UNIT–IV

DC GENERATORS

Solved Problems.

I Basic problems based on E.M.F equation of D.C generator

① A 4 pole, lap wound, d.c generator has a useful flux of 0.07 Wb per pole. Calculate the generated e.m.f. when it is rotated at a speed of 900 r.p.m with the help of prime mover. Armature consists of 440 number of conductors. Also calculate the generated e.m.f. if lap wound armature is replaced by wave wound armature.

soln

Given: $P=4$; $Z=440$; $\phi=0.07\,Wb$; $N=900$ r.p.m.

$$E=\frac{\phi PNZ}{60A}$$

i) For lap wound, $A=P=4$

$$E=\frac{\phi NZ}{60}=\frac{0.07\times 900\times 440}{60}=462\,V$$

ii) For wave wound $A=2$

$$E=\frac{\phi PNZ}{120}=\frac{0.07\times 4\times 900\times 440}{120}=924\,V$$

② A wave wound, 6 pole, long shunt compound d.c generator has 600 armature conductors. The generator is driven at 300 r.p.m. Calculate the e.m.f generated if the flux/pole is 0.060 Wb. If now, the generator is required to produce e.m.f of 550 V, at a reduced value of flux/pole of 0.055 Wb, calculate the speed at which the armature of the generator must be driven.

soln

$P=6$, $Z=600$, $N_1=300$ r.p.m, $\phi_1=0.06\,Wb$, wave wound

for $N_1=300$ r.p.m the e.m.f generated is,

$$E_{g_1}=\frac{\phi_1 PN_1Z}{60A}=\frac{0.06\times 6\times 300\times 600}{60\times 2}=540V$$

$$\boxed{E_{g_1}=540V}$$

New value of flux $\phi_2=0.055\,Wb$, $E_{g_2}=550V$

$$E_{g_2}=\frac{\phi_2 PN_2Z}{60A}$$

(i.e) $550 = \frac{0.055 \times 6 \times N_2 \times 600}{60 \times 2}$

$N_2 = 333.33$ r.p.m

It can be observed that to increase the generated e.m.f with reduced flux, the speed must be increased.

③ A 4 pole, lap wound, d.c generator has 42 coils with 8 turns per coils. It is driven at 1120 r.p.m. If useful flux per pole is 21 mWb, calculate the generated e.m.f. Find the speed at which is it is to be driven to generate the same e.m.f as calculated above, with wave wound armature.

Solu

$P = 4,\ \phi = 21\ mWb = 21 \times 10^{-3}\ Wb,\ N = 1120$ r.p.m

Coils = 42 and turns/coil = 8

total turns = coils × turns / coil

$= 42 \times 8 = 336$

$Z = 2 \times$ total turns

$= 2 \times 336$

$Z = 672$

i) For lap wound, $A = P$

$$E = \frac{\phi N Z}{60} = \frac{21 \times 10^{-3} \times 1120 \times 672}{60} = 263.424\ V$$

$E = 263.424\ V$

ii) For wave wound $A = 2$ and $E = 263.424\ V$

$$E = \frac{\phi N P Z}{120}$$

$$263.424 = \frac{21 \times 10^{-3} \times N \times 4 \times 672}{120}$$

$N = 560$ r.p.m

④ A 12 pole D.C generator has simple wave wound armature containing 144 coils of 10 turns each. This resistance of each turns is 0.011Ω. Its flux per pole is 0.05 Wb and it is running at a speed of 200 r.p.m. obtain the induced armature voltage and the effective armature resistance.

Solu

$P = 12$, 144 coils, wave i.e $A = 2$, 10 turns / coil

Resistance of each turn $= 0.011\Omega$, $\phi = 0.05$ Wb

Total turns $= 144 \times 10 = 1440$

Z = Total conductors $= 1440 \times 2 = 2880$

$$E_g = \frac{\phi P N Z}{60 A} = \frac{0.05 \times 12 \times 200 \times 2880}{60 \times 2} = 2880\,V$$

For $A=2$ parallel paths, there are $2880/2 = 1440$ conductors per parallel path i.e. 720 turns per parallel path.

$\therefore$ Resistance / parallel path $= 720 \times 0.011 = 7.92\Omega$

Such two paths in parallel hence $R_a = 7.92 \parallel 7.92$

$R_a = 3.96\Omega$

II Problems based on Demagnetising & Cross magnetising conductors

① A 4 pole d.c generator has a wave wound armature with 722 conductors which deliver 50 A on full load. If the brush lead is 8°. Calculate the armature demagnetising and cross magnetising ampere-turns per pole.

Soln

Given data:

$P = 4$, $Z = 722$, $I_a = 50A$

For wave wound $I = \frac{I_a}{2} = \frac{50}{2} = 25A$

Brush shift $\theta_m = 8^\circ$

$$AT_d/\text{pole} = ZI\frac{\theta_m}{360} = \frac{722 \times 25 \times 8}{360} = 401.11$$

$$AT_c/\text{pole} = ZI\left[\frac{1}{2P} - \frac{\theta_m}{360}\right] = 722 \times 25\left[\frac{1}{2 \times 4} - \frac{8}{360}\right] = 1855.13$$

② The brushes of a 400 kW, 500V, 6-pole D.C generator is given a lead of 12° electrical. Calculate (i) The demagnetizing ampere-turns, ii) The cross-magnetizing ampere-turns and iii) series turns required to balance the demagnetizing component. The machine has 1000 conductors and the leakage coefficient is 1.4.

