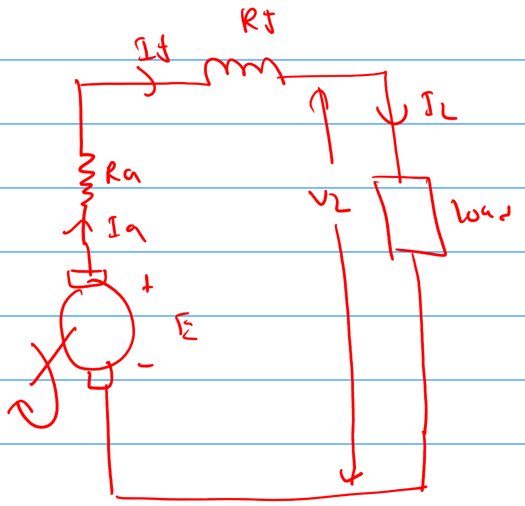
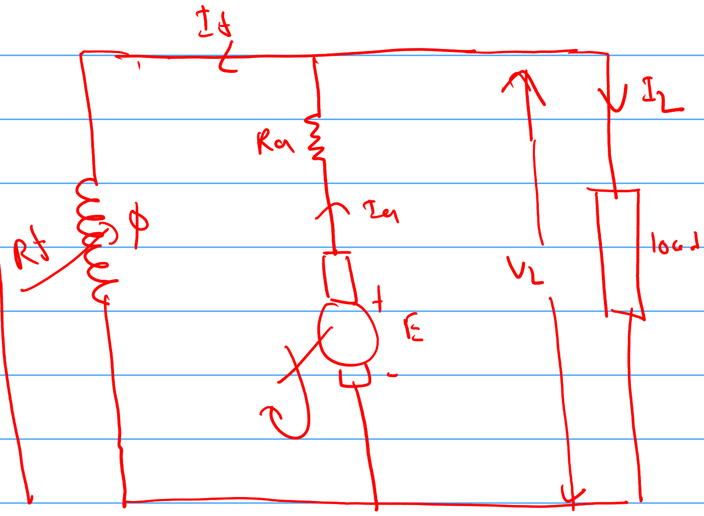
Numerical Hints :

