machine.

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- Separately excited DC machine.
- Series DC machine.

4.1 Separately Excited DC Machine

If there is no internal voltage induced at the field windings and there is no field current so external power source is connected at the field winding to produce current and voltage these winding is known as separate windings.

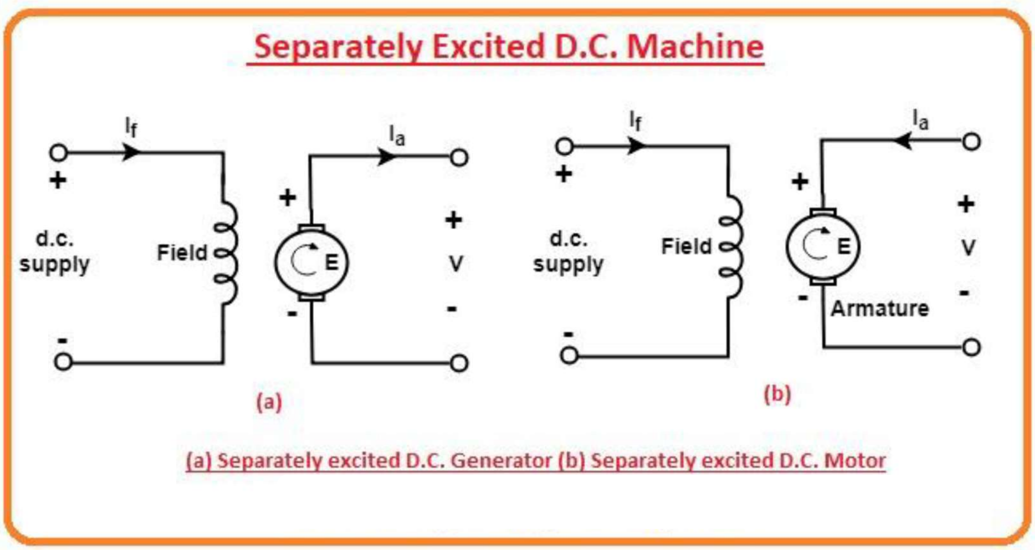

Fig 12. Separately Excited DC Machine.

4.2 Self-Excited DC Machines

4.2.1 Shunt DC Machine

- In this type of DC machine, the field winding (it is located at the stator of a machine) linked with the armature winding (wound rotor) in parallel.
- Due to a parallel connection, the voltage across the field windings is equaled to the supply voltage in the case of a motor and equals generated voltage in the case of a generator.
- These windings have large no of turns.

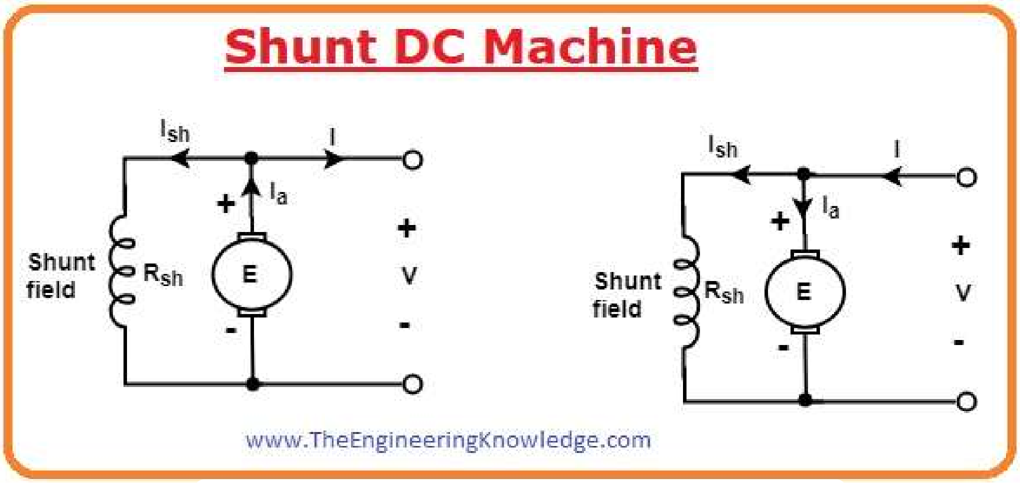

Fig 13. Shunt DC Machine.

4.2.2 Series Wound DC Machine

- In these DC machines, the field windings are connected with the armature windings in series connection schemes.
- As this winding is in series so the armature current also passes through it that has high value for less power losses the turns of the field windings are less in this machine.