Soln

Assuming lap connection

power = 400 kW, $P = 6$, $\theta_e = 12°$ electrical

$V = 500$ volts, $Z = 1000$, λ = Leakage coefficient = 1.4

Lap connection gives $A = P = 6$

$$I = \frac{I_a}{A} \text{ and } I_a = \frac{\text{power}}{V} = \frac{400 \times 10^3}{500} = 800A$$

$$I = \frac{800}{6} = 133.33A$$

$$\theta_m = \frac{\theta_e}{P/2} = \frac{12}{6/2} = 4°$$

i) Demagnetizing AT are

$$AT_d \text{ per pole} = ZI \frac{\theta_m}{360} = \frac{1000 \times 133.33 \times 4}{360} = 1481.44$$

ii) Cross magnetizing AT are,

$$AT_c \text{ per pole} = Z.I\left[\frac{1}{2P} - \frac{\theta_m}{360}\right]$$

$$= 1000 \times 133.33\left[\frac{1}{12} - \frac{4}{360}\right]$$

$$= 9629.38$$

iii) Series field winding is in series with armature carrying full load armature current of 800 A. Series turns required to balance demagnetizing component.

$$= \frac{AT_d \times \lambda}{\text{Load current}}$$

$$= \frac{1481.44 \times 1.4}{800}$$

$$= 2.59$$

$$\approx 3$$

III Problms based on Reduction of Effects of Armature reaction.

① Calculate the number of conductors on each pole piece in a compensating winding for a 10 pole d.c generator wich has lap wound armature containing 800 conductors. Assume rati of pole arc to pole pitch to be 0.7.

solu

$P = 10,\ Z = 800,$

$$\frac{\text{pole arc}}{\text{pole pitch}} = 0.7$$

Ampere turns per pole for compensating winding $= \frac{I_a Z}{2AP} \times \frac{\text{Pole arc}}{\text{Pole pitch}}$

Number of turns per pole for compensating winding

$$= \frac{Z}{2AP} \times \frac{\text{pole arc}}{\text{pole pitch}}$$

$$= \frac{800}{2 \times 10 \times 10} \times 0.7 = 2.8$$

Since 2 conductors form one turn.

Compensating conductors / pole $= 2 \times 2.8 = 5.6$

$\approx 6.$

IV Problms base on commutation:

① A 4 pole lap wound armature running at 1800 r.p.m delivers a current of 150 A and has 64 commutator segments. The brush sparts 1.2 segments and inductance of each armature coil is 0.06 mH.

Calculate the value of reactance voltage assuming i) Linear commutation (ii) Sinusoidal commutation. Neglect mica thickness.

solu

The given values are,

$I = 150\,A$ $\quad N = 8000$ r.p.m $\quad W_b = 1.2$ segments

$W_m = 0$ $\quad L = 0.06\,mH$ $\quad$ 64 segments.

There are total 64 segments on the entire periphery. It is nessary to calulate the peripheral speed in segments per second as W_b is given in segments.

Now the commutator speed is 1800 r.p.m i.e

$$n_s = \frac{1800}{60} = 30 \text{ r.p.s i.e revolutions per second}$$

And in one revolution, 64 segments get covered. Hence

V = peripheral speed in segments/second

= No. of revolutions per second × Total segments on commutator

$= 30 \times 64$

$= 1920$ segments/second

$$T_c = \frac{W_b - W_m}{V} = \frac{1.2 - 0}{1920} = 6.25 \times 10^{-4} \text{ second.}$$

I = current through a conductor $= \frac{I_L}{A} = \frac{150}{4} = 37.5A$

For linear commutation,

Self induced e.m.f,

$$E = L \times \frac{2I}{T_c} = 0.06 \times 10^{-3} \times \frac{2 \times 37.5}{6.25 \times 10^{-4}} = 7.2V$$

For sinusoidal commutation,

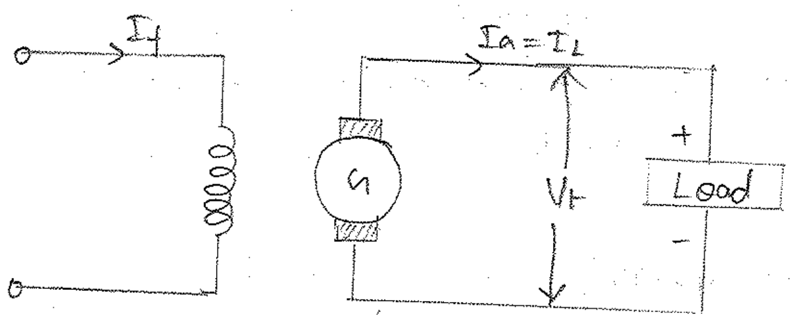
$$E = 1.11 L \frac{2I}{T_c} = 1.11E = 7.992V$$

$$E = 7.992V$$

V problem base on Separately Exited Generator :-

① A separately excited D.C generator, when running at 1000 r.p.m supplied 200 A at 125V. What will be the load current when speed drops to 800 r.p.m, if I_f is unchanged? Given that the armature resistance = 0.04 and brush drop = 2V

(2)



Soln

$N_1 = 1000$ r.p.m , $I_{L1} = 200A$,

$V_{t1} = 125V$, $R_a = 0.04\Omega$

$V_{t1} = E_g - I_a R_a - V_{brush}$

$125 = E_{g1} - I_{a1} R_a - V_{brush}$

$I_{a1} = I_{L1} = 200A$, $V_{brush} = 2V$

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

Now, $E_g \propto N\phi \propto NI_f \propto N$

$\frac{E_{g1}}{E_{g2}} = \frac{N_1}{N_2}$ i.e. $\frac{135}{E_{g2}} = \frac{1000}{800}$

$E_{g2} = 108V$

$V_{t2} = E_{g2} - I_{a2} R_a - V_{brush}$ $(\because I_{a2} = I_{L2})$

The load is constant hence load resistance is constant.

