



POSTAL BOOK PACKAGE 2025

ELECTRONICS ENGINEERING

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CONVENTIONAL Practice Sets

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BASIC ELECTRICAL ENGINEERING

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DC Machines

- Q1** An 8-pole dc generator has 500 armature conductors and a useful flux of 0.05 Wb. What will be the emf generated, if it is lap-connected and runs at 1,200 rpm? What must be the speed at which it is to be driven to produce the same emf, if it is wave-wound?

Solution:

EMF generated when the generator is lap-connected,

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{A} = \frac{0.05 \times 500 \times 1,200}{60} \times \frac{8}{8} = 500 \text{ V}$$

\therefore in lap-connected armature, number of parallel paths, $A = P = 8$

If the armature is wave connected, then

\therefore in wave-connected armature $A = 2$

$$N' = \frac{E_g \times 60}{\phi \times Z} \times \frac{A}{P} = \frac{500 \times 60}{0.05 \times 500} \times \frac{2}{8} = 300 \text{ rpm}$$

- Q2** A 4-pole, 900 r.p.m. d.c. machine has a terminal voltage of 220 V and an induced voltage of 240 V at rated speed. The armature circuit resistance is 0.2 Ω . Is the machine operating as a generator or a motor? Compute the armature current and the number of armature coils if the air-gap flux/pole is 10 m Wb and the armature turns per coil are 8. The armature is wave-wound.

Solution:

Since the induced voltage E is more than the terminal voltage v , the machine is working as a generator.

$$E - V = I_a R_a \Rightarrow 20 = I_a \times 0.2 \Rightarrow I_a = 100 \text{ A}$$

$$\text{Now, } E_b = \frac{\phi Z N}{60} \times \left(\frac{P}{A}\right) \text{ or } 240 = 10 \times 10^{-3} \times Z \times \frac{900}{60} \times \frac{4}{2} \Rightarrow Z = 800$$

Since there are 8 turns in a coil, it means there are 16 active conductors/coil. Hence, the number of coils = $\frac{800}{16} = 50$.

- Q3** A DC machine has total armature ampere conductors of 4500 and total flux in the machine is 0.14 Wb. Calculate the torque developed in the machine.

Solution:

The torque equation of a DC machine is $\tau = \frac{PZ}{2\pi A} \phi I_a$

where, P = Number of poles, Z = Total armature conductors, ϕ = Flux, I_a = Armature current and A = Number of parallel paths.

Let us assume lap winding

$$\Rightarrow A = P$$

$$\therefore \tau = \frac{Z I_a \phi}{2\pi}$$

Given, $Z I_a = 4500$; $\phi = 0.14 \text{ Wb}$

$$\tau = \frac{4500}{2\pi} \times 0.14 = 100.2676 \text{ Nm}$$

Q4 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:

Short-shunt compound Generator circuit diagram is shown in figure.

$$\text{Voltage drop in series winding} = 30 \times 0.3 = 9 \text{ V}$$

$$\text{Voltage across shunt winding} = 220 + 9 = 229 \text{ V}$$

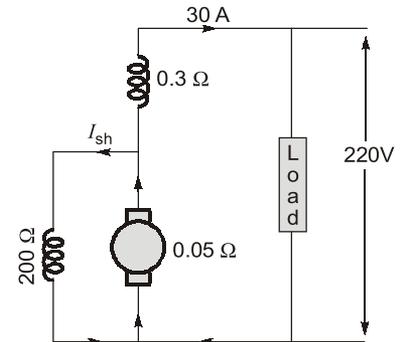
$$I_{sh} = \frac{229}{200} = 1.145 \text{ A}$$

$$I_a = 30 + 1.145 = 31.145 \text{ A}$$

$$I_a R_a = 31.145 \times 0.05 = 1.56 \text{ V}$$

$$\text{Brush drop} = 2 \times 1 = 2 \text{ V}$$

$$E_g = V + \text{Brush drop} + I_a R_a + \text{Series drop} = 220 + 9 + 2 + 1.56 = 232.56 \text{ V}$$



Q5 A separately excited generator, when running at 1000 r.p.m. supplied 200 A at 125 V. What will be the load current when the speed drops to 800 r.p.m. if I_f is unchanged? Given brush drop = 2 V and armature resistance = 0.04 Ω.