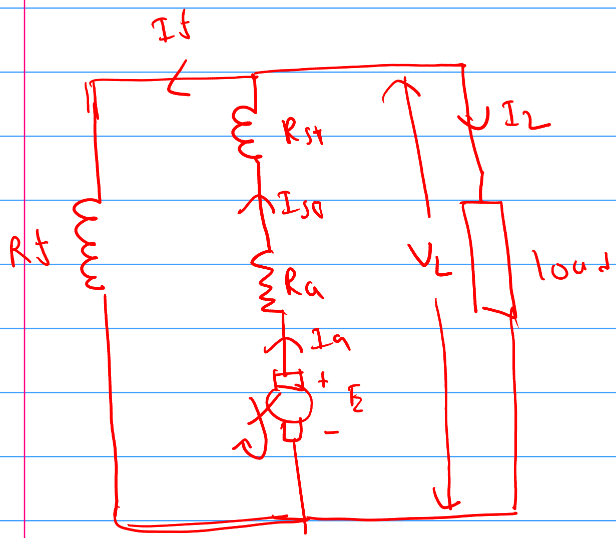
① dc - series generator



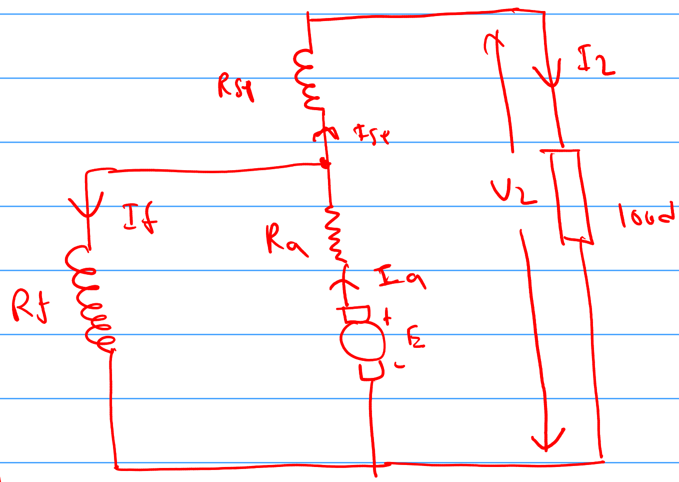
② dc - shunt generator



③ long shunt dc C-generator

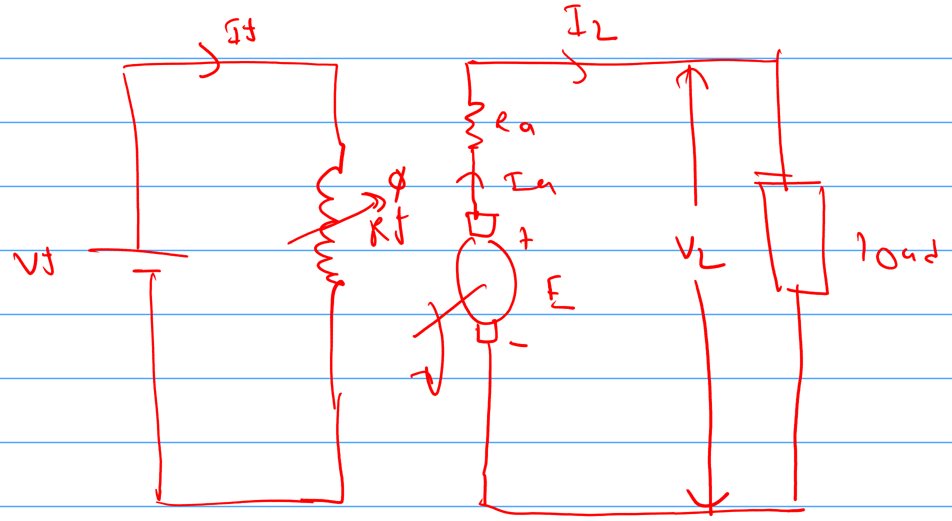


④ short shunt dc C. generator



$$\eta = \frac{\text{electrical power o/p}}{\text{mechanical power i/p or BHP of engine}} = \frac{P_{out} \rightarrow V_L I_L}{P_{out} + \text{Iron loss} + \text{Cu-loss and friction loss}}$$

Seperately excited DC gen



Total armature power developed $(P_a) = E \times I_a$

Current in each armature conductor $= \dfrac{I_a}{\text{no of carbon brushes}}$

or, $\dfrac{I_a}{\text{no of parallel path}}$

A = 2 for wave wound

$$VR = \frac{|E - V|}{V} \times 100\% \quad \boxed{\omega \propto \frac{E}{I_f}}$$

If constant

$\dfrac{N_2}{N_1} = \dfrac{E_2}{E_1}$

If changing

$\dfrac{N_2}{N_1} = \dfrac{E_2}{E_1} \dfrac{I_{f_1}}{I_{f_2}}$

$T_a = \dfrac{1}{2\pi} \, Z \phi \, \dfrac{P}{A} \, I_a$ most of the time used

For a 2-pole generator always P = 2, A = 2

(if winding not mention take A = P)

① A short shunt compound dc generator supplies a load current of 150A at 230V. The generator has following winding resistance.

Armature resistance = $0{\cdot}15\,\Omega \Rightarrow R_a$

Series field resistance = $0{\cdot}1\,\Omega = R_{se}$

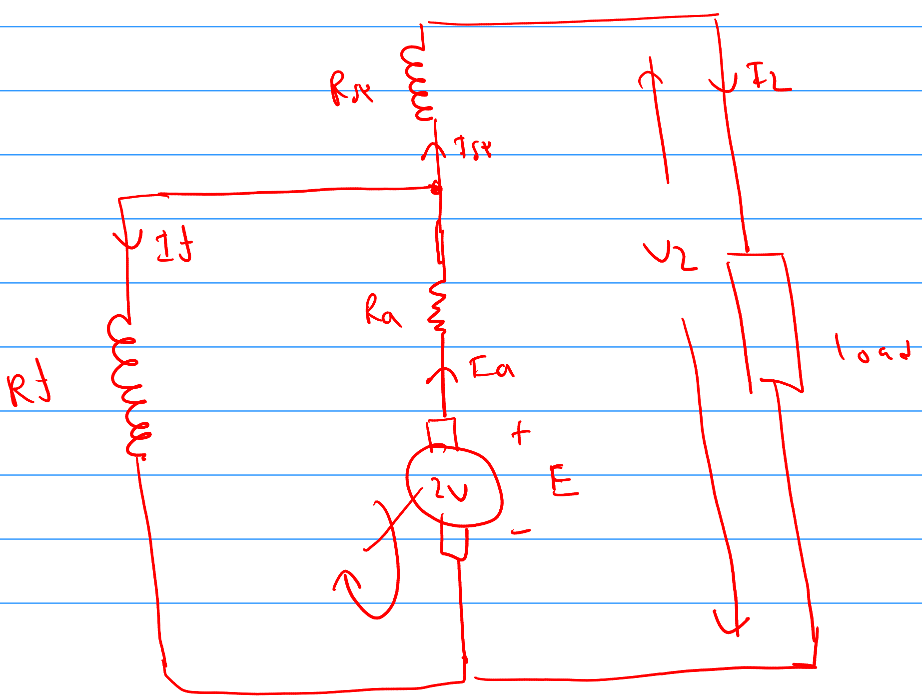
Shunt field resistance = $100\,\Omega = R_f$

Calculate ⓐ emf generated if the carbon brush drop is 2V per brush and also

ⓑ Calculate the ratio of voltage generated if the same generator is connected as long shunt C. generator to the original shunt compound generator.

ⓒ Iron loss and friction loss is 80W. Calculate η in both type of gen.

Soln ÷



Now

KCL

$I_a = I_f + I_{se}$ $\qquad (I_{se} = I_L)$

$I_a = I_f + 150$ — (i)

Using KVL in left loop

$E = 2 + I_a R_a + I_f R_f$

or, $E = 2 + 0.15 I_a + 100 I_f$ — (ii)

or, $E = 2 + 0.15 (I_f + 150) + 100 I_f$

or, $E = 24.5 + 100.15 I_f$ — (iii)

KVL in right loop

$E = 2 + 0.15 (I_f + 150) + I_{se} R_{se} + V_L$

or, $E = 2 + 0.15 I_f + 22.5 + 150 \times 0.1 + 230$

or, $E = 269.5 + 0.15 I_f$ — (iv)

Solving (iii) and (iv)