$R_L = \frac{V_{t1}}{I_{L1}} = \frac{V_{t2}}{I_{L2}}$

$R_L = \frac{125}{200} = 0.625\Omega$

$V_{t2} = I_{L2} \times R_L = 0.625 I_{L2}$

$0.625 I_{L2} = 108 - I_{L2} \times 0.04 - 2$

$I_{L2} = 159.398A$

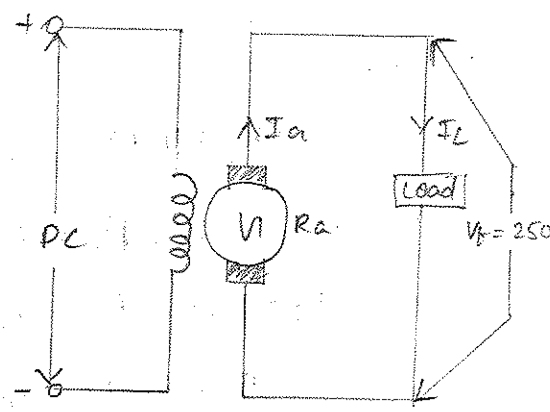
(2) A 250V, 10kW, separately excited generator has an induced e.m.f of 255V at full load. If the brush drop is 2V per brush, calculate the armature resistance of the generator.

Solu

Consider seperately excited generator

$$I_a = I_L$$

Note that 250V, 10kW generator means the full load capacity of generator is to supply 10kW load at a terminal voltage $V_t = 250V$.



$V_t = 250V$ and $P = 10kW$

$$P = V_t \times I_L$$

$$I_L = \frac{10 \times 10^3}{250} = 40A$$

$$I_a = I_L = 40A$$

$$E = V_t + I_a R_a + V_{brush}$$

Now there are two brushes and brush drop is 2 V/brush

$$V_{brush} = 2 \times 2 = 4V$$

$$E = 250 + 40 \times R_a + 4$$

where $E = 255$ V

$$255 = 250 + 40 R_a + 4$$

$$\boxed{R_a = 0.025\Omega}$$

VI Shunt generator.

(1) A 4 pole lap wound d.c shunt generator has a useful flux/pole of 0.6Wb. The armature winding consists of 200 turns, each turn having a resistance of 0.003Ω, calculate the terminal voltage when running at 1000 r.p.m. if armature current is 45A.

solu

$P = 4$, lap wound, $A = P = 4$, $N = 1000$ r.p.m, $I_a = 45A$

$\phi = 0.6Wb$, 200 turns, 0.003Ω per turn

5 (2)

total $R_a = 0.003 \times 200$

$R_a = 0.6\,\Omega$

For the d.c generator, $E_g = \dfrac{\phi P N Z}{60 A}$

Z = Total conductors = $2 \times$ Number of turns

$= 2 \times 200 = 400$

$$E_g = \frac{0.6 \times 4 \times 1000 \times 400}{60 \times 4} = 4000\,V$$

For the shunt generator, $E_g = V_t + I_a R_a$

$4000 = V_t + 45 \times 0.6$

$V_t = 3973\,V$

(2) A 4-pole, lap connected D.C machine has 540 armature conductors. If the flux per pole is 0.03 Wb and runs at 1500 r.p.m, determine the e.m.f generated. If this machine is driven as a shunt generator with the same field flux and speed, calculate the terminal voltage when it supplies a load resistance of $40\,\Omega$. Given armature resistance as $2\,\Omega$ and shunt field circuit resistance as $450\,\Omega$. Also find the load current.

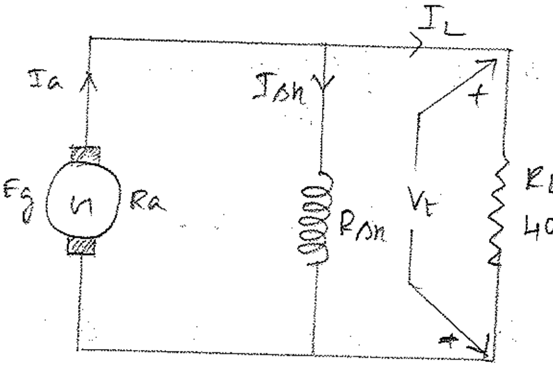
Soln

$P = 4$, Lap i.e $A = P$, $Z = 540$, $\phi = 0.03\,Wb$, $N = 1500$ r.p.m, $R_a = 2\,\Omega$, $R_{sh} = 450\,\Omega$

$$E_g = \frac{\phi P N Z}{60 A} = \frac{0.03 \times 4 \times 1500 \times 540}{60 \times 4} = 405\,V$$

$V_t = E_g - I_a R_a \rightarrow (1)$

$I_L = \dfrac{V_t}{R_L} = \dfrac{V_t}{40} \rightarrow (2)$



$I_{sh} = \dfrac{V_t}{R_{sh}} = \dfrac{V_t}{450} \rightarrow (3)$

$I_a = I_L + I_{sh}$

$= \dfrac{V_t}{40} + \dfrac{V_t}{450}$

$I_a = 0.027222\,V_t \rightarrow (4)$

substituting (4) in equation (1),

$$V_t = E_g - 0.027222\, V_t \times R_a$$

i.e $[1+0.027222 \times 2]\, V_t = 405$

$$V_t = 384.088\text{V} \quad \text{and}$$

$$I_L = \frac{V_t}{40} = 9.6022\text{A}$$

(3) A 10 pole D.C shunt generator with 800 wave connected conductors are running at 600 r.p.m supplies a load of 15Ω resistance at a terminal voltage of 240V. The armature resistance is 0.28Ω and field resistance is 240Ω. Determine the armature current, the induced emf and flux per pole.

