

Introduction to Dc Machines:-

Basic principle $\Rightarrow$ Electromagnetic induction (for any electrical device)
 $\Downarrow$
 Faraday's Law's

1st Law:- when a moving conductor kept in a magnetic field it induces some e.m.f.

2nd Law:- the magnitude of induced emf is directly proportional to rate of change of flux linkages.

$$\propto \frac{d\phi}{dt} \text{ (or) } \frac{d\psi}{dt} \rightarrow \text{flux linkages}$$

Induced Emf:- voltage (one of the force)

Electromotive force is the electrical action produced by a non-electrical source. A device that converts one form of energy into electrical energy it