$E = 269.8675\,V$, $I_f = 2.45\,A$, $I_a = 152.45\,A$

$$\boxed{E_{ss(4)} = 269.8675\,V}$$

$$\eta_{ss} = \frac{P_{out}}{P_{out} + \text{Iron and friction loss} + Cu\text{-loss}}$$

$P_{out} = V_L I_L = 230 \times 150 = 34500\ W$

Iron and friction loss = 80W

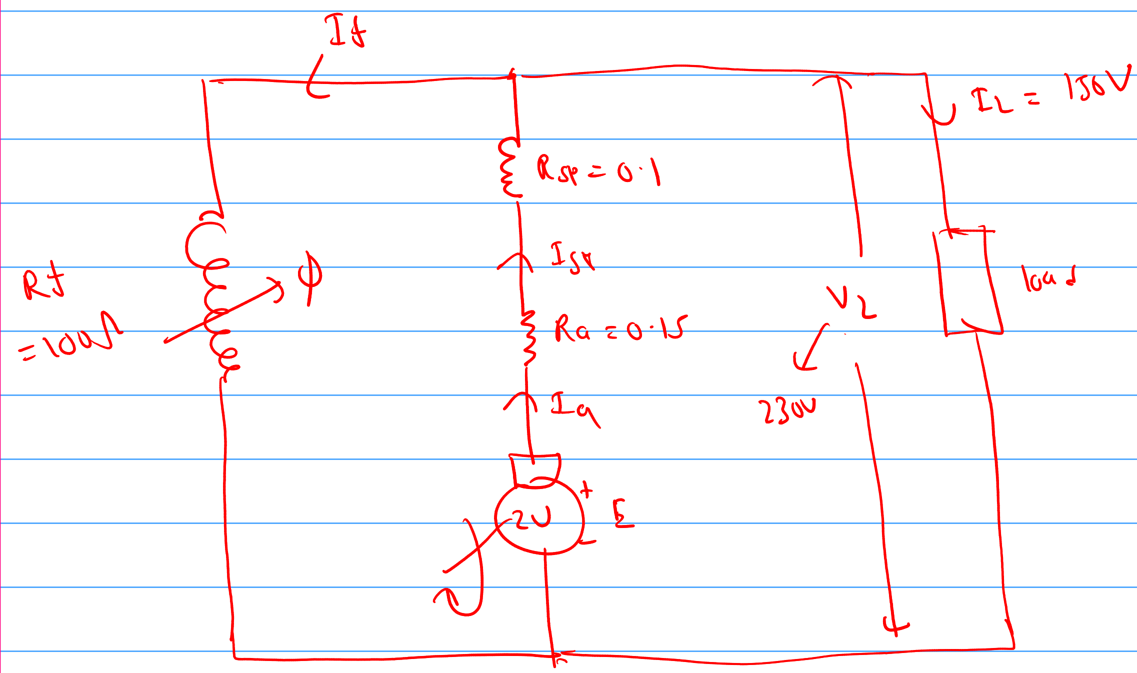
$Cu\text{-loss} = I_a^2 R_a + I_f^2 R_f + I_{se}^2 R_{se}$

$= (152.45)^2 \times 0.15 + (2.45)^2 \times 100 + (150)^2 \times 0.1$

$= 6636.4\ W$

$$\boxed{\eta = \frac{34500}{34500 + 80 + 6636.4} = 0.837 = 83.7\%}$$

now if it is connect in long shunt c. Generator



KCL at A

$$I_a = I_{se} = I_f + I_L$$

or $I_a = I_f + 150$ —— (i)

KVL at right loop

on $E = 2 + I_a R_a + I_{se} R_{se} + V_L$

or $E = 2 + I_a R_a + I_a R_{se} + V_L$

or $E = 2 + I_a(0.15 + 0.1) + 230$

on $E = 2 + 0.25(I_f + 150) + 230$

$\therefore$ $E = 269.5 + 0.25 I_f$ —— (ii)

KVL at left loop

$$E = 2 + I_a(0.15 + 0.1) + I_f R_f$$

on $E = 2 + 0.25(I_f + 150) + 100 I_f$

$\therefore$ $E = 39.5 + 100.25 I_f$ —— (iii)

solving (ii) and (iii)

$\boxed{E_{1scn} = 270.075\ V}$, $I_f = 2.3\ A$, $I_a = I_{se} = 152.3\ A$

$$\eta = \frac{P_{out}}{P_{out} + \text{iron loss and friction} + \text{Cu-loss}}$$

$P_{out} = V_L I_L = 34500\ W$

Iron loss $= 80W$

$$Cu\text{-}loss = I_a^2 R_a + I_f^2 R_f + I_{se}^2 R_{se}$$
$$= (152.3)^2 \times 0.15 + 2.3^2 \times 100 + (152.3)^2 \times 0.1$$
$$= 6327.8225\ W$$