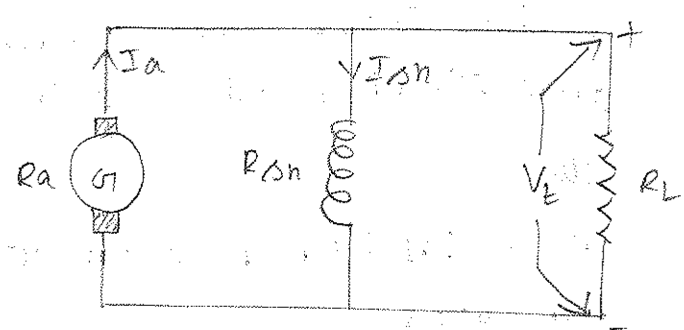
Soln

$P = 10$, $Z = 800$, wave i.e $\Rightarrow A = 2$, $N \Rightarrow 600$ r.p.m

$R_L = 15\Omega$, $V_t = 240V$, $R_a = 0.28\Omega$, $R_{sh} = 240\Omega$

$$I_L = \frac{V_t}{R_L} = \frac{240}{15} = 16\text{A}$$

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{240}{240} = 1\text{A}$$



$$I_a = I_L + I_{sh} = 17\text{A}$$

$$E_g = V_t + I_a R_a$$

$$= 240 + 17 \times 0.28$$

$$= 244.76\text{V}$$

$$E_g = \frac{\phi P N Z}{60 A}$$

$$244.76 = \frac{\phi \times 10 \times 600 \times 800}{60 \times 2}$$

$$\phi = 6.119 \text{ mWb.}$$

(4) A 4-pole, lap wound d.c machines has 728 armature conductors. Its field winding is excited from a dc source to create an air gap flux of 32 mWb/pole. The machine is run from a prime mover at 1600 r.p.m.

It supplies a current of 100 A to an electric load.

i) calculate the electromagnetic power developed.

ii) What is the mechanical power that is fed from the prime mover to the generator?

iii) What is the torque provided by the prime mover?

Soln

$P=4,\ A=P$ for lap, $Z=728,\ \phi=32\,mWb$

$N=1600$ r.p.m, $I_L=100A$

i) $$E_g=\frac{\phi PNZ}{60A}=\frac{32\times10^{-3}\times4\times1600\times728}{60\times4}=621.22V$$

$$P_g=E_g I_a=621.22\times100=62.122\ KW$$

ii) mechanical power fed from the prime mover to the generator is,

$$P_m=P_g=62.122\ kW$$

iii) Torque provided is,

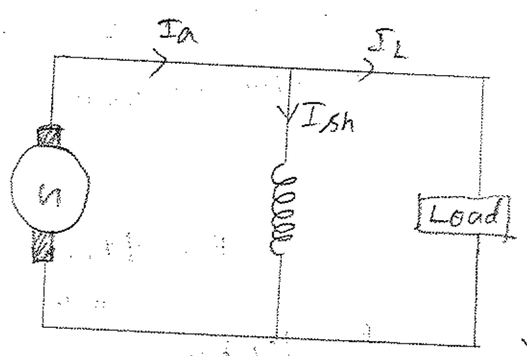
$$T_m=\frac{P_m}{\left(\frac{2\pi N}{60}\right)}=\frac{62.122\times10^3}{\left(\frac{2\pi\times1600}{60}\right)}=370.767\,Nm$$

(5) A 4 pole DC shunt generator with lap connected armature supplies 5 kilowatt at 230 volts. The armature and field copper losses are 360 watts and 200 watts respectively. Calculate the armature current and generated EMF?

Soln

$P=4$, lap $A=P$, $P=5KW$, $V_t=230V$

$$I_L=\frac{P}{V_t}=\frac{5000}{230}=21.7391A$$



Armature copper loss $=I_a^2R_a$

Field copper loss $=I_{sh}^2R_{sh}$

$$I_{sh}=\frac{V_t}{R_{sh}}\quad \text{i.e Field copper loss}=\frac{V_t^2}{R_{sh}}=200$$

$$R_{sh}=\frac{V_t^2}{200}=\frac{230^2}{200}=264.5\,\Omega$$

$$I_{sh} = \frac{V_t}{R_{sh}} = 0.8695A$$

$$\therefore \; I_a = I_L + I_{sh} = 21.7391 + 0.8695$$

$$= 22.6086A$$

$$I_a^2 R_a = 360 \quad \text{i.e } R_a = \frac{360}{(22.6086)^2} = 0.704\Omega$$

$$\therefore \; E_g = V_t + I_a R_a = 230 + 22.6086 \times 0.704$$

$$= 245.923V$$

V problem based on series generator

① A D.C series generator has armature resistance of 0.5Ω and series field resistance of 0.03Ω. It drives a load of 50 A. If it has 6 turns/coil and total 540 coils on the armature and is driven at 1500 r.p.m calculate the terminal voltage at the load. Assume 4 poles, lap type winding, flux per pole as 2 mWb and total brush drop as 2V.

