4.1 DC GENERATOR - INTRODUCTION

An electrical generator is a rotating machine which converts mechanical energy into electrical energy. It is shown in figure 4.1. This energy conversion is based on the principle of electromagnetic induction. According to Faraday's laws of electromagnetic induction, whenever a conductor is moved in a magnetic field, dynamically induced e.m.f is produced in the conductor.

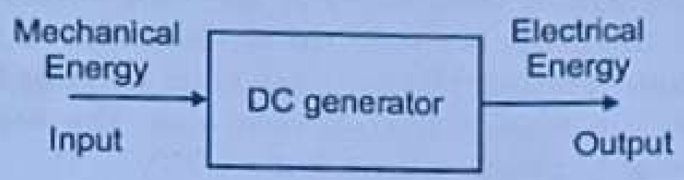


Figure 4.1

When an external load is connected to the conductor, the induced e.m.f. causes a current to flow in the load. Thus the mechanical energy, which is given in the form of motion to the conductor is converted into electrical energy. If a single conductor is used, the e.m.f. produced is small. Large number of conductors are used to obtain greater e.m.f. and the rotating conductor assembly is called an armature.

4.1.1 *Constructional Details*

Figure 4.2 shows a DC generator with its major parts as given below.

1. Magnetic frame or Yoke
2. Poles, interpoles, windings, pole shoes
3. Armature
4. Commutator
5. Brushes, bearings and shaft

Magnetic frame

The magnetic frame or yoke serves two purposes.

1. It acts as a protecting cover for the whole machine and provides mechanical support for the poles.
2. It carries the magnetic flux produced by the poles. The flux per pole divides at the yoke so that the yoke carries only half the flux produced by each pole.

4.1.2 *Principle of Operation*

Let us consider a single turn coil ABCD (figure 4.7) rotated on a shaft within a uniform magnetic field of flux density. It is rotated in an anticlockwise direction.

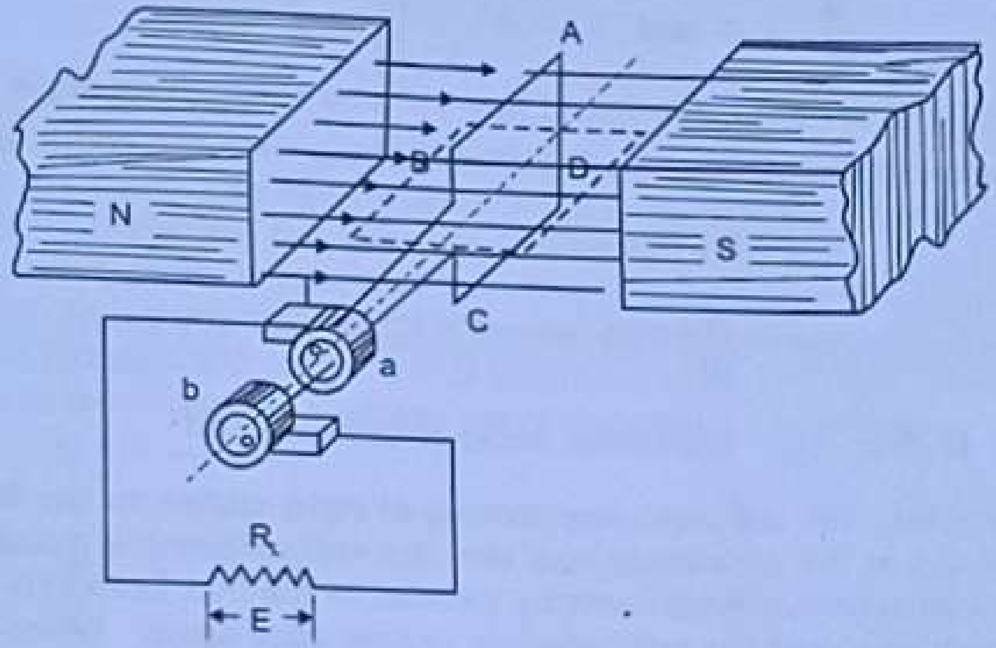


Figure 4.7

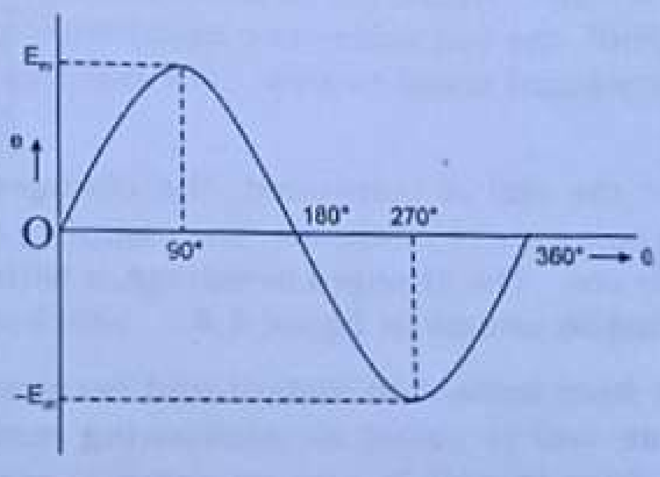


Figure 4.8

Let 'ℓ' be the length and 'b' be the breadth of the coil in meters. When the coil sides AB and CD are moving parallel to the magnetic field, the flux lines are not being cut and no emf is induced in the coil. At this position, we assume the angle of rotation 'θ' as zero.