now,

$$\boxed{\eta = \frac{34500}{34500 + 80 + 6327.8225} = 0.8433 = 84.33\%}$$

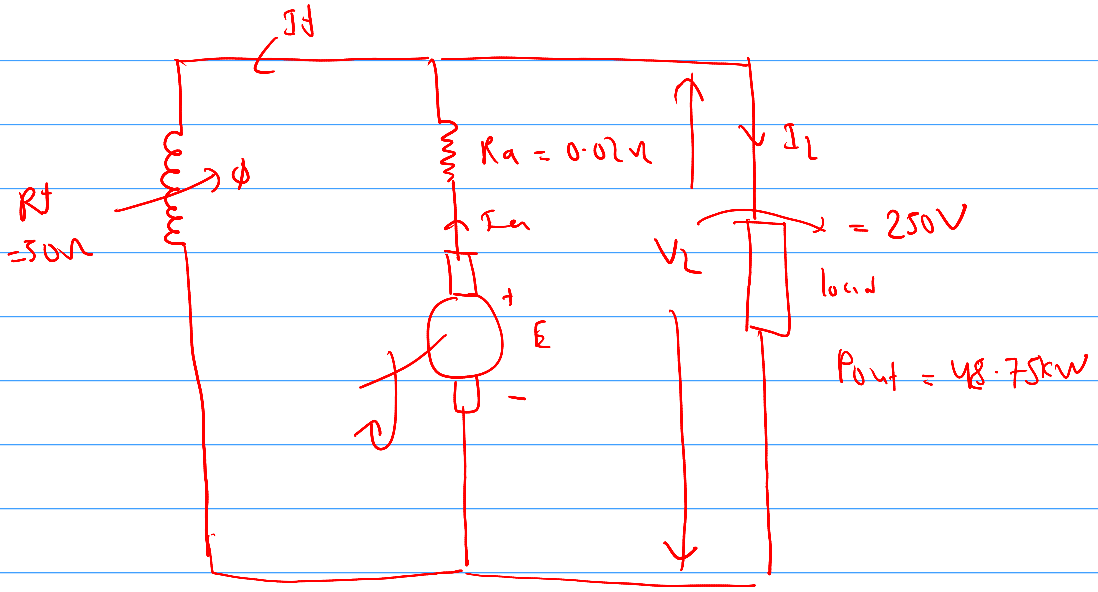
$$\boxed{\frac{E_{LS}\cos\alpha}{E_{SS}\cos\alpha} = \frac{270.075}{269.867} = 1.0009}$$ #

A dc shunt generator giving an output of 48.75kW at 250V across the load. The armature winding resistance and field winding resistance are 0.02Ω and 50Ω respectively. no load power loss is 950W. calculate η of the generator and B.H.P of the driving engine.

soln:-

$R_a = 0.02\Omega$, $R_f = 50\Omega$, no-load power loss $= 950W$
(iron and friction loss)

B.H.P of driving engine = mech power input to the generator



now

$$P_{out} = I_L V_L$$

$$48.75 \times 10^3 = I_L \times 250 \; ; \; I_L = 195$$

now,

KCL

$$I_a = I_f + I_L = I_f + 195A \quad \text{— (i)}$$

KVL at right loop

$$E = I_a R_a + V_L$$

or, $E = 0.02(I_f + 195) + 250$

or, $E = 0.02 I_f + 253.9$ — (ii)

KVL at left loop

$$E = I_a R_a + I_f R_f$$

or, $E = 0.02(I_f + 195) + 50 I_f$

or, $E = 50.02 I_f + 3.9$ — (iii)

From (ii) and (iii)

$E = 254\ V$, $I_f = 5A$, $I_a = 200A$

Now

$$\eta = \frac{P_{out}}{P_{out} + \text{iron and friction loss} + Cu\text{-loss}}$$

$P_{out} = 48.75 \times 10^3\ W$, iron loss $= 950\ W$

$$Cu\text{-loss} = I_a^2 R_a + I_f^2 R_f$$
$$= (200)^2 \times 0.02 + (5)^2 \times 50$$
$$= 2050\ W$$

$$\boxed{\eta = \frac{48.75 \times 10^3}{48.75 \times 10^3 + 950 + 2050} = 0.9420 = 94.20\%}$$

mech power i/p $= 48.75 \times 10^3 + 950 + 2050$

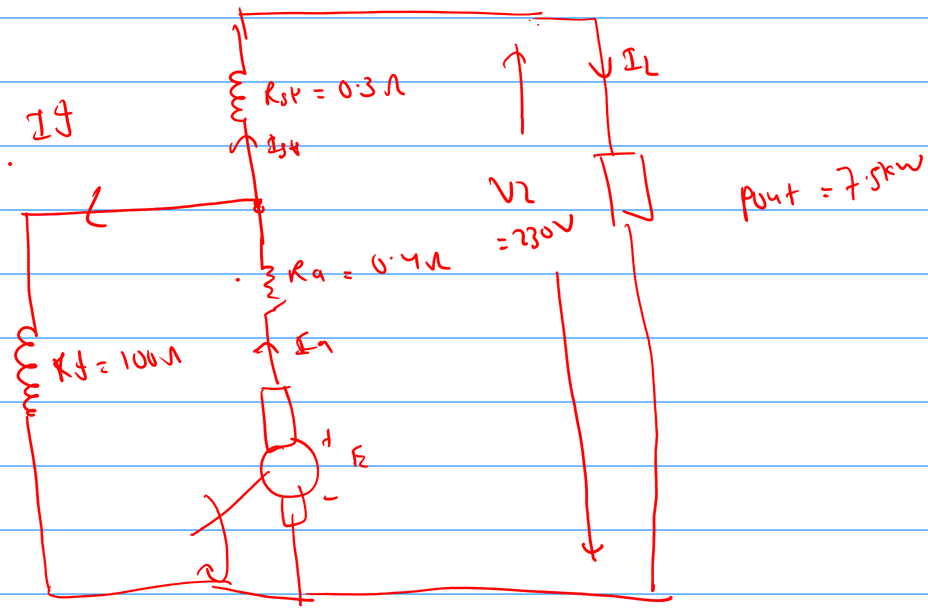
$= 51750\ W$

$1\ B.H.P = 745\ W$

$$\boxed{\text{mech power i/p} = \frac{51750}{745}\ BHP = 69.46\ BHP}$$

A short shunt cumulative compound dc generator supplies 7.5 kw at 230 V. The shunt field, series field and armature resistance are 100, 0.3 and 0.4 ohms respectively. Calculate the induced emf and the load resistance.