solu

consider the series generator

$R_a = 0.5\Omega$, $R_{se} = 0.03\Omega$

$V_{brush} = 2V$

$N = 1500$ r.p.m

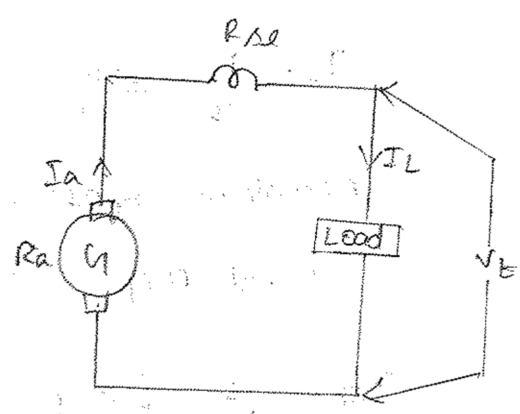
Total coils are 540 with 6 turns/coil

$\therefore$ Total turns $= 540 \times 6 = 3240$

$\therefore$ Total conductors $Z = 2 \times$ turns

$= 2 \times 3240$

$= 6480$



$$E = \frac{\phi P N Z}{60A}$$

For lap type, $A = P$

$$\phi = 2mWb = 2 \times 10^{-3} Wb$$

$$\therefore \; E = \frac{2 \times 10^{-3} \times 1500 \times 6480}{60} = 324V$$

$$E = V_t + I_a(R_a + R_{se}) + V_{brush}$$

where $I_a = I_L = 50A$

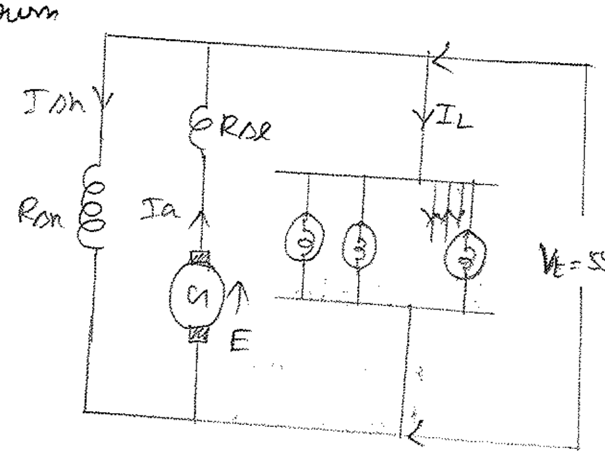
$$324 = V_t + 50(0.5 + 0.03) + 2$$
$$V_t = 295.5V$$

VI Problem based on compound generator:-

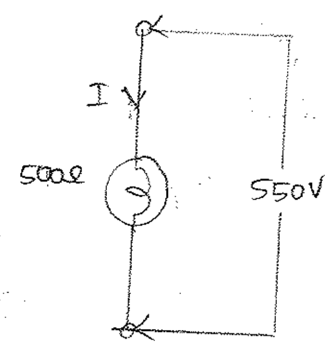
(1) A long shunt d.c compound generator drives 20 lamps, all are connected in parallel. Terminal voltage is 550V with each lamp resistance as 500 Ω. If $R_{sh} = 25\Omega$, $R_a = 0.06\Omega$ and $R_{se} = 0.04\Omega$, calculate the armature current and the generated e.m.f

Solu

Consider the arrangement as shown



As all lamps are in parallel, the voltage across all of them is same which is terminal voltage of generator $V_t = 550V$. Consider only one lamp as shown.



So current drawn by each lamp is

$$I = \frac{V_t}{R_{lamp}} = \frac{550}{500} = 1.1A$$

Such 20 lamps are used as a load

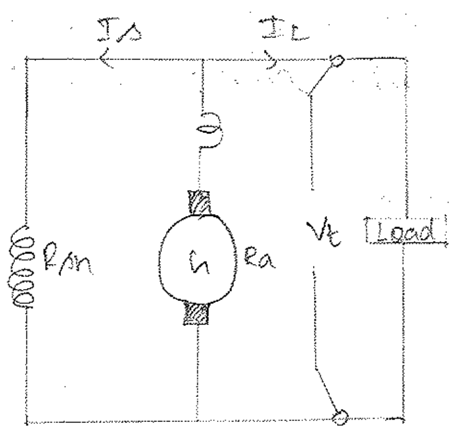
$$I_L = 20 \times I_{lamp} = 20 \times 1.1 = 22A$$

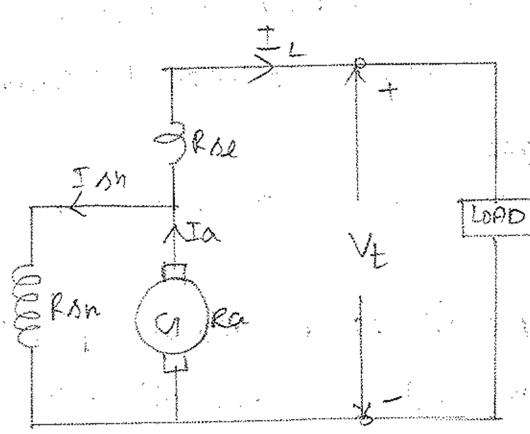
Now $I_{sh} = \frac{V_t}{R_{sh}} = \frac{550}{25} = 22A$

$$I_a = I_L + I_{sh} = 44A$$
$$E = V_t + I_a R_a + I_a R_{se}$$
$$= 550 + 44 + 0.06 + 44 \times 0.04$$
$$\boxed{E = 554.4V}$$