Solution:

Given data: The load resistance, $R = \frac{125}{200} = 0.625 \Omega$, in figure.

$$E_{g1} = 125 + 200 \times 0.04 + 2 = 135 \text{ V}$$

$$N_1 = 1000 \text{ r.p.m.}$$

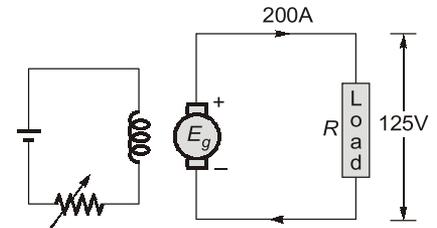
Since, $E_g \propto N$. Therefore, $E_{g2} = E_{g1} \cdot \frac{N_2}{N_1}$

$$\text{At } 800 \text{ r.p.m. } E_{g2} = 135 \times \frac{800}{1000} = 108 \text{ V}$$

if I is the new load current, then terminal voltage V is given by

$$V = 108 - 0.04 I - 2 = 106 - 0.04 I$$

$$I = \frac{V}{R} = \frac{(106 - 0.04 I)}{0.625} = 159.4 \text{ A}$$



Q6 A 4-pole, long-shunt lap-wound generator supplies 25 kW at a terminal voltage of 500 V. The armature resistance is 0.03 ohm, series field resistance is 0.04 ohm and shunt field resistance is 200 ohm. The voltage drop per brush may be taken as 1.0 V. Determine the e.m.f. generated. Calculate also the No. of conductors if the speed is 1200 r.p.m. and flux per pole is 0.02 weber. Neglect armature reaction.

Solution:

$$I = \frac{25000}{500} = 50 \text{ A}$$

$$I_{sh} = \frac{500}{200} = 2.5 \text{ A}$$

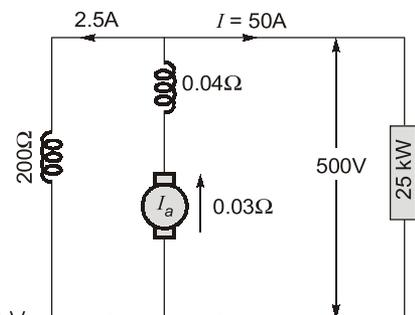
$$I_a = I + I_{sh} = 50 + 2.5 = 52.5 \text{ A}$$

$$\text{Series field drop} = 52.5 \times 0.04 = 2.1 \text{ V}$$

$$\text{Armature drop} = 52.5 \times 0.03 = 1.575 \text{ V}$$

$$\text{Brush drop} = 2 \times 1 = 2 \text{ V}$$

$$\text{Generated e.m.f., } E_g = 500 + 2.1 + 1.575 + 2 = 505.68 \text{ V}$$



Generated emf, $E_g = \frac{\phi ZN}{60} \times \left(\frac{P}{A}\right)$ $A = P$ (\therefore Lap-wound)

$$\therefore Z = \frac{60E_g}{N\phi} = \frac{60 \times 505.68}{1200 \times 0.02} = 1264.2$$

Number of conductors, $Z \simeq 1264$

Q7 The following information is given for a 300 kW, 600-V, long-shunt compound generator: Shunt field resistance = 75Ω , armature resistance including brush resistance = 0.03Ω , commutating field winding resistance = 0.011Ω , series field resistance = 0.012Ω , diverter resistance = 0.036Ω . When the machine is delivering full load, calculate the voltage and power generated by the armature.

Solution:

Given data: Power output = 300,000 W; Output current = $\frac{300000}{600} = 500$ A

$$I_{sh} = \frac{600}{75} = 8 \text{ A}; \quad I_a = 500 + 8 = 508 \text{ A}$$

A diverter is a resistance shunting the series field resistance of compound generator to adjust the degree of compounding to produce a desired voltage regulation.

Since the series field resistance and diverter resistance are in parallel their combined resistance is