Soln:-



Now $P_{out} = 7.5 \times 10^3\,W = V_L I_L$

or $7.5 \times 10^3 = 230 \times I_L$; $I_L = 32.60\,A$

$I_L = I_{se}$

KCL

$I_a = I_f + I_{se} = I_f + 32.60$ — (i)

Using KVL at right loop

now,

$E = I_a R_a + I_{se} R_{se} + V_L$

$E = (I_f + 32.60) \times 0.4 + 32.60 \times 0.3 + 230$

or $E = 0.4 I_f + 252.82$ —— (ii)

KVL left loop

$E = I_a R_a + I_f R_f$

or $E = (I_f + 32.60) \times 0.4 + 100 I_f$

or $E = 100.4 I_f + 13.04$ —— (iii)

solving (ii) and (iii)

$\boxed{E = 253.77V}$ $I_f = 2.39A$ $I_a = 35A$

now,

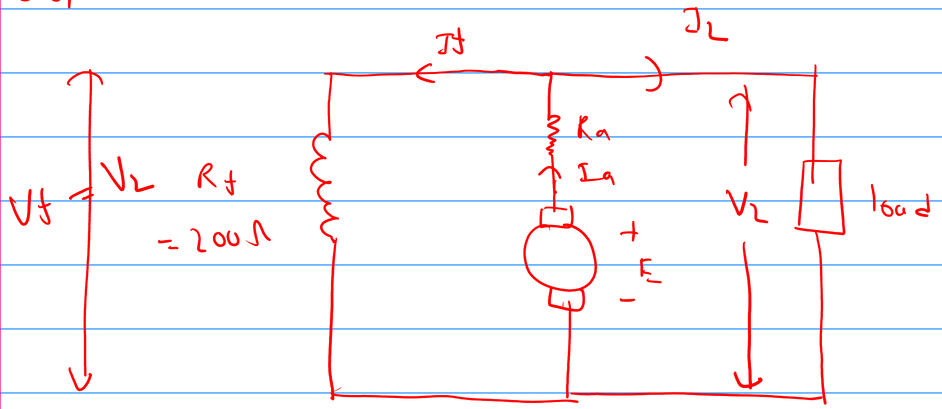
$V_L = I_L R_L$

or $\boxed{R_L = \frac{V_L}{I_L} = \frac{230}{32.60} = 7.05\Omega}$

The resistance of the field circuit of a shunt excited dc generator is 200Ω. When the output of the generator is 100 kW, the terminal voltage is 500V and the generated emf 525V. Calculate (a) the armature resistance and (b) the value of the generated emf when the output is 60kW, if the terminal voltage then is 520V. [2074]

tion:

Soln ÷



$P_o = 100kW$, terminal voltage $(V_L) = 500V$, generate emf $(E) = 525V$

$R_a = ?$ (b) $E = ?$ when $P_{out} = 60\,kW$ and $V_L = 520V$

Now,

$P_{out} = V_L I_L$

or, $100 \times 10^3 = 500 \times I_L$; $I_L = 200A$

Now,

$I_a = I_f + I_L$ or, $I_a = I_f + 200$ —(i)

KVL at right loop

$E = I_a R_a + V_L$

or, $525 = (I_f + 200) R_a + 500$

or, $25 = R_a (I_f + 200)$ — (ii)

Now,

$V_f = I_f R_f$

or, $I_f = \frac{V_f}{R_f} = \frac{V_L}{R_f} = \frac{500}{200} = 2.5\ A$

$I_a = 2.5 + 200 = 202.5\ A$

now,

$$25 = R_a \times 202.5 \quad ; \quad \boxed{R_a = 0.1234\,\Omega}$$

(c) when $P_{out} = 60\,kW$, $V_L = 520V$, $E = ?$

$$I_L = \frac{P_{out}}{V_L} = \frac{60\times10^3}{520} = 115.384\ A$$

$$I_f = \frac{V_f}{R_f} = \frac{520}{200} = 2.6\ A$$

$$I_a = I_f + I_L = 117.984\ A$$

Now,

KVL

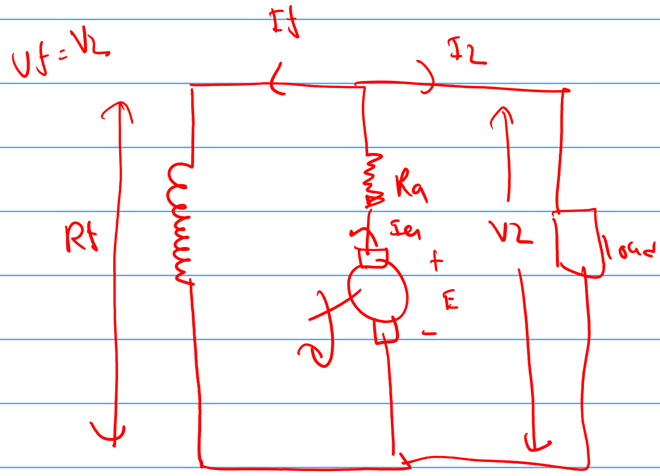
$$E = I_a R_a + V_L$$

or, $E = 117.984 \times 0.1234 + 520$

$\therefore$ $\boxed{E = 534.56\,V}$

A 6 pole wave wound shunt generator has 1200 conductors. The useful flux per pole is 0.02Wb, the armature resistance 0.4Ω and the speed 400rpm. If the shunt resistance is 220Ω, calculate the maximum current which the generator can deliver to an external load if the terminal voltage is not to fall below 440V. [2073]