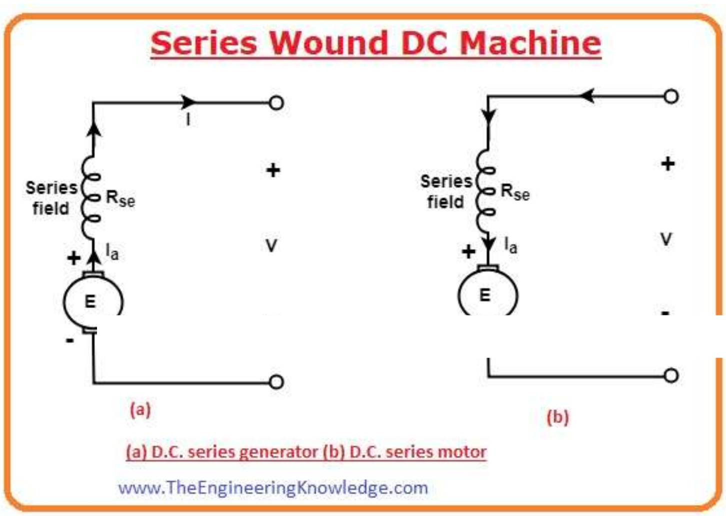

Fig 14. Series DC Machine.

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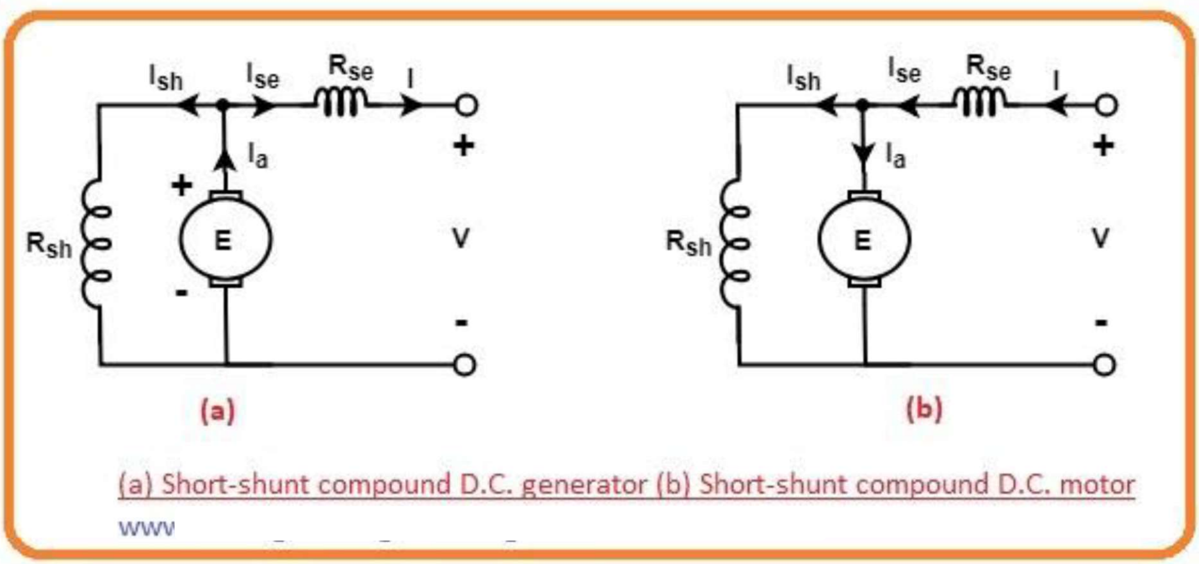
4.2.3 Compound DC Machine

- This motor consists of series and shunts windings in its circuitry. two windings are placed at every pole of the machine.
- The number of turns in the series is less due to the large value of armature current flowing through it and shunt windings have large no of turns.
- There are two methods by which these two windings are connected in these machines if the field windings are in parallel with the armature windings, then the machines are known as the short shunt compound. In the given figure, you can see these arrangements.
- If the field windings are in parallel with the armature and series windings the machines are known as the long shunt compound machines. In the given figure, you can see resultant circuitry. That is a complete post on the DC machines if you have any questions about this post asks in comments.



(a) Short-shunt compound D.C. generator (b) Short-shunt compound D.C. motor
www

Fig 15. Short-Shunt DC Machine.