$$= \frac{0.012 \times 0.036}{0.048} = 0.009 \Omega$$

$$\text{Total armature circuit resistance} = 0.03 + 0.011 + 0.009$$

$$= 0.05 \Omega$$

$$\text{Voltage drop} = 508 \times 0.05$$

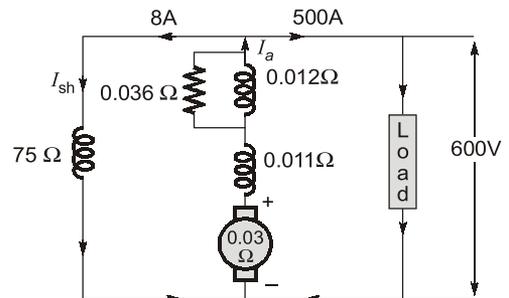
$$= 25.4 \text{ V}$$

$$\text{Voltage generated by armature} = 600 + 25.4 = 625.4 \text{ V}$$

$$\text{Power generated} = 625.4 \times 508$$

$$= 317,700$$

$$\text{Power generated in kW} = 317.7 \text{ kW}$$



Q8 A shunt generator has a full load current of 196 A at 220 V. The stray losses are 720 W and the shunt field coil resistance is 55Ω . If it has a full load efficiency of 88%, find the armature resistance. Also, find the load current corresponding to maximum efficiency.

Solution:

$$\text{Output} = 220 \times 196 = 43,120 \text{ W}; \eta = 88\% \text{ (overall efficiency)}$$

$$\text{Electrical input} = \frac{43120}{0.88} = 49,000 \text{ W}$$

$$\text{Total losses} = 49,000 - 43,120 = 5,880 \text{ W}$$

$$\text{Shunt field current} = \frac{220}{55} = 4 \text{ A}$$

$$\therefore I_a = 196 + 4 = 200 \text{ A}$$

$$\therefore \text{Shunt Cu loss} = 220 \times 4 = 880 \text{ W}; \text{ Stray losses} = 720 \text{ W}$$

$$\text{Constant losses} = 880 + 720 = 1,600 \text{ W}$$

$$\therefore \text{Armature Cu loss} = 5,880 - 1,600 = 4,280 \text{ W}$$

$$\therefore I_a^2 R_a = 4,280 \text{ W}$$

$$200^2 R_a = 4,280 \text{ or } R_a = 4,280 / 200 \times 200 = 0.107 \Omega$$

$$\text{For maximum efficiency} \quad I^2 R_a = \text{constant losses} = 1,600 \text{ W}; I = \sqrt{\frac{1600}{0.107}} = 122.28 \text{ A}$$

Q.9 A long-shunt compound-wound generator gives 240 volts at full load output of 100 A. The resistances of various windings of the machine are: armature (including brush contact) 0.1Ω , series field 0.02Ω , interpole field 0.025Ω , field (including regulating resistance) 100Ω . The iron loss at full load is 1000 W; windage and friction losses total 500 W. Calculate full load efficiency of the machine.

Solution:

$$\text{Output} = 240 \times 100 = 24,000 \text{ W}$$

$$\text{Total armature circuit resistance} = 0.1 + 0.02 + 0.025 = 0.145 \Omega$$

$$I_{sh} = \frac{240}{100} = 2.4 \text{ A}$$

$$\therefore I_a = 100 + 2.4 = 102.4 \text{ A}$$

$$\therefore \text{Armature circuit copper loss} = (102.4)^2 \times 0.145 = 1,521 \text{ W}$$

$$\text{Shunt field copper loss} = 2.4 \times 240 = 576 \text{ W}$$

$$\text{Iron loss} = 1000 \text{ W}; \text{ Friction loss} = 500 \text{ W}$$

$$\text{Total loss} = 1,521 + 1,500 + 576 = 3,597 \text{ W}; \eta = \frac{24,000}{24,000 + 3,597} \times 100 = 87\%$$

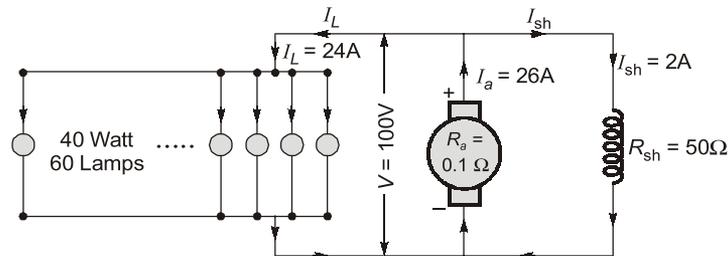
Q.10 A 4-pole generator with lap-connected armature having field and armature resistances of 50Ω and 0.1Ω respectively supplies 60, 40 W lamps at 100 V. Calculate the total armature current, current per path and the generated emf. Assume a constant drop of 1 V per brush.