Soln →



$R_f = 220\Omega$, $R_a = 0.4\Omega$

no of armature conductors (Z) = 1200

$\phi = 0.02$ wb

speed (N) = 400 rpm

P = 6 (no of poles)

A = no of parallel path

= 2 for wave wound

= P for lap wound

$\therefore$ A = 2 , $V_2 = 440V$

Now,

$$E = \frac{Z\phi N}{60} \times \frac{P}{A} = \frac{1200 \times 0.02 \times 400}{60} \times \frac{6}{2}$$

$$= 480V$$

Now, $I_L = ?$

$$V_f = I_f \times R_f$$

or, $$I_f = \frac{440}{220} = 2A$$

Now,

$$E = I_a R_a + V$$

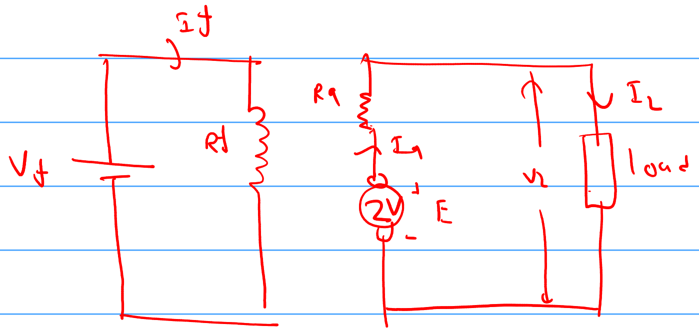
or $480 = I_a \times 0.4 + 440$; $I_a = 100A$

$\therefore$ $I_a = I_f + I_L$ or $100 - 2 = I_L$ $\therefore$ $\boxed{I_L = 98A}$

⊥ different type

A separately excited generator when running at 1200 rpm supplies 200A at 125V to a circuit of constant resistance. What will be the current when the speed is dropped to 1000 rpm, if the field current is unaltered? Armature resistance =0.04Ω, total drop at brushes = 2V. [2074]

Soln:-



$N_1 = 1200$ rpm,

$I_L = 200A$

$V_L = 125A$

generator supplies so I_L, V_L

$$R_L = \frac{V_L}{I_L} = \frac{125}{200} = 0.625\,\Omega$$

KVL let emf now be E_1

$$E_1 = 2 + I_a R_a + V_L$$

or, $E_1 = 2 + 200 \times 0.04 + 125 = 135\,V$

Now, $N_2 = 1000$ rpm

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

or, $E_2 = \frac{N_2}{N_1} \times E_1 = \frac{1000}{1200} \times 135 = 112.5\,V$

find $I_2 = ?$
when field is unaltered # I_L is changed so we use $I_L R_L$

now,

$$E_2 = 2 + I_a R_a + V_2 \quad (I_L R_L)$$

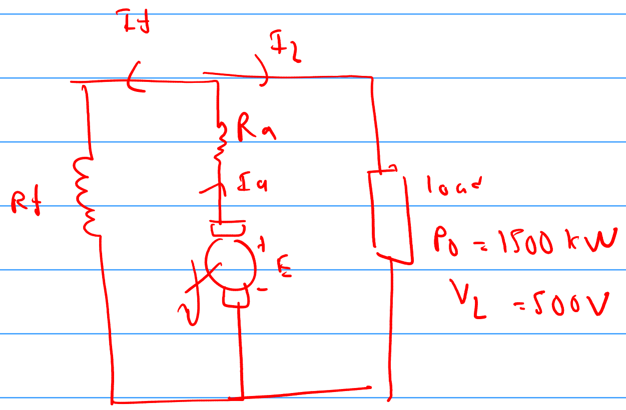
or

$$112.5 = 2 + I_L(0.04 + 0.625)$$

$$\therefore \boxed{I_L = 166.165\,A}$$

A 1500 Kw, 500 V, 16 pole, dc shunt general runs at 150 rpm. What must be the useful flux per pole if there are 2500 conductors in the armature and the winding is lap connected and full–load armature copper loss is 25 kw? Calculate the area of the pole shoe if the air gap flux density has uniform value of 0.9 wb/m^2. Neglect change in speed. Take $R_f = 55\Omega$.