② In a 110V compound generator, the armature, shunt and series windings are 0.06 Ω, 25 Ω and 0.04 Ω respectively. The load consists of 200 lamps each rated at 55W, 110V. Find the total e.m.f and armature current, when the machine is connected for a) Long shunt b) Short shunt. How will be ampere-turns of the series windings be changed, if in (1) a diverter of resistance 0.1 Ω is connected across the series field. Ignore the armature reaction and brush drop.

solution





Given data:-

$R_a = 0.06\,\Omega$

$R_{se} = 0.04\,\Omega$

$R_{sh} = 25\,\Omega$

a) Long shunt

For each lamp,

$$I_{lamp} = \frac{P_{lamp}}{V_t} = \frac{55}{110} = 0.5A$$

$$I_L = 200 \times I_{lamp}$$
$$= 200 \times 0.5$$
$$I_L = 100A$$

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{110}{25} = 4.4A$$

$$I_a = I_L + I_{sh} = 100 + 4.4 = 104.4A$$

$$E_g = V_t + I_a R_{se} + I_a R_a$$
$$= 110 + 104.4 \times 0.04 + 104.4 \times 0.06$$
$$E_g = 120.44V$$

b) Short shunt

The load current remains same as $I_L = 100\,A$

The drop across shunt field,

$$E_g - I_a R_a = V_t + I_L R_{se}$$

$$I_{sh} = \frac{V_t + I_L R_{se}}{R_{sh}} = \frac{110 + (100 \times 0.04)}{25} = 4.56\,A$$

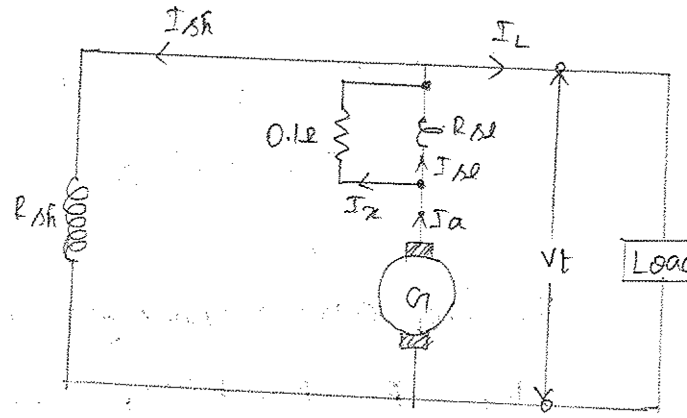
$$I_a = I_L + I_{sh}$$

$$I_a = 104.56\,A$$

$$E_g = V_t + I_L R_{se} + I_a R_a$$

$$= 110 + 100 \times 0.04 + 104.56 \times 0.06 = 120.2736\,V$$

Now in long shunt, a diverter of 0.1Ω is connected across the series field as shown.



$I_L = 100A$, $I_{sh} = 4.4A$

$I_a = 104.4A$

As per current division rule,

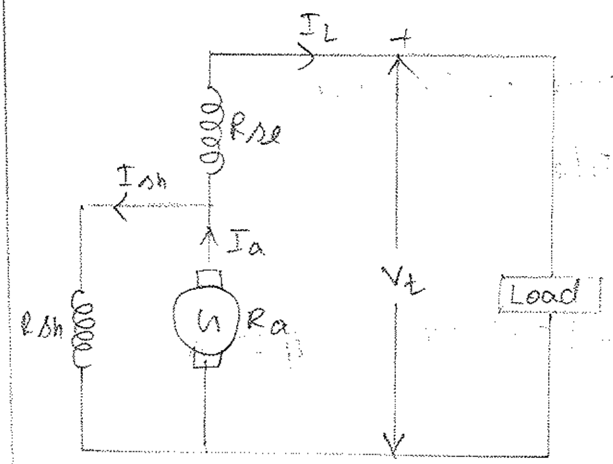
$$I_{se} = I_a \times \frac{0.1}{0.1 + 0.04}$$

$$I_{se} = 74.5714\,A$$

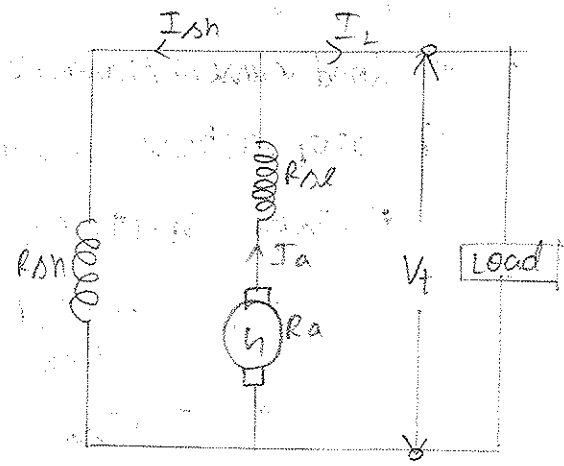
But the turns of series field winding remains same. Hence originally ampere-turns where $[104.4 \times N]$ and due to divert ampere-turns are $[74.5714 \times N]$ where N are the number of turns of series field winding. Hence there is reduction of $[29.828N]$ ampere-turns.