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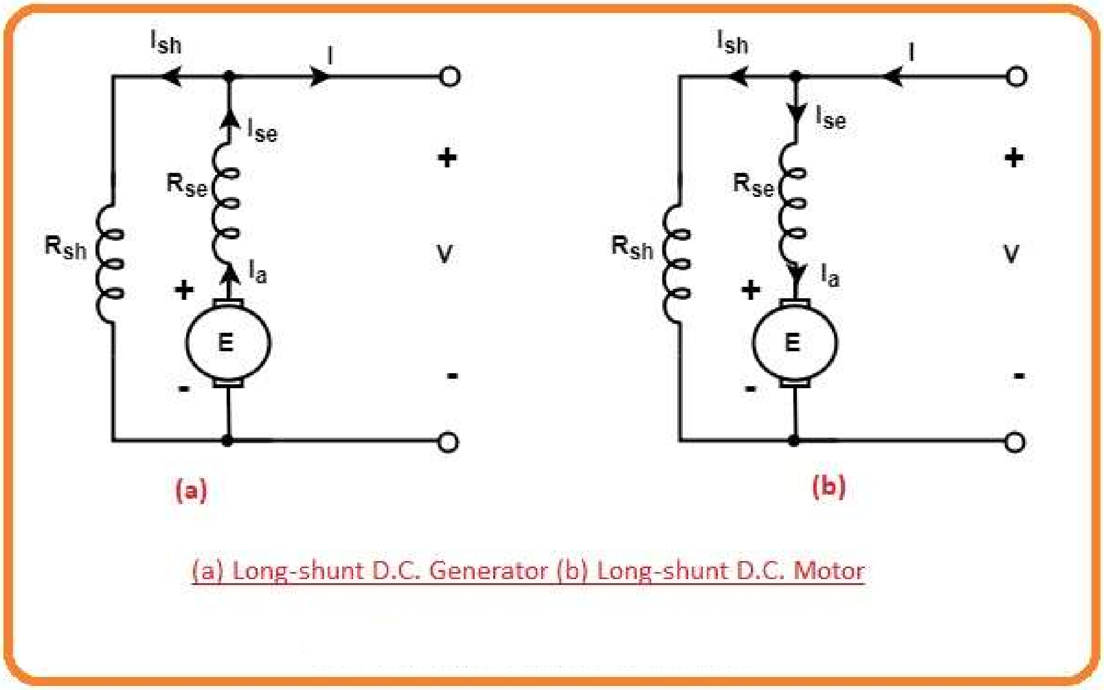
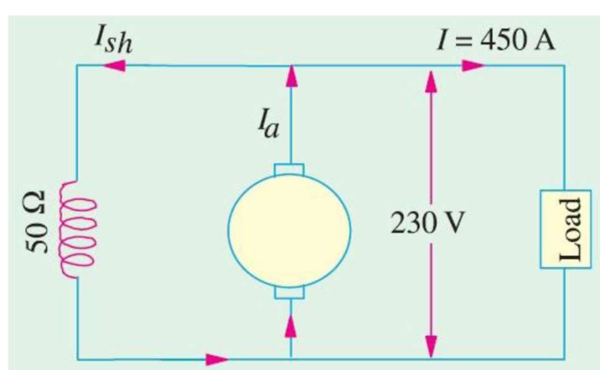


Fig 16. Long-Shunt DC Machine.

Example 1: A shunt generator delivers 450 A at 230 V and the resistance of the shunt field and armature are 50 Ω and 0.03 Ω respectively. Calculate the generated e.m.f.

Solution



Current through shunt field winding is

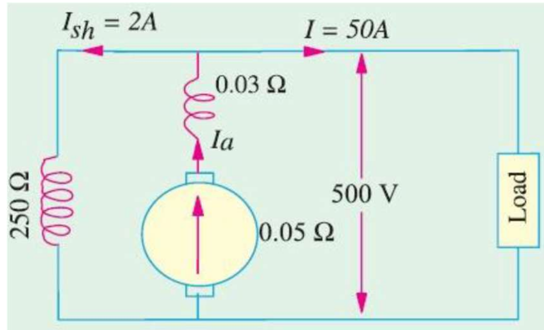
$I_{sh} = 230/50 = 4.6$ A

Load current $I = 450$ A

$\therefore$ Armature current $I_a = I + I_{sh}$

= 450 + 4.6 = 454.6 A

Armature voltage drop I_aR_a = 454.6 × 0.03 = **13.6 V**



Example 2: A long-shunt compound generator delivers a load current of 50 A at 500 V and has armature, series field and shunt field resistances of 0.05 Ω, 0.03 Ω and 250 Ω respectively.