Soln ÷



$N = 150$ rpm, $Z = 2500$

$A = P$ for lap winding

$P_o = 1500$ kW, $V_L = 500$V

$P = 16$ pole, $\phi = ?$

armature Cu-loss $= I_a^2 R_a = 25$ kw

$B = 0.9$ wb/m^2, $A = ?$ $R_f = 55\Omega$

Now,

$$E = \frac{2\phi N}{60} \times \frac{P}{A}$$

or, $$E = \frac{2500 \times \phi \times 150}{60} \times \frac{\cancel{6}}{\cancel{6}}$$

or, $$E = 6250\,\phi \quad \text{— (i)}$$

Now,

or $$E = I_a R_a + V_L$$

or $$E = I_a R_a + 500 \quad \text{— (ii)}$$

or $$I_a^2 R_a = 25 \times 10^3\ W \quad \text{— (iii)}$$

$$I_a = I_f + I_L$$

$$I_a = 3000 + 9.09$$

$$= 3009.09\ A$$

$$P_o = V_L I_L$$

or $$I_L = \frac{P_o}{V_L} = \frac{1500 \times 10^3}{500}$$

$$= 3000\ A$$

$$V_f = I_f R_f$$

$$I_f = \frac{V_f}{R_f} = \frac{500}{55} = 9.09\ A$$

$$I_a^2 R_a = 25 \times 10^3$$

or, $$(3009.09)^2 \times R_a = 25 \times 10^3$$

so $$R_a = 2.76 \times 10^{-3}\ \Omega$$

Now Eqn (ii) is

$$E = 2.76 \times 10^{-3} \times 3009.09 + 500$$

$$= 508.305\ V$$

now from (i)

$E = 6250\,\phi$

or $508.305 = 6250\,\phi$

$\therefore \phi = 0.081\ wb$

now, $\phi = BA$

or $\boxed{A = \dfrac{\phi}{B} = \dfrac{0.081}{0.9} = 0.09\ m^2}$

A dc shunt generator has an output of 10 kw at 500 V; the speed being 1000 rpm. The armature circuit resistance is 0.5 and the field resistance is 250. Calculate speed when running as a shunt motor taking 50 kw at 500 V.

Soln: find $E_g = ?$ $P_{out} = 10kW$, $V_L = 500V$, $N_g = 1000\ rpm$

$R_a = 0.5$ $R_f = 250$

(ϕ is const so, If is const)

For motor

$P_{out} = 50\ kW$ $V_L = 500V$

find $E_m = ?$

$\dfrac{E_m}{E_g} = \dfrac{N_m}{N_g}$ $\therefore \boxed{N_m = \dfrac{E_m \times N_g}{E_g}}$

A 20kw, 240w dc shunt generator has armature and field resistance of 0.05Ω and 80Ω respectively. Calculate the total armature power developed when working:

(i) as a generator delivering 20kW output [2067]

taking 20kw input

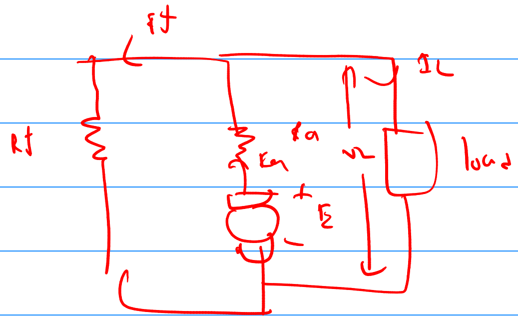
Soln :-

$P_{out} = 20kw$

$V_L = 240V$

$R_a = 0.05\Omega$

$R_f = 80\Omega$



$$I_f = \frac{V_L}{R_f} = \frac{240}{80} = 3A$$

(i) as generator

$$I_L = \frac{20\times10^3}{240} = 83.33A$$

$$I_a = 83.33 + 3 = 86.33 A$$

$$E = I_a R_a + V_L$$

or $E = 86.33 \times 0.05 + 240 = 244.16V$

Total armature power developed $(P_a) = E \times I_a$

$= 244.16 \times 86.33$

$= 21078.90 W$

A4-pole dc generator has 51 slots and each contains 20 conductors. Flux per pole si 7 mWb and runs at 1500 rpm. Find the produced emf of the machine if its armatøre is wave wound.

Soln:-

$\phi = 7 mwb = 0.007 wb$

$p = 4$

$N = 1500$

$\boxed{Z = \text{number of slots} \times \text{no of conductors}}$

$= 51 \times 20 = 1020$

$A = 2$ (wave wound)

$$E_g = \frac{Z \phi N}{60} \times \frac{P}{A} = \frac{0.007 \times 1020 \times 1500}{60} \times \frac{4}{2}$$

$= 357 V$

Imp

A 2-pole dc shunt generator charges a 100v battery of negligible internal resistance. the armature of the machine is made up of 1,000 conductors, eech of 2mΩ resistance. The charging currents are found to be 10A and 20A for generator sped of 1055 and 1105 rpm respectively. Find the field circuit resistance and flux per pole of the generator. Neglect armature reaction effects.

tion:

soln:-

$Z = 1000$

armature Resistance per conductor = $2\,m\Omega = 0.002\,\Omega$

no of parallel path (A) = 2

armature Resistance per path = no of conductor per path × resistance of each conductor

$$= \frac{1000}{2} \times 0.002$$

$$= 1\,\Omega$$

armature resistance

$$R_a = \frac{\text{armature resistance per path}}{\text{no of parallel path}} = \frac{1}{2} = 0.5\,\Omega$$

now,

let end generate at speed N_1 of 1055 rpm and N_2 of 1105 rpm be E_1 and E_2

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{1105}{1055} \quad \text{---(i)} \quad \left(\begin{array}{l} \phi \text{ is const} \\ I_f \text{ is const} \end{array} \right)$$