$\therefore$ % reduction in series field AT $\dfrac{29.828N \times 100}{104.4 \times N} = 28.57\%$

(3) In a 400 volts, DC compound generator, the resistance of the armature, series and shunt windings are 0.10 ohm, 0.05 ohm and 100 ohms respectively. The machines supplies power to 20 numbers resistive heaters, each rated 500 watt, 400 volts. Calculate the induced emf and armature currents when the generator is connected in (1) Short shunt (2) long shunt. Allow brush contact drop of 2 volts per brush. (AV: May-15, Marks 10).



Short Shunt



Long Shunt

solu

i) Short Shunt

$R_a = 0.1\Omega$, $R_{se} = 0.05\Omega$, $R_{sh} = 100\Omega$

Each heater, $P = 500W$, $V_t = 400V$

$\therefore I/\text{heater} = \frac{P}{V_t} = 1.25A$

$I_L = [I/\text{heater}] \times 20$

$I_L = 25A$

The drop across shunt field winding is,

$E_g - I_a R_a - \text{Brush drop} = V_t + I_L R_{se}$

$\therefore I_{sh} = \frac{V_t + I_L R_{se}}{R_{sh}} = \frac{400 + 25 \times 0.05}{100} = 4.0125A$

$\therefore I_a = I_L + I_{sh} = 25 + 4.0215 = 29.0125A$

$E_g = V_t + I_a R_a + I_L R_{se} + \text{Brush drop}$

$= 400 + 29.0125 \times 0.1 + 25 \times 0.05 + 2 \times 2 = 408.1512V$

ii) Long Shunt:

The load remains same

$\therefore I_L = 25A$

$I_{sh} = \frac{V_t}{R_{sh}} = \frac{400}{100} = 4A$

$\therefore I_a = I_L + I_{sh} = 29A$

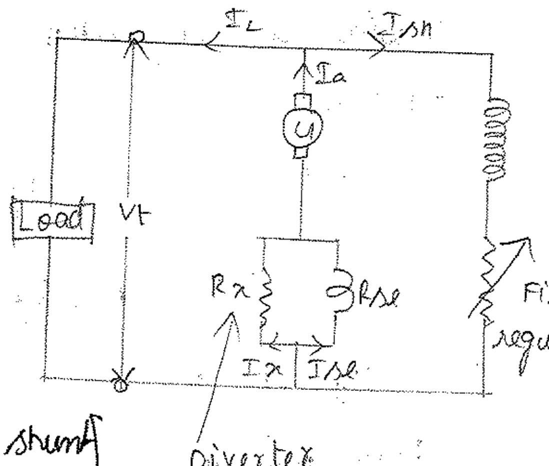
$\therefore E_g = V_t + I_a R_a + I_a R_{se} + \text{Brush drop} = 408.35V$

VII Problems based on Load characteristics of D.C compound generator.

(1) A long shunt compound generator has a shunt field winding of 1000 turns per pole and series field winding of 4 turns per pole and a resistance of 0.05Ω. In order to obtain the same voltage both at load and full load for operating a shunt generator, it is nessary to increase the field current by 0.2A. The full load armature current of the compound generator is 80A. Calculate the diverter resistance connected in parallel of series field to obtain flat compound operation?

soln

Given: $I_a = 80A$



Additional ampere-turns required to maintain rated voltage on full load for operation as a shunt generator.

$$= \begin{pmatrix}\text{Number of turns} \\ \text{on shunt field}\end{pmatrix} \times \begin{pmatrix}\text{Additional shunt} \\ \text{field current}\end{pmatrix}$$

$$= 1000 \times 0.2 = 200AT$$

Number of series turns per pole, $N_{se} = 4$

∴ current required by series field to produce 200AT is,

$$I_{se} = \frac{200}{N_{se}} = \frac{200}{4} = 50A$$

$$I_x = I_a - I_{se} = 80 - 50 = 30A$$

$$I_x R_x = I_{se} R_{se}. \quad R_{se} = 0.05\Omega \text{ given}$$

$$\therefore 30 \times R_x = 50 \times 0.05 \quad \text{i.e } R_x = 0.08333\Omega$$

VIII Critical field Resistance in D.C shunt generator.

(1) A shunt generator running at a speed of 1000 r.p.m gave the following magnetization curve:

Emf; V:	95	179	224	251	272	281
Induced emf (V)	1.0	20	3.0	4.0	5.0	6.0

If the field circuit resistance is 60Ω, determine:

i) The voltage to which the machine will build up running at the same speed.

ii) The value of the field regulating resistance if the machine is to build up to 130V, when its field coils are grouped into two parallel circuits and generator is run at 500 r.p.m.

soln

Draw the open circuit characteristics on the graph paper from the given data.

Draw the line corresponding to $R_{sh} = 60\Omega$. For this, consider an equation of line $y = mx$, passing through the origin.

$y = E_0$ $\quad x = I_f$ $\quad m = \text{slope} = R_{sh}$

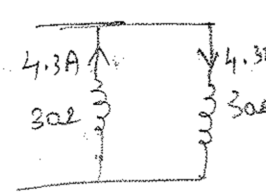
$\therefore E_0 = R_{sh} I_f$

$I_f = 3A$, $E_0 = 60 \times 3 = 180V$

Thus this line passes through origin and (3,180) point.

(i) Thus the voltage to which the machine will build up running at the same speed is 260 V.