Calculate the generated voltage and the armature current. Allow 1 V per brush for contact drop.

Solution

I_{sh} = 500/250 = 2 A

Current through armature and series winding is Ia = 50 + 2 = 52 A

Voltage drop on series field winding = 52 × 0.03 = 1.56 V

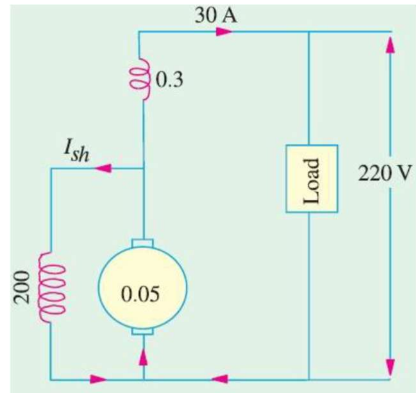
Armature voltage drop I_aR_a = 52 × 0.05 = 2.6 V

Drop at brushes = 2 × 1 = 2 V

Now, $E_g = V + I_aR_a$ + series drop + brush drop = 500 + 2.6 + 1.56 + 2 = **506.16 V**

Example 3: A short-shunt compound generator delivers a load current of 30 A at 220 V, and has armature, series-field and shunt-field resistances of 0.05 Ω, 0.30 Ω and 200 Ω respectively. Calculate the induced e.m.f. and the armature current. Allow 1.0 V per brush for contact drop.

Solution



Generator circuit diagram is shown in Fig.

Voltage-drop in series winding = 30 × 0.3 = 9 V

Voltage across shunt winding = 220 + 9 = 229 V

I_{sh} = 229/200 = 1.145 A

I_a = 30 + 1.145 = 31.145 A

I_aR_a = 31.145 × 0.05 = 1.56 V

Brush drop = 2 × 1 = 2 V

$E_g = V$ + series drop + brush drop + I_aR_a = 220 + 9 + 2 + 1.56 = 232.56 V

Example 4: In a long-shunt compound generator, the terminal voltage is 230 V when generator delivers 150 A. Determine

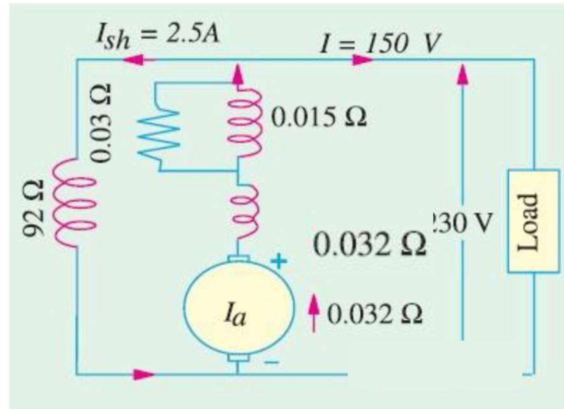
(i) induced e.m.f.

(ii) total power generated

(iii) distribution of this power.

Given that shunt field, series field, divertor and armature resistance are 92 Ω, 0.015 Ω, 0.03 Ω and 0.032 Ω respectively.

Solution.



$I_{sh} = 230/92 = 2.5$ A

$I_a = 150 + 2.5 = 152.5$ A

Since series field resistance and diverter resistances are in parallel, their combined resistance is = 0.03 × 0.015/0.045 = 0.01 Ω

Total armature circuit resistance is = 0.032 + 0.01 = 0.042 Ω

Voltage drop = 152.5 × 0.042 = 6.4 V

(i) Voltage generated by armature

$Eg = 230 + 6.4 =$ **236.4 V**

(ii) Total power generated in armature

$E_g I_a = 236.4 \times 152.5 =$ **36,051 W**

(iii) Power lost in armature

$Ia^2 Ra = 152.5^2 \times 0.032 = 744$ W

Power lost in series field and divertor = $152.5^2 \times 0.01 = 232$ W

Power dissipated in shunt winding = $VI_{sh} = 230 \times 0.01 = 575$ W

Power delivered to load = 230 × 150 = 34500 W

Total = 36,051 W.