$V_L = 100V$

For N_1

$I_{L_1} = 10A$

For N_2

$I_{L_2} = 20A$

I_f is same in both speeds

$I_{a_1} = 10 + I_f \longrightarrow I_L$ and I_a only changes

$I_{a_2} = 20 + I_f$

now $E_1 = I_{a_1} R_1 + V_L$

$E_1 = 100 + 0.5(10 + I_f)$

$E_2 = 100 + 0.5(20 + I_f)$

$$\frac{E_2}{E_1} = \frac{110 + 0.5 I_f}{105 + 0.5 I_f} = \frac{1105}{1055}$$

$\therefore I_f = 1A$

$$R_f = \frac{V_L}{I_f} = \frac{100}{1} = 100\,\Omega$$

$E_1 = 100 + 0.5 \times (10 + 1) = 105.5\,V$

$$E_1 = \frac{Z \phi N}{60} \times \frac{P}{A}$$

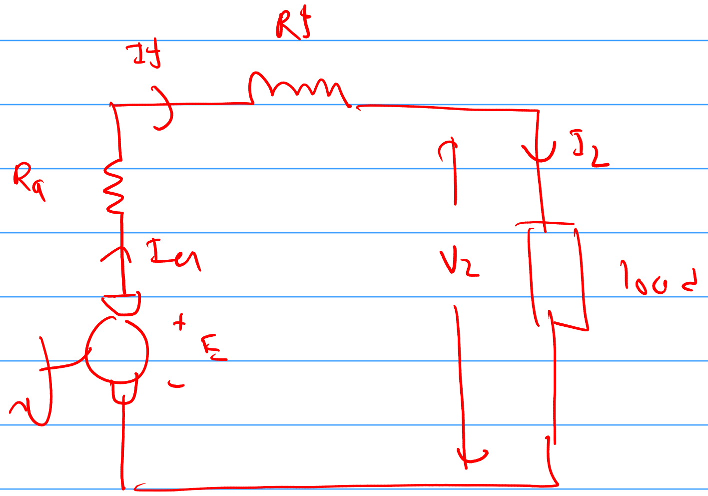
or $105.5 = \dfrac{1000 \times \phi \times 1055}{60} \times \dfrac{2}{2}$

$\therefore \boxed{\phi = 6\,mWb}$

$\checkmark \; \frac{E_2}{E_1} = \frac{I_{f2}}{I_{f1}} \cdot \frac{N_2}{N_1}$ yo wala ma use bhako cha #

A dc series generate is running at 800 rpm and delivering a power of 6 kw to the load at 120 V. The armature and field winding resistance are 2.2 ohm and 1.80 ohm resp. When the load is increased to 9 kw, the speed is increased to 1200 rpm. Calculate the new values of armature current and load terminal voltage.

Soln:-



Soln:-

$N_1 = 800$ rpm

$P_{out} = 6$ kW $= 6000$ W

$V_{L1} = 120$V

$R_a = 2.2\Omega$

$R_f = 1.8\Omega$

when load is increase to 9kW

$P_{out} = 9000$W, $V_{L2} = ?$, $N_2 = 1200$ rpm,

$\downarrow I_2V_2$ 2 changes

$I_{a2} = ?$ $V_{L2} = ?$

now,

$$I_{a_1} = \frac{P_o}{V_{t}} = \frac{6000}{120} = 50A$$

same

$$E_1 = V_{t_1} + I_{a_1} R_a + I_{f_1} R_f$$

or, $E_1 = 120 + 50 \times (R_a + R_f)$

or, $E_1 = 120 + 50 \times (2.2 + 1.8)$

$= 320V$

$$E_2 = V_{t_2} + I_{a_2}(R_f + R_a)$$

or, $E_2 = V_{t_2} + I_{a_2} \times 4$

$$E_2 = \frac{P_{out}}{I_{t_2}} + 4 I_{a_2}$$

$$E_2 = \frac{9000}{I_{a_2}} + 4 I_{a_2} \quad \text{——} (*)$$

$I_{t_2} = I_{a_2}$

now,

($I_f = I_a = I_L$ changes so) ϕ change

$$\frac{E_2}{E_1} = \frac{I_{f_2}}{I_{f_1}} \frac{N_2}{N_1}$$

or, $$\frac{\frac{9000}{I_{a_2}} + 4 I_{a_2}}{320} = \frac{1200}{600} \times \frac{I_{a_2}}{50}$$

$\therefore I_{a_2} = 40.08A$

$$\therefore V_{t_2} = \frac{P_{out}}{I_{t_2}} = \frac{P_{out}}{I_{a_2}} = \frac{9000}{40.08} = 224.55V$$

3 **Calculate the resistance of the load which consumes a power of 5 kW from a dc shunt generator whose load characteristics is described by the equation.**

$$V_L = 250 - 0.5 I_L$$

Soln:-

$$V_L = \frac{P_{out}}{I_L} = \frac{5000}{I_L} \quad \text{—(i)}$$

$$V_L = 250 - 0.5 I_L$$

$$250 - 0.5 I_L = \frac{5000}{I_L}$$

$$\therefore I_L = 20.87 \text{ A}$$

$$V_L = 250 - 0.5 \times 20.87 = 245.826$$

$$V_L = I_L R_L$$

$$R_L = \frac{V_L}{I_L} = \frac{245.826}{20.87} = 11.77\,\Omega$$

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