Now generator runs at $N_2 = 500$ r.p.m



$$E_{02} = \frac{N_2}{N_1} = E_{01} = \frac{500}{1000} E_{01} = \frac{E_{01}}{2}$$

E_{02} (V)	47.5	89.5	112	125.5	136	140.5
I_f (A)	1	2	3	4	5	6

Draw new o.cc for $N_2 = 500$ r.p.m from above readings. Draw horizontal line of 130V from A to meet new o.cc at B. Draw vertical line from B to meet I_f axis at C. The corresponding current is 4.3 A.

This is the current through each parallel path.

I_f (total) $= 4.3 \times 2 = 8.6A$

$$R'_{sh} = \frac{E_0}{I_f(\text{total})} = \frac{130}{8.6} = 15.116\Omega$$

$R_{sh} = 30 \parallel 30 = 15\Omega$

The original box R_{sh} is divided into two groups i.e each of 30Ω and then connected in parallel. (8)

$\therefore$ Field regulating resistance $= 15.1162 - 15$
$= 0.1162\,\Omega$

IX Parallel operation of generator:-

① Two shunt generators each limit with a no load voltage of 200V are run in parallel. Their external characteristics can be taken as straight lines over this operating ranges. Generator No. 1 is rated at 200kW and its full load voltage is 190V. Generator No. 2 is rated at 100kW at 185V. Calculate the bus bar voltage when the total load is 3000A. How is the load divided b/w the two?

Solu

V = Bus bar voltage

P_1 = Load carried by generator 1,

P_2 = Load carried by generator 2.

x_1, x_2 = Load carried by each generator in terms of percentage of rated load.

$$V = 200 - [(200-190)(x_1/100)] = 200 - \frac{10x_1}{100}$$

$$V = 200 - [(200-185)(x_2/100)] = 200 - \frac{15x_2}{100}$$

As bus bar voltage is same,

$$200 - \frac{10x_1}{100} = 200 - \frac{15x_2}{100}$$

$$\frac{15x_2}{100} = \frac{10x_1}{100} \quad \therefore \; x_2 = \frac{2}{3}x_1$$

Power delivered in d.c circuits is given by VI watt

$\therefore$ The load on both generators is given by,

$$\left[200x_1 \cdot \frac{1000}{100}\right] + \left[100x_2 \cdot \frac{1000}{100}\right] = V \times 3000$$

$$\left[200x_1 \cdot \frac{1000}{100}\right] + \left[100 \cdot \frac{2}{3}x_1 \cdot \frac{1000}{100}\right] = \left[200 - \frac{10x_1}{100}\right]3000$$

Solving, $\quad x_1 = 202.24$ percent

$\therefore$ Bus bar voltage, $V = 200 - \frac{(10)x_1}{100} = 200 - \frac{(10)(202.24)}{100} = 179.77$ Volt

The division of load between the two generators is obtained as below

$$X_1 = \frac{P_1 \times 100}{200000} \; ; \; X_2 = \frac{P_2 \times 100}{100000}$$

$$\frac{X_1}{X_2} = \frac{P_1 \times 100000}{P_2 \times 200000} = \frac{P_1}{2P_2} \text{ and}$$

$$\frac{X_1}{X_2} = \frac{3}{2}$$

$$\frac{3}{2} = \frac{P_1}{2P_2} = \frac{VI_1}{2VI_2} = \frac{I_1}{2I_2}$$

$\therefore$ i.e $3I_2 = I_1$

But $I_1 + I_2 = 3000$ i.e $\Rightarrow 3I_1 + I_2 = 3000$

i.e $I_2 = 750A$

$I_1 = 3000 - I_2 = 3000 - 750 = 2250A$

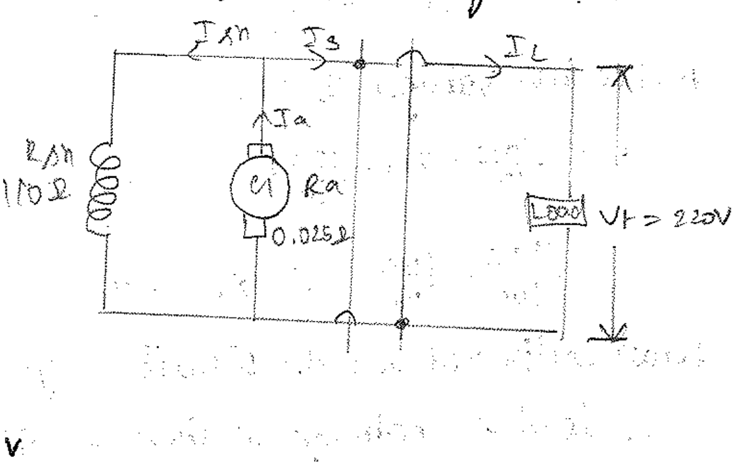
(2) A.dc shunt generator is supplying load connected to a bus-bar voltage of 220V. It has an armature resistance of 0.025Ω and field resistance of 110Ω. calculate the value of load current and load power when it generates an e.m.f of 230V. Neglect the effect of armature reaction. Draw circuit diagram.

Given:

$V_t = 220V$

$R_a = 0.025Ω$

$R_{sh} = 110Ω$



soln

$I_a = I_L + I_{sh}$ & $E_g = 230V$

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{220}{110} = 2A$$

$E_g = V_t + I_a R_a$ i.e $230 = 220 + I_a \times 0.025$

$$I_a = \frac{230 - 220}{0.025} = 400A$$

$I_L = I_a - I_{sh} = 400 - 2 = 398A$

$P_L = V_t \times I_L = 220 \times 398 = 87.56\ kW$