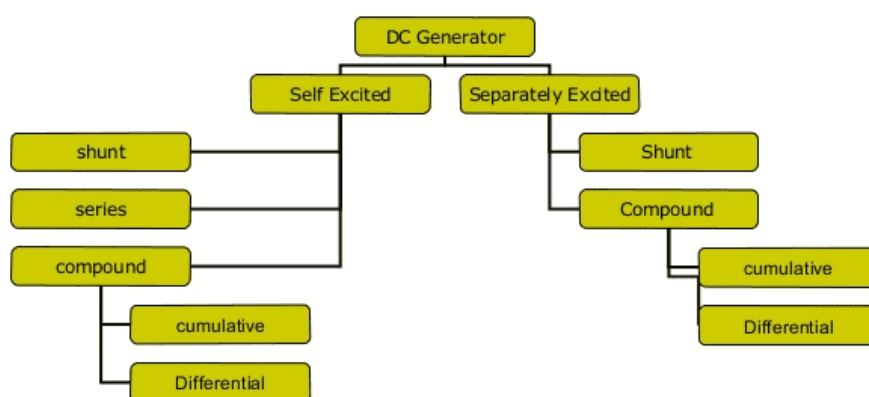


A Clear Classification of DC Generators

 linquip.com/blog/classification-of-types-of-dc-generators/

March 3, 2021

DC Generator Classification



Types of DC Generators – DC generators are electrical devices for converting mechanical energy to electrical power. Cutting magnetic flux by the armature produces EMF based on Faraday's Laws and electro induction. EMF is the cause of current flow in the circuit.

Types of DC Generators

DC generators are categorized into three main types based on the methods of field excitation: Permanent Magnet, Separately Excited, and Self-Excited DC generators. The first type excites the field coils by using Permanent magnets, while the separately excited one includes an external force for excitation. A self-excited DC generator includes another generator itself and field coils excited by it. The diagram for DC generators' types is as below, and the permanent magnet field is not included because of not being widely used in the industry.

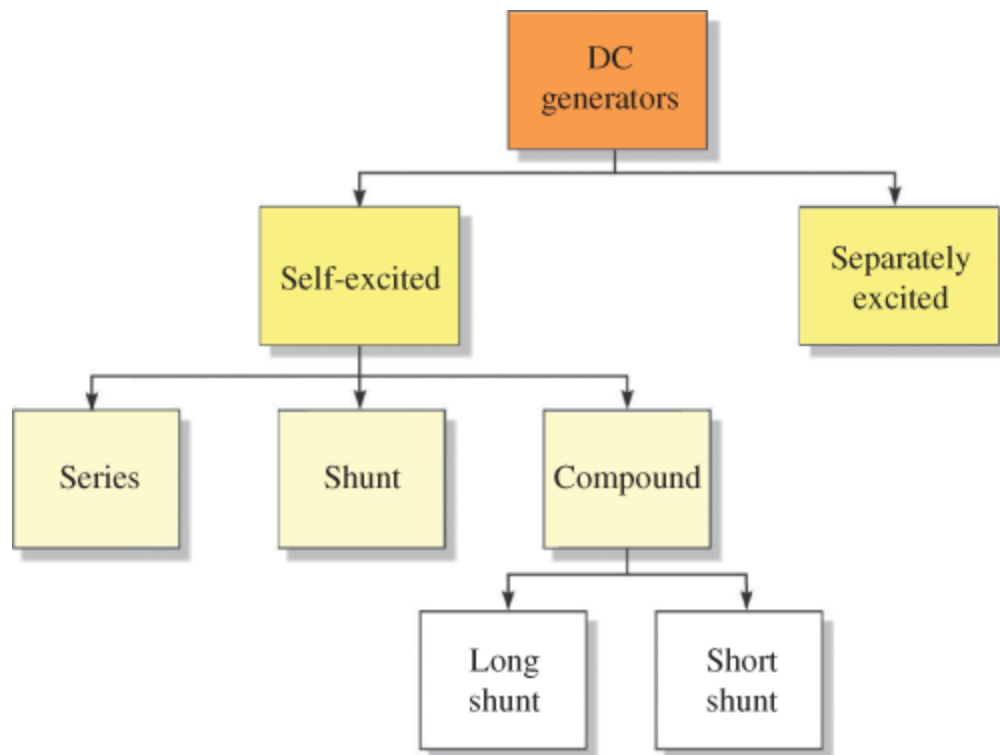


figure1. Types of DC generators (reference: electricalacademia.com)

Permanent Magnet DC Generators

This kind of generator utilizing permanent magnets for creating the flux in the magnetic circuit is known as the Permanent magnet DC generators and is the most basic type of generator. There are an armature and one or many permanent magnets placed around the armature. This type cannot supply much power due to the design of the generator and does not employ in industry application. Permanent magnet DC generators usually are used in small applications, the same as dynamos in motorcycles.