This vertical position of the coil is the starting position. According to Faraday's law II, the emf induced is proportional to the rate of change of flux linkages.

$$e = -N\frac{d\phi}{dt} \qquad ..(4.1)$$

where "N" is the number of turns, "ϕ" is the flux and "t" is the time.

$$\text{As} \quad N = 1, \; e = -\frac{d\phi}{dt} \; \text{volts}$$

Initially, when the coil is moving parallel to the flux lines, no flux line is cut and hence

$$\frac{d\phi}{dt} = 0 \quad \text{and} \quad e = 0 \qquad ..(4.2)$$

After time "t" secs, the coil would have rotated through an angle ωt radians in the anti-clockwise direction. The flux then linking with the coil is $B \ell b \cos \omega t$.

$$\phi = B \ell b \cos \omega t$$

$$\therefore \; e = -\frac{d}{dt}(B \ell b \cos \omega t) = E_m \sin \omega t \qquad ..(4.3)$$

where $E_m = B \ell b \omega$, E_m - maximum value of induced emf

When $\theta = 90°$, the coil sides are moving at right angles to the flux lines. The flux lines are cut at the maximum rate and the emf induced is maximum. When $\theta = 180°$, the coil sides are again moving parallel to the flux lines (AB and CD have exchanged positions) and the emf induced, is zero once again. When $\theta = 270°$, the coil sides again move at right angles to the flux lines but with their position reversed when compared with $\theta = 90°$. Hence the induced emf is maximum in the opposite direction. When $\theta = 360°$, the coil sides once again move parallel to the magnetic field making the induced emf equal to zero. The coil has now come back to the starting point.

If the rotation of the coil is continued, the changes in the emf are again repeated. For the two pole generator shown, one complete cycle of changes occurs in one revolution of the coil. The changes in voltage, e with respect to the angle or even time can be plotted as shown in figure 4.8.

The emf changes from instant to instant and becomes alternatively positive and negative. Such an emf is called an alternating emf. If the coil sides are connected to two slip rings 'a' and 'b' and an external resistance R is connected across them, a current flows through the resistor, which is again alternating.

The induced emf in the coil can be increased by

1) increasing the flux density (B) and

2) by increasing the angular velocity (ω).

4.1.3 E.M.F. Induced in a DC Generator

Let ϕ be the flux per pole in webers.

Let P be the number of poles.

Let Z be the total number of conductors in the armature. All the Z conductors are not connected in series. They are divided into groups and let A be the number of parallel paths into which these conductors are grouped.

Each parallel path will have Z/A conductors in series.

Let N be the speed of rotation in revolutions per minute (rpm).

Consider one conductor on the periphery of the armature. As this conductor makes one complete revolution, it cuts P ϕ webers. As the speed is N rpm, the time taken for one revolution is 60/N Secs.

Since the emf induced in the conductor = rate of change of flux cut,

$$e \;\alpha\; \frac{d\phi}{dt} = \frac{P\phi}{60/N}$$

$$e = \frac{NP\phi}{60} \text{volts} \qquad ..(4.4)$$

Since there are Z/A conductors in series in each parallel path the emf induced

$$E_g = \frac{NP\phi}{60}\,\frac{Z}{A} = \frac{\phi ZN}{60}\,\frac{P}{A} \text{ Volts} \qquad ..(4.5)$$

The armature conductors are generally connected in two different ways, viz, lap winding and wave winding. For lap wound armatures, the number of parallel paths is equal to the number of poles (i.e., A = P). In wave wound machines, A = 2, always.

EXAMPLE 1

Calculate the emf generated by a 6 pole DC generator having 480 conductors and driven at a speed of 1200 rpm. The flux per pole is 0.012 wb. Assume the generator to be (a) lap wound, (b) wave wound.

Solution:

$$E_g = \frac{\phi ZN}{60} \times \frac{P}{A} \text{ volts}$$

a) For a lap wound machine, $A = P = 6$

$$E_g = \frac{0.012 \times 480 \times 1200 \times 6}{60 \times 6} = 115.2 \text{ volts}$$

$$\boxed{E_g = 115.2V}$$

b) For a wave wound machine, $A = 2$

$$E_g = \frac{0.012 \times 480 \times 1200 \times 6}{60 \times 2} = 345.6 \text{volts}$$

$$\boxed{E_g = 345.6\,V}$$

EXAMPLE 2

A wave connected armature winding has 19 slots with 54 conductors per slot. If the flux per pole is 0.025 wb and number of poles is 8, find the speed at which the generator should be run to give 513V. Also find the speed if the armature is lap connected.

Solution:

Given data:

$P = 8$, $\phi = 0.025$wb, $Z = 19 \times 54 = 1026$, $A = 2$ (for wave)

$E_g = 513$ volts; $E_g = \phi \frac{ZN}{60} \frac{P}{A}$

Substituting, $N = \dfrac{60 \times 513 \times 2}{0.025 \times 19 \times 54 \times 8} = 300$ rpm

$$\boxed{N = 300 \text{ rpm}}$$

For lap wound, $A = P = 8$

$$\therefore \quad N = \frac{60 \times 513 \times 8}{0.025 \times 1026 \times 8} = 1200 \text{ rpm}$$

$$\boxed{N = 1200 \text{ rpm}}$$

EXAMPLE 3

The armature of a 4-pole, 600 rpm, lap wound generator has 100 slots. If each coil has 4 turns, calculate the flux per pole required to generate an emf of 300V.