Solution:

Total lamp load,
Terminal voltage,

$$P_L = \text{Number of lamps} \times \text{wattage of each lamp} = 60 \times 40 = 2,400 \text{ W}$$

$$V = 100 \text{ V}$$



Load current, $I_L = \frac{P_L}{V} = \frac{2,400}{100} = 24 \text{ A}$

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

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

\therefore For lap-connected $A = P = 4$

Current per path, $I_c = \frac{I_a}{A} = \frac{26}{4} = 6.5 \text{ A}$

Generated emf, $E_g = V + I_a R_a + \text{brush drop} = 100 + (26 \times 0.1) + (2 \times 1) = 104.6 \text{ V}$

Q.11 A 250 V dc shunt motor having an armature resistance of 0.25Ω carries an armature current of 50 A and runs at 750 rpm. If the flux is reduced by 10%, find the speed. Assume that the torque remains the same.

Solution:

Supplied Voltage, $V = 250 \text{ V}$

Armature current, $I_{a1} = 50 \text{ A}$

Back emf, $E_{b1} = V - I_{a1} R_a = 250 - 50 \times 0.25 = 237.5 \text{ V}$

Flux, $\phi_2 = 0.9 \phi_1$

\therefore Flux has been reduced by 10%

Since torque developed remains unchanged,

$$I_{a2}\phi_2 = I_{a1}\phi_1 \text{ as } T \propto \phi I_a$$

or Armature current,

$$I_{a2} = I_{a1} \times \frac{\phi_1}{\phi_2} = 50 \times \frac{1}{0.9} = 55.55 \text{ A}$$

Back emf,

$$E_2 = V - I_{a2} R_a = 250 - 55.55 \times 0.25 = 236.11 \text{ V}$$

\therefore

$$E_b \propto \phi N$$

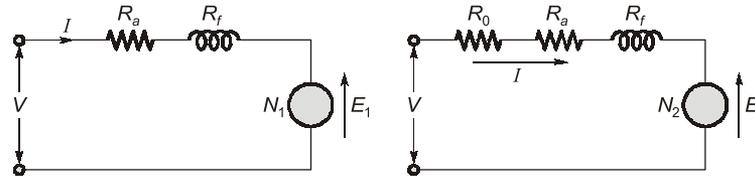
Speed,

$$N_2 = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2} \times N_1 = \frac{236.11}{237.5} \times \frac{1}{0.9} \times 750 = 828.5 \text{ rpm}$$

Q.12 A series motor has an armature resistance of 0.7 ohm and field resistance of 0.3 ohm. It takes a current of 15 A from a 200 V supply and runs at 800 r.p.m. Find the speed at which it will run, when connected in series with a 5 ohm resistance and taking the same current at the same supply voltage.

Solution:

Given data: $R_a = 0.7 \Omega$; $R_f = 0.3 \Omega$; $R_0 = 5 \Omega$; $I = 15 \text{ A}$; $V = 200 \text{ V}$; $N_1 = 800 \text{ rpm}$



We have to calculate N_2 .

We know that,

$$E \propto \phi N$$

[ϕ = Field flux]

But, as I has not changed, so ϕ will remain same in this case,

\Rightarrow

$$E \propto N$$

\Rightarrow

$$\frac{E_1}{E_2} = \frac{N_1}{N_2} \quad \dots(1)$$

Now,

$$E_1 = V - I(R_a + R_f) \\ = 200 - 15(1) = 185 \text{ V}$$

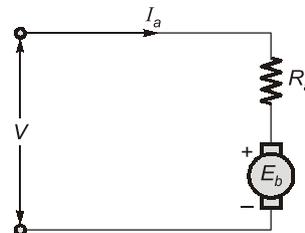
$$E_2 = V - I(R_a + R_f + R_0) \\ = 200 - 15(6) = 110 \text{ V}$$

From equation (1),

$$N_2 = \frac{N_1 E_2}{E_1} = \frac{800 \times 110}{185} = 475.6756 \text{ rpm}$$

Q.13 A DC motor with permanent magnet field is running with 200 V DC supply and consuming 2 A current. A voltmeter is connected across its armature and DC supply is disconnected. The voltmeter reads 190 V just after disconnection of DC supply. Calculate the armature resistance of the machine.

Solution:



Equivalent circuit of the motor

Given data: $V = 200 \text{ V}$;

$I_a = 2 \text{ A}$; $E_b = 190 \text{ V}$ this is present because of field magnets

We can write,

$$V = I_a R_a + E_b \quad \text{[Neglecting voltage drop across brushes]}$$

\Rightarrow

$$200 = 2R_a + 190$$

\Rightarrow

$$R_a = 5 \Omega$$