Figure 2 illustrates the basic form of the permanent magnet DC generators, and as we know, voltage is created when the wire cuts the field and the amount of it is dependent on the wire loops and the rate of rotation in the field. Also, the amount of the voltage is the function of the angle between the magnetic flux and the moving surface. As each loop rotates, the voltage varies from 0 to the maximum amount of itself as the function of the angle and makes an absolute amount of sinusoidal voltage. Increasing the number of the loops at different angles makes the voltage to be constant at its maximum value.

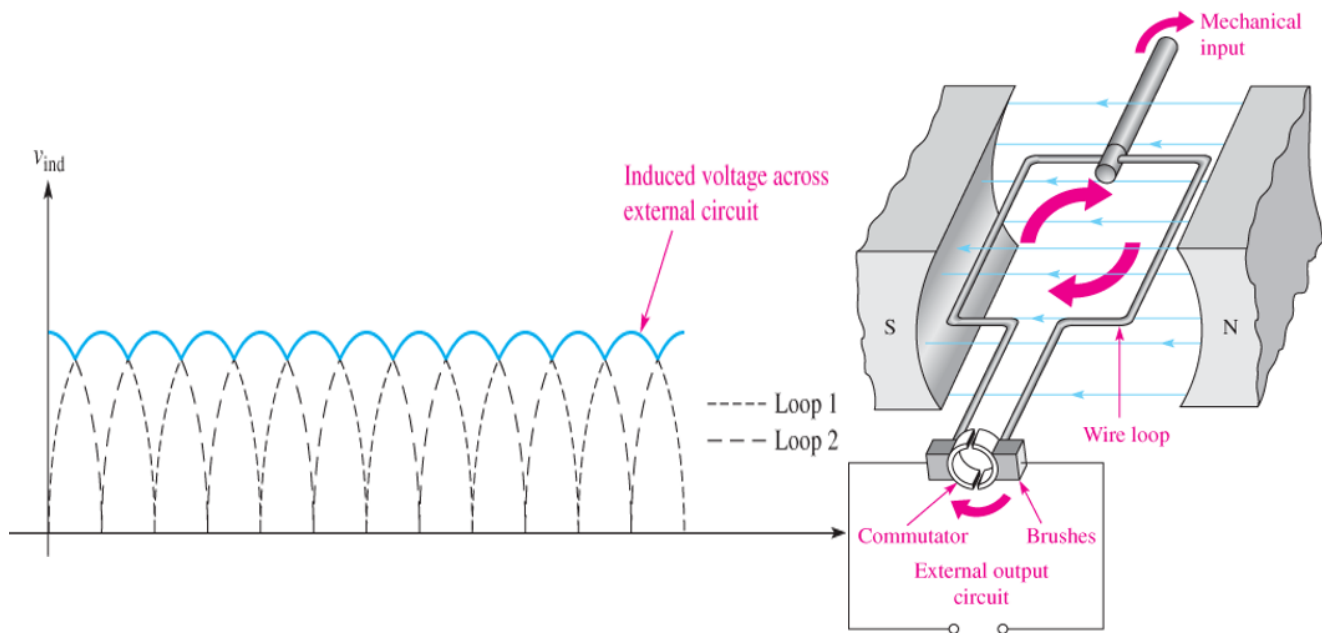


Figure2. Permanent magnetic DC generators (reference: electricalacademia.com)

the induced voltage is calculated as:

$$V_{ind} = Blv$$

where:

V_{ind} = induced voltage, in V

B = flux density that is perpendicular to the motion, in Wb/m²

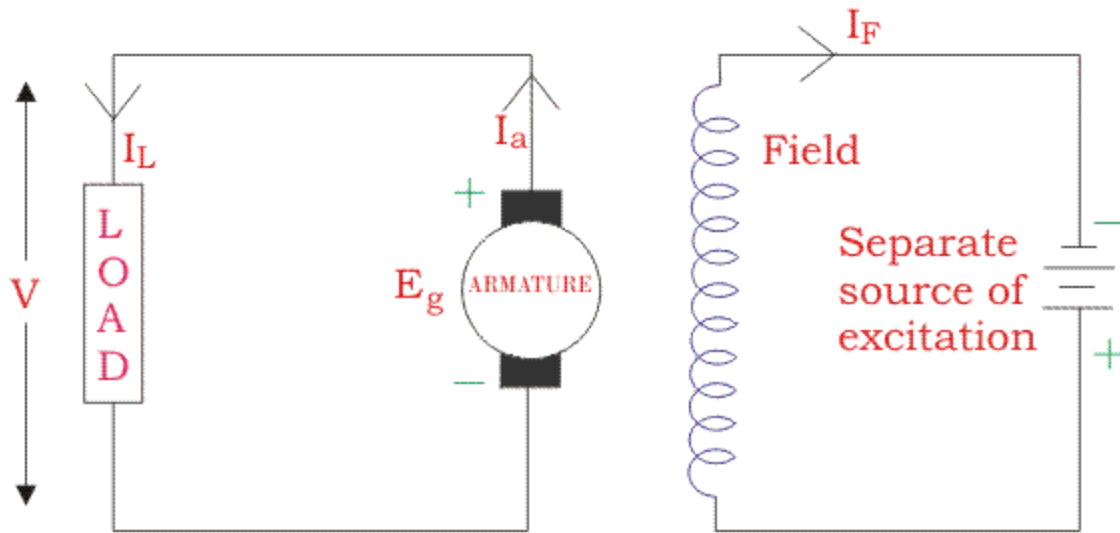
l = length of the conductor, in m

v = velocity of the conductor, in m/s

Separately Excited DC Generators

External DC source (e.g., battery) is used in this system for energizing field magnets. As the rotation speed increases, it can provide a higher EMF and voltage in the output. The circuit diagram for the separately excited DC generators is illustrated in figure 3, and the symbols are as below:

- I_L = Load current
- I_a = Armature current
- E_g = Generated EMF (Electromagnetic Force)
- V = Terminal voltage



Separately Excited DC Generator

Figure3. Circuit diagram of the separately excited DC generators (reference: electrical4u.com)

The generated power and the delivered power to the external force can be calculated as:

$$I_a = I_L = I$$

$$V = IR_a$$

$$P_g = E_g \times I$$

$$P_l = V I$$

Self-Excited DC Generators

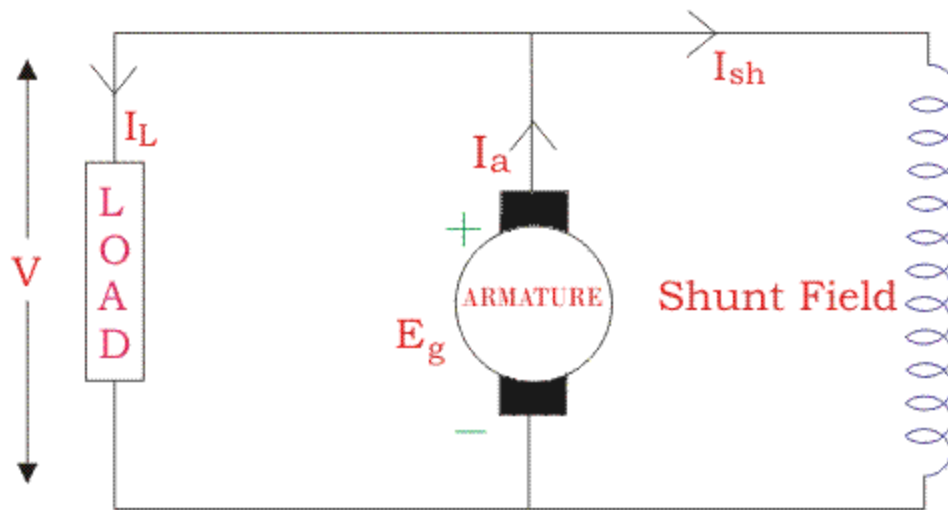
Self-excited DC generators have field magnets that are energized by their own supplied current, and the field coils are connected to the armature internally. There is always some flux in the poles because of the residual magnetism. As the armature rotates, some current is produced, and this small current flows through the field coils with the load and strengthening the pole flux. By increasing the pole flux, the EMF and the current increase, and the accumulative process is continuing until the excitation is necessary. Self-excited DC generators are classified based on the field coils and their position as follows:

1. Shunt Wound Generators

2. Compound Wound Generators
3. Series Wound Generators

Shunt Wound DC Generators

The field windings are connected to the armature conductors parallelly to excite the generator. Field windings are the insulated current-carrying coils that produce the needed magnetic field for excitation of the generator. A shunt generator excites by residual magnetism in poles, and the field windings have the same voltage as the terminals in the shunt-wound generator, while the actual value of this voltage depends on the load and its speed. The circuit diagram for this type is as below:



Shunt Wound Generator

Figure4. Circuit diagram of the Shunt Wound DC Generators (reference: electrical4u.com)

where:

- V = Terminal voltage
- E_g = Generated EMF
- I_{sh} = Current flowing through the shunt field
- I_a = Armature current
- I_L = Load current
- R_{sh} = Shunt winding resistance
- R_a = Armature resistance

Armature current I_a consists of two parts of shunt field current I_{sh} and load current I_L .

$$I_a = I_{sh} + I_L$$

When the I_L is the maximum, the effective power for the load would be the maximum. As a result, it is better to keep the shunt current as low as possible. So it is reasonable to keep the resistance of the shunt high.

$$I_{sh} = \frac{V}{R_{sh}}$$

$$V = E_g - I_a R_a$$

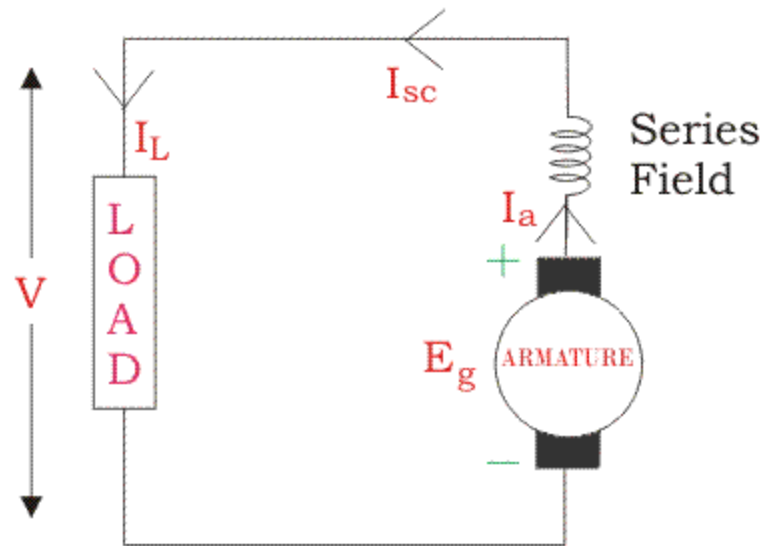
Generated power and power delivered to the load are:

$$P_g = E_g \times I_g$$

$$P_L = V \times I_L$$

Series wound generators

The field winding is in series with armature conductors in series-wound generators. Figure 5 is the circuit diagram for this generator. Current in the field coil is the same as the load and flows in both. Field windings are designed with few turns and using thick wires to have low electrical resistance. The circuit diagram for this type is as below:



Series Wound Generator

Figure5. circuit diagram of the series Wound DC Generators (reference: electrical4u.com)

$$I_a = I_L = I_{sc} = I$$

$$V = E_g - I^2 \times R_a$$

Generated power and power delivered to the load are:

$$P_g = I \times E_g$$

$$P_L = I \times V$$

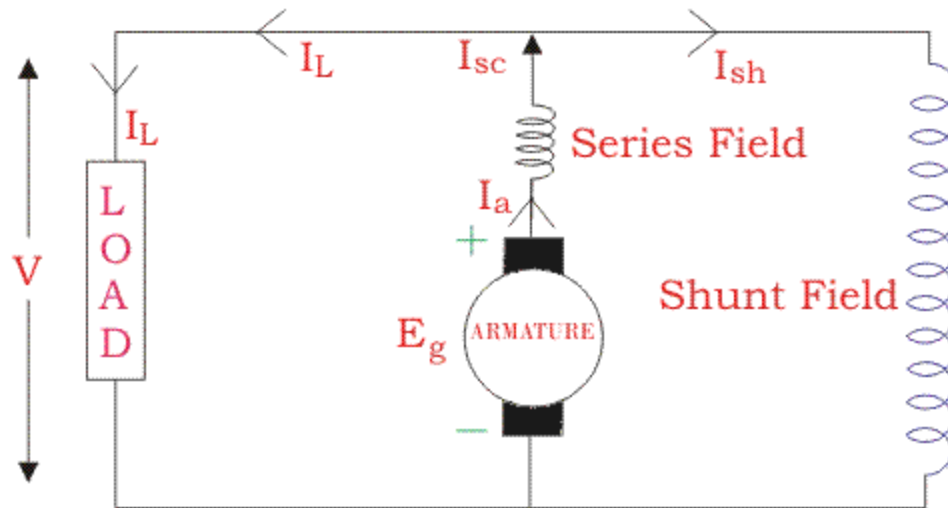
Compound Wound DC Generators

The output voltage and EMF depend on the load current in the series wound type, and on the other hand, in the shunt type, the output is proportional to the inverse of the load current. To overcome the disadvantage of both types, compound wound generators are available, combining both series and shunt. The circuit of the compound wound generators includes

both series and shunt field winding. There are a series and a parallel winding with the armature and include two types of short shunt compound wound generator and long shunt compound wound generator.

Long Shunt Compound DC Generators

In long shunt compound DC generators, the shunt windings are parallel with both series field and armature. The circuit diagram for this type is as below:



Long Shunt Compound Wound Generator

Figure6. circuit diagram of the short Shunt Compound Wound DC Generators (reference: electrical4u.com)

The currents in the circuit are:

$$I_{sh} = \frac{V}{R_{sh}}$$

$$I_{cs} = I_L + I_{sh}$$

$$I_{cs} = I_a$$

The load voltage is equal to:

$$V = E_g - I_a(R_a + R_{sc})$$

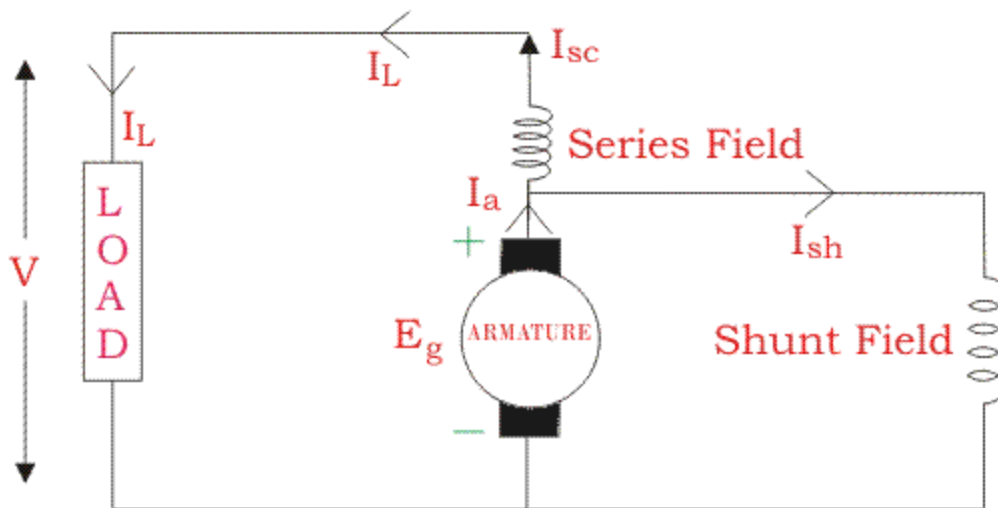
Generated power and the delivered power to the load are:

$$P_g = I_G \times E_g$$

$$P_l = I_G \times V$$

Short Shunt-Wound DC Generator

In short type, an armature is parallel with the shunt field windings, as shown in the following figure:



Short Shunt Compound Wound Generator

Figure6. circuit diagram of the short Shunt Compound Wound DC Generators (reference: electrical4u.com)

The currents in this systems are:

$$I_{sc} = I_l$$

$$I_{sh} = \frac{V + I_{sc} R_{sc}}{R_{sh}}$$

$$I_a = I_{sc} + I_l$$

The load voltage, load power, and the generated power are:

$$V = E_g - I_a R_a - I_{sc} R_{sc}$$

$$P_l = I_G \times V$$

$$P_g = I_G \times E_g$$

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