Given data:

Numbers of poles = 4; Speed = 600 rpm; Numbers of slots = 100; $E_g = 300V$

Each turn has two active conductors and 100 coils are required to fill 100 slots. Therefore number of conductors $Z = 100 \times 4 \times 2 = 800$; for lap wound generator $A = P = 4$.

To find:

Flux per pole (ϕ).

Solution:

$$\text{Generated emf} \quad E_g = \frac{P\phi ZN}{60A}$$

$$\therefore \text{ Flux / pole} \quad \phi = \frac{E_g \times 60A}{PZN} = \frac{300 \times 60 \times 4}{4 \times 800 \times 600}$$

$$\boxed{\phi = 37.5 \text{ mwb}}$$

EXAMPLE 4

A 6-pole, lap wound armature rotated at 350 rpm is required to generate 300V. The useful flux per pole is 0.05wb. If the armature has 120 slots, calculate the number of conductors per slot.

Given data:

Numbers of poles, P = 6, Speed, N = 350 rpm, Generated emf, $E_g = 300V$,

Flux per pole, $\phi = 0.05$wb, Numbers of slots = 120, For lap wound generator, A=P=6

To find:

Numbers of conductors / slot:

Solution:

$$\text{Generated emf } E_g = \frac{P\phi ZN}{60A}$$

$$\text{Numbers of conductors} \quad Z = \frac{E_g \times 60A}{P\phi N} = \frac{300 \times 60 \times 4}{4 \times 0.05 \times 350} = 1029$$

$$\therefore \text{ Numbers of conductors / slot} = \frac{1029}{120} = 8.575$$

$$\boxed{\text{Conductors/slot} = 9}$$

EXAMPLE 5

The armature of a 4 pole DC generator has 85 slots and the commutator has 245 segments. It is wound to give lap winding having one turn per coil. If the flux per pole is 35mwb, calculate the generated emf at a speed of 1200rpm.

Given data:

Numbers of slots = 85, Numbers of commutator segments = 245, P = 4

Flux / pole = 35 mwb, For lap wound A = P = 4, N = 1200 rpm

To find:

Generated emf E_g.

Solution:

The number of coils is equal to the number of commutator segments. Each turn has 2 active conductors.

$\therefore$ Numbers of conductors $Z = 245 \times 2 = 490$

$$E_g = \frac{P\phi ZN}{60A} = \frac{4 \times 35 \times 10^{-3} \times 490 \times 1200}{60 \times 4}$$

$$\boxed{E_g = 343\text{ V}}$$

EXAMPLE 6

A 4-pole, wave wound generator has 40 slots and 10 conductors are placed per slot. Find, the generated emf when the generator is driven at 1200 rpm and $\phi = 0.02$ wb.

(AU/Mech-Dec 2005)

Given data:

Number of poles P = 4

Total number of conductors Z = Numbers slots × conductors per slot

$Z = 40 \times 10 = 400$

Flux per pole $\phi = 0.02$ wb, Speed N = 1200 rpm.

To find:

Generated emf (E_g)

Solution:

$$\text{Generated emf } E_g = \frac{P\phi ZN}{60A}\text{ ; for a wave wound machine } A = 2$$

$$E_g = \frac{4 \times 0.02 \times 400 \times 1200}{60 \times 2}$$

$$\boxed{E_g = 320\text{ V}}$$

EXAMPLE 7

A 4-pole machine has 60 slots and 8 conductors per slot. The total flux per pole is 20mwb. For relative speed of 1500rpm, between field flux and armature winding, calculate the generated armature voltage if the machine is a DC machine with lap winding.

(AU/EEE - Dec 2003)

Given data:

Number of poles P = 4

Number of conductors Z=Number of slots × conductor per slot = 60 × 8 = 480

Speed N = 1500 rpm

Flux per pole ϕ = 20mwb

For lap winding A = P = 4

To find:

Generated armature voltage (E_g)

Solution:

$$E_g = \frac{P\phi ZN}{60A} = \frac{4 \times 20 \times 10^{-3} \times 480 \times 1500}{60 \times 4}$$

$$\boxed{E_g = 240\text{ V}}$$

EXAMPLE 8

A 8 pole, DC generator has a simplex wave-wound armature containing 32 coils of 6 turns each. Its flux per pole is 0.06 wb. The machine is running at 250 rpm. Calculate the induced armature voltage.

(GATE - 2004)

Given data:

Number poles $P = 8$

Total number of conductors $Z = 2 \times 32 \times 6 = 384$

Flux per pole $\phi = 0.06$ wb

For wave wound $A = 2$

Solution:

Induced armature voltage $E_g = \dfrac{P\phi ZN}{60A} = \dfrac{8 \times 0.06 \times 384 \times 250}{60 \times 2}$

$$\boxed{E_g = 384\text{ V}}$$

4.1.4 Types of DC Generators

DC generators can be classified according to their methods of field excitation. There are two types of d.c. generators on the basis of excitation.

1. Separately excited d.c. generators 2. Self excited d.c. generators.

Separately excited DC generators

If the field winding is excited by a separate d.c. supply, then the generator is called separately excited d.c. generator. Figure 4.10 shows the diagram of a separately excited generator.

The field winding has large number of turns of thin wire.

From this diagram,

Armature current I_a = Load current I_L

R_a = Resistance of the armature winding

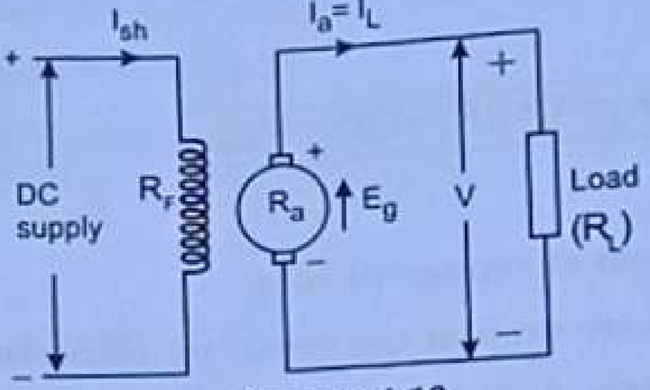


Figure 4.10

Terminal voltage $V = E_g - I_a R_a - V_{brush}$

V_{brush} = voltage drop at the contacts of the brush.

Generally V_{brush} is neglected because of very low value.

Generated emf $E_g = V + I_a R_a + V_{brush}$.

Electric power developed $= E_g I_a$

Power delivered to load $= V I_a$

Self-excited DC Generators

If in a d.c. generator field winding is supplied from the armature of the generator itself, then it is called a self-excited d.c. generator. Residual flux is present in the poles. When the armature is rotated, a small emf is produced in the armature winding because of residual flux. This emf produces a small field current in the field winding.Then flux per pole increases. The increased flux increases the induced emf, which further increases the field current. Because of this cumulative process, generator produces its rated voltage. The self-excited generators can be classified depending upon how the field winding is connected to the armature.

There are three types,

1. Series generator, 2. Shunt generator, 3. Compound generator.

i) Series Generator

The field winding is connected in series with the armature. This type of D.C. generator is called D.C. series generator.

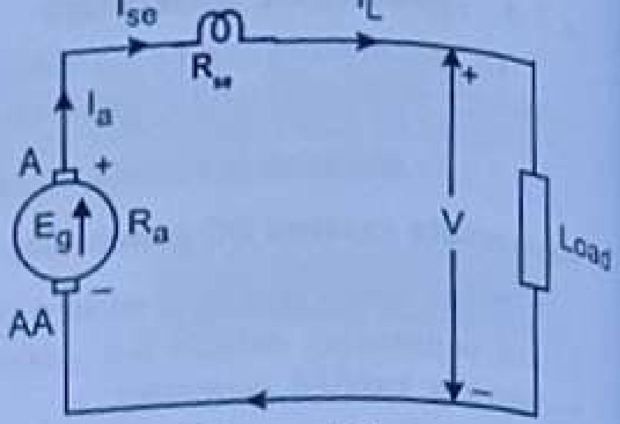


Figure 4.11

Here, the armature current flows through the field winding as well as the load. The d.c. series generator connection diagram is shown in figure 4.11.

The field winding has less number of turns of thick wire. It has low resistance.

It is denoted by R_{se}. Here, armature, field and load are all in series. So they carry the same current.

$$\boxed{\therefore I_a = I_{se} = I_L}$$

Generated emf

$$\boxed{E_g = V + I_a R_a + I_a R_{se} + V_{brush}}$$

where

V = terminal voltage in volts

$I_a R_a$ = voltage drop in the armature resistance.

$I_a R_{se}$ = voltage drop in the series field winding resistance

V_{brush} = brush drop

$\therefore$ Terminal voltage $V = E_g - I_a R_a - I_a R_{se} - V_{brush}$

Power developed in the armature = $E_g I_a$

Power delivered to load = $V I_a$ or $V I_L$

ii) Shunt Generator

In a d.c. shunt generator, field winding is connected across the armature. The load is also connected across the armature.

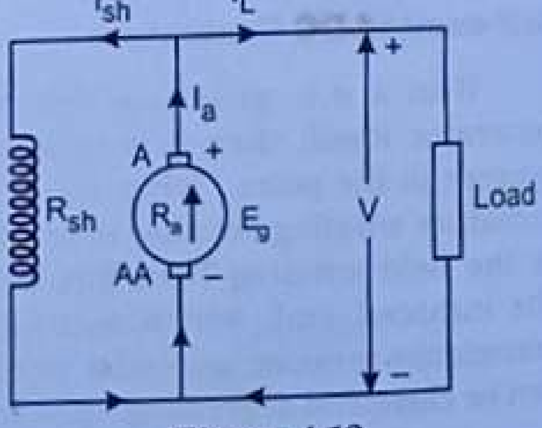


Figure 4.12

The shunt field winding has more number of turns of thin wire. It has high resistance.

Therefore, a small amount of current flows through the field winding and large amount of current flows through the armature. Figure 4.12 shows connections diagram of a D.C. shunt generator.

Terminal voltage $V = E_g - I_a R_a$

Shunt field current $I_{sh} = \frac{V}{R_{sh}}$

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

Power developed by armature $= E_g I_a$

Power delivered to load $= V I_L$

iii) Compound Generator

The compound generator consists of both shunt field and series field windings. One winding is in series and other winding is in parallel with the armature. Depending upon the shunt field and series field connections, compound generator can be classified as

1. Long shunt compound generator 2. Short shunt compound generator

Long shunt compound generator

Figure 4.13 shows connection diagram of a long shunt compound generator. Here, shunt field winding is connected across both series field and armature windings.

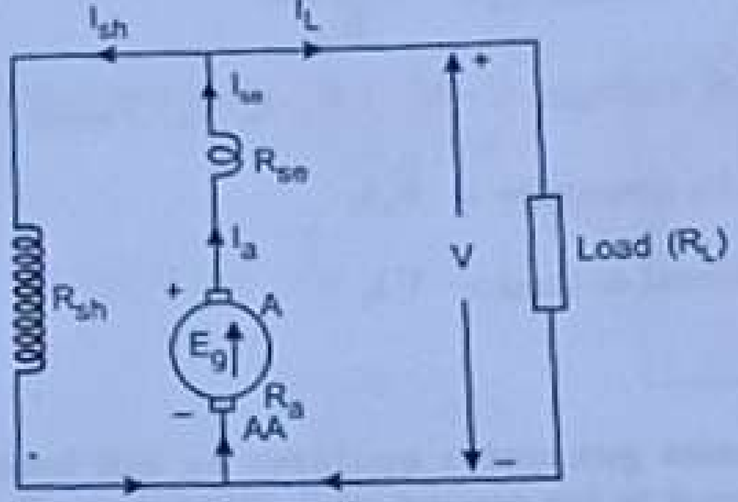


Figure 4.13

From this figure 4.13, series field current $I_{se} = I_a = I_L + I_{sh}$

Shunt field current $I_{sh} = \frac{V}{R_{sh}}$

Generated.emf $E_g = V + I_a(R_a + R_{se}) + V_{brush}$

Terminal voltage $V = E_g - I_a(R_a + R_{se}) - V_{brush}$

Power developed in armature $= E_g I_a$

Power delivered to load $= V I_L$

Short Shunt Compound Generator

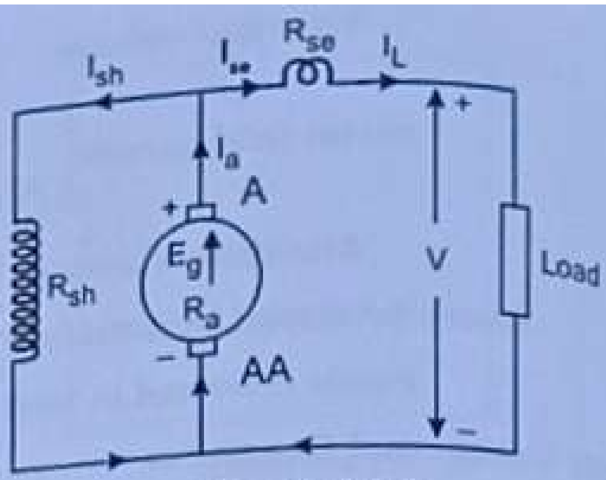


Figure 4.14

Figure 4.14 shows short shunt compound generator. Here, shunt field winding is connected in parallel with the armature and this combination is connected in series with series field winding.

From this figure 4.14,

Series field current $= I_{se} = I_L$

Load current $= I_L$

Armature current $I_a = I_{sh} + I_{se}$

Generated emf $E_g = V + I_a R_a + I_{se} R_{se} + V_{brush}$

Voltage across shunt field winding $= I_{sh} R_{sh}$

$$I_{sh} R_{sh} = E_g - I_a R_a - V_{brush}$$
$$= V + I_a R_a + I_{se} R_{se} + V_{brush} - I_a R_a - V_{brush}$$
$$= V + I_{se} R_{se}$$

$\therefore$ Shunt field current $I_{sh} = \dfrac{V + I_{se} R_{se}}{R_{sh}}$

Terminal voltage $V = E_g - I_a R_a - I_{se} R_{se} - V_{brush}$

Power developed in armature $= E_g I_a$

Power delivered to load $= V I_L$

EXAMPLE 9

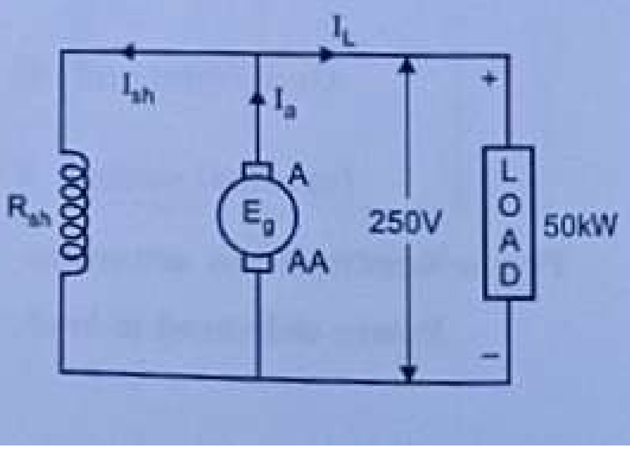
A 50 kW, 250-volt shunt generator operates on full load at 1500rpm. The armature has 6 poles and is lap wound with 200 turns. Find the induced emf and the flux per pole at full load. Given that the armature and field resistances are 0.01 and 125 Ohms respectively. Neglect armature reaction.

Solution:

For a load power of 50kW at a terminal voltage of 250-volts, load current,

$$I_L = \frac{50 \times 10^3}{250} = 200\,A$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{125} = 2A$$



For a shunt generator,

$$I_a = I_L + I_{sh} = 202\,A$$

Induced emf, $E_g = V + I_L + I_{sh}$ (neglecting armature reaction and other drops)

$$= 250 + 202 \times 0.01 = 252.02V$$

$$\boxed{E_g = 252.02V}$$

$Z = 200 \times 2$ (since 1 turn = 2 conductors)

$N = 1500$ rpm

$P = A = 6$ (lap wound)

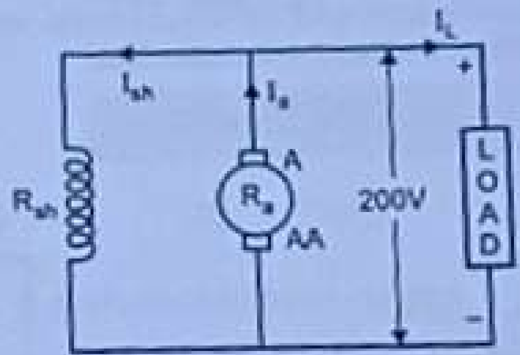
Therefore $\phi = \dfrac{252.02 \times 60 \times 6}{400 \times 1500 \times 6} = 0.025205\,Wb$

$$\boxed{\phi = 0.025205\ wb}$$

EXAMPLE 10

A 4-pole lap connected shunt generator has $R_{sh} = 100\Omega$ and $R_a = 0.1\Omega$ and supplies sixty lamps each rated 40W, 200V. Calculate the armature current, induced emf and current in each parallel path of the armature. Allow a brush drop of 1V per brush.

Solution:



Total load supplied $P_0 = 60 \times 40$

$= 2400$ watts

Load current $= \dfrac{P_0}{V}$

$$I_L = \frac{2400}{200} = 12A$$

Field current $I_{sh} = \dfrac{V}{R_{sh}} = \dfrac{200}{100} = 2A$

Armature current $I_a = I_L + I_{sh} = 12 + 2 = 14$ A

Numbers of parallel paths = Numbers of poles = 4 (lap)

Therefore current per path $= 14/4 = 3.5$ A

Induced e.m.f. $= V + I_a R_a$ + brush drop

$$= 200 + 14 \times 0.1 + 2 \times 1$$

$$\boxed{Eg = 203.4 \text{ volts}}$$

EXAMPLE 11

A compound generator delivers a load current of 50A at 500V. The resistances are $R_a = 0.05\Omega$, $R_{se} = 0.03\Omega$ and $R_{sh} = 250\Omega$. Find the induced emf if contact drop is 1.0 V per brush. Neglect armature reaction. Assume (a) long shunt, b) short shunt connection.

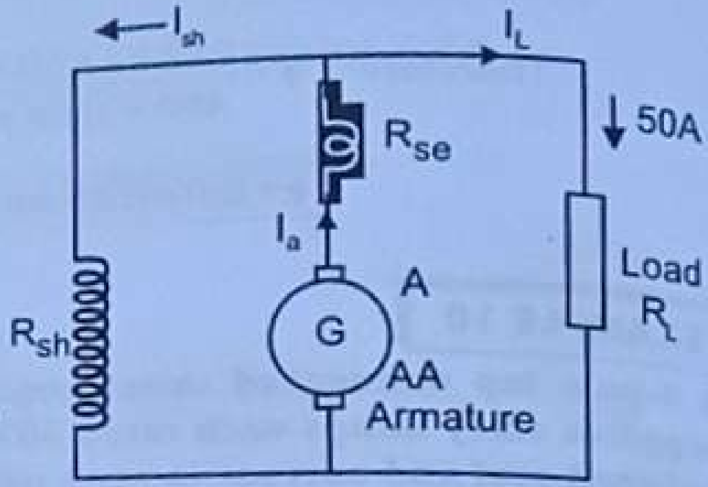
(MKU/Nov-2000)

Solution:

Long shunt connection

$$V = 500V$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{500}{250} = 2A$$



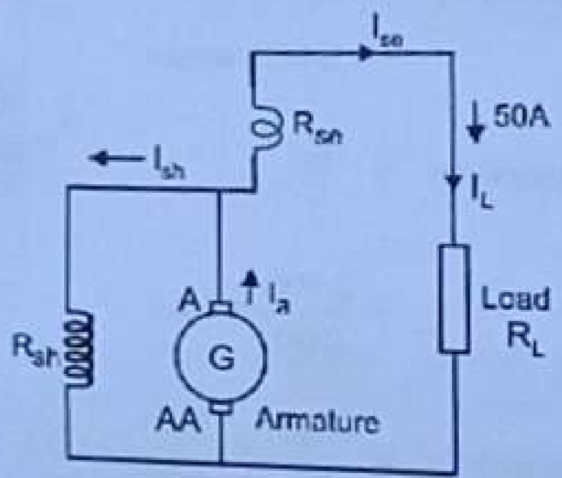
$$I_a = I_{sh} + I_L = 2 + 50 = 52A$$

$$E_g = V + I_a(R_{se} + R_a) + \text{Brushdrop}$$

$$= 500 + 52(0.03 + 0.05) + 2 \times 1$$

$$E_g = 506.16V$$

Short shunt connection



Now the shunt field current is obtained by dividing $(V + I_L R_{se})$ by the shunt field resistance.

$$I_{sh} = \frac{500 + 50 \times 0.03}{250} = 2.006 \text{ Amps}$$

$$I_a = I_L + I_{sh} = 50 + 2.006 = 52.006 A$$

$$E_g = V + I_a R_a + I_{se} R_{se} + V_{brush}$$

$$= 500 + 52.006 \times 0.05 + 50 \times 0.03 + 2$$

$$\boxed{E_g = 506.1003V}$$

EXAMPLE 12

A separately excited generator has induced emf of 250V and a full load terminal voltage of 240V. If the value of $R_a = 0.01\Omega$, find the full load current and output of the generator. Neglect armature reaction and brush drop.

Solution:

$$V = 240\,V \qquad E_g = 250V$$

$$E_g = V + I_a R_a$$

$$I_a = \frac{E_g - V}{R_a}$$

$$I_a = \frac{250 - 240}{0.01} = 1000A = I_L$$

$$\text{Output power} = VI_L = 240 \times 1000 = 240kW$$

$$\boxed{P = 240\ kW}$$

EXAMPLE 13

A 30 kW, 300V dc shunt generator has armature and field resistances of 0.05Ω and 100Ω respectively. Calculate the total power developed by the armature when it delivers full load output.

(AU/Mech - Dec 2012)

Given data:

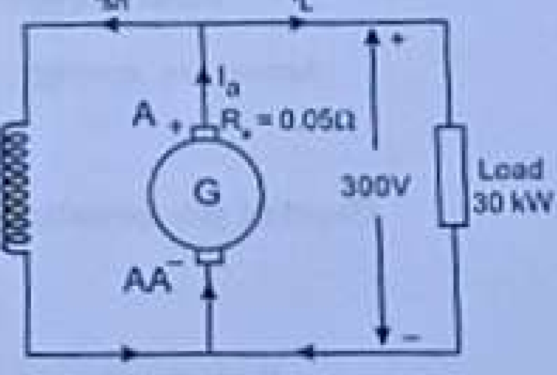
$P = 30kW;\quad V = 300V;\quad R_a = 0.05\Omega;\quad R_{sh} = 100\Omega$

To find:

Total power developed by the armature when it delivers full load output.

Solution:

Figure shows the dc shunt generator on load.



$$\text{Load current, } I_L = \frac{P}{V} = \frac{30 \times 10^3}{300}$$

$$= 100A$$

$$\text{Field current, } I_{sh} = \frac{V}{R_{sh}} = \frac{300}{100}$$

$$= 3A$$

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

$$I_a = 100 + 3 = 103A$$

$$\text{Generated emf } E_g = V + I_a R_a = 300 + 103 \times 0.05 = 305.15V$$

$$\text{Power developed by armature} = E_g I_a = 305.15 \times 103 = 31.43\ kW.$$

EXAMPLE 14

A 4-pole shunt generator, with a lap wound armature has field resistance of 50Ω and armature circuit resistance of 0.1Ω. The generator is supplying sixty 100V, 40W lamps. Find the total armature current in each armature conductor and generated emf. The brush contact drop is 1V per brush.

(AU/CSE-Dec 2003, 2007)

Given data:

Poles $P = 4$

Field resistance $R_{sh} = 50\ \Omega$

Armature resistance $R_a = 0.1\Omega$

Total power supplied $P_0 = 60 \times 40 = 2400$ W

Brush drop $V_{brush} = 2 \times 1 = 2$ V

Terminal voltage $V = 100$ V

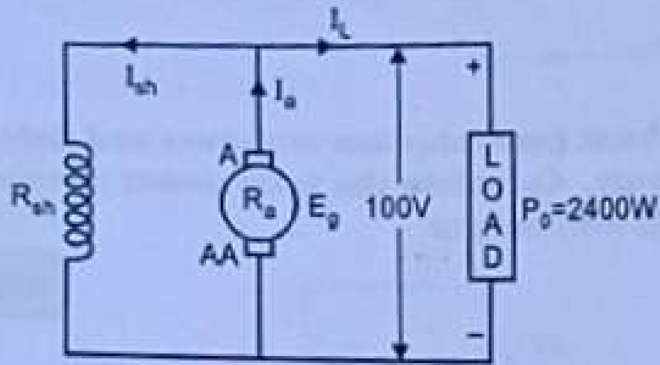
To find:

Armature current I_a

Generated emf E_g

Solution:

Figure shows circuit diagram of dc shunt generator.



Total power supplied $P_0 = 60 \times 40 = 2400$ W

$$\text{Load current } I_L = \frac{P_o}{V} = \frac{2400}{100} = 24\text{ A}$$

$$\text{Field current } I_{sh} = \frac{V}{R_{sh}} = \frac{100}{50} = 2\text{ A}$$

$$\text{Armature current } I_a = I_L + I_{sh} = 24 + 2 = 26\text{ A}$$

$$\boxed{I_a = 26\text{A}}$$

Current per armature parallel path

$$= \frac{I_a}{A} = \frac{I_a}{P} = \frac{26}{4} = 6.5\text{ A} \quad \text{[For lap wound A = P]}$$

$$\text{Generated emf } E_g = V + I_a R_a + V_{brush}$$

$$= 100 + 26 \times 0.1 + 1 \times 2$$

$$\boxed{E_g = 104.6\text{V}}$$

EXAMPLE 15

An 8-pole DC shunt generator with 778 wave connected armature conductors and running at 500 rpm supplies a load of 12.5Ω resistance at a terminal voltage of 250V. The armature resistance is 0.24Ω and field resistance is 250Ω. Find the armature current, the induced emf and the flux per pole.

(MKU/EEE-Nov2002)

Given data:

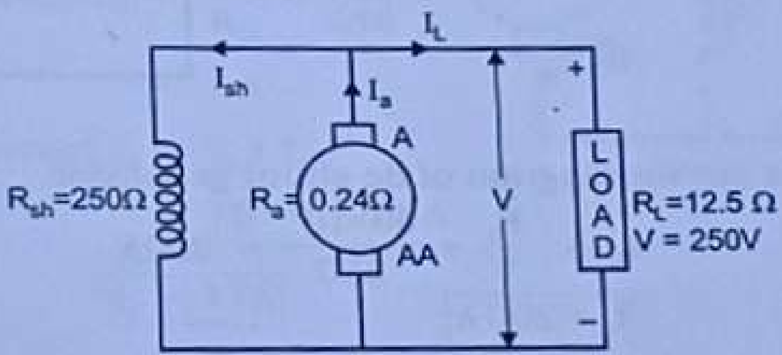
Numbers of poles	$P = 8$
Numbers of armature conductors	$Z = 778$
Speed	$N = 500$ rpm
Load resistance	$R_L = 12.5\Omega$
Terminal voltage	$V = 250V$
Armature resistance	$R_a = 0.24\Omega$
Shunt field resistance	$R_{sh} = 250\Omega$
Wave connected machine	$A = 2$

To find:

Armature current (I_a), Induced emf (E_g), Flux per pole (f).

Solution:

Figure shows circuit diagram of dc shunt generator.



i) Armature current (I_a)

Load current $$I_L = \frac{V}{R_L} = \frac{250}{12.5} = 20A$$

Shunt field current $$I_{sh} = \frac{V}{R_{sh}} = \frac{250}{250} = 1A$$

$$\therefore\ I_a = I_L + I_{sh} = 20 + 1 = 21A$$

$$\boxed{I_a = 21A}$$

ii) Induced emf E_g

$$E_g = V + I_a R_a = 250 + 21 \times 0.24 = 255.04\ V$$

$$\boxed{E_g = 255.04V}$$

iii) Flux per pole (ϕ)

$$E_g = \frac{P\phi ZN}{60A}$$

$$\phi = \frac{E_g\, 60A}{PZN} = \frac{255.04 \times 60 \times 2}{8 \times 778 \times 500} = 9.83$$

$$\boxed{\phi = 9.83 mwb}$$

EXAMPLE 16

A 50kW, 250V, dc shunt generator has a field circuit resistance of 60Ω and an armature resistance of 0.02Ω. Calculate (i) load current, field current and armature current. (ii) the generated armature voltage when delivering rated current at rated speed and voltage.

(MKU/ EEE-Apr2003)

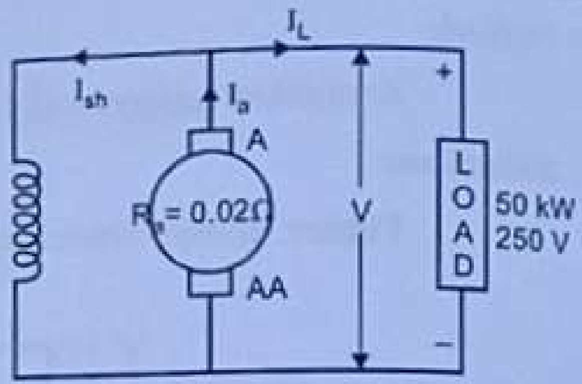
Given data:

Terminal voltage $V = 250V$

Output power $P_0 = 50\ kW$

Armature resistance $R_a = 0.02\Omega$

Shunt field resistance $R_{sh} = 60\ \Omega$



To find:

i) I_L, I_{sh}, I_a ii) E_g

Solution:

Figure shows circuit diagram of dc shunt generator.

i) Load current $I_L = \frac{P_0}{V} = \frac{50 \times 10^3}{250} = 200A$

$$\boxed{I_L = 200A}$$

Field current $I_{sh} = \frac{V}{R_{sh}} = \frac{250}{60} = 4.166A$

$$\boxed{I_{sh} = 4.166A}$$

Armature current $I_a = I_L + I_{sh} = 200 + 4.166$

$$\boxed{I_a = 204.166A}$$

ii) Generated emf E_g

$$E_g = V + I_a R_a = 250 + 204.166 \times 0.02$$

$$\boxed{E_g = 254.08V}$$

4.1.5 *Applications of DC Generators*

DC supply has for almost all applications been replaced by alternating current. AC has the chief advantage that the voltage level can be easily stepped up or down. However, DC is in use for some special applications and where the DC equipment is still in operation.

Shunt generators are used for supplying nearly constant loads. They are used for battery charging, for supplying the fields of synchronous machines and separately excited DC machines.

Since the output voltage of a series generator increases with load, series generators are ideal for use as boosters for adding a voltage to the transmission line and to compensate for the line drop. The series generator is connected in series with the line and operated in the straight line portion (unsaturated) of the characteristic.

Compound generators maintain better voltage regulation and hence find use where constancy of voltage is required eg., for a self contained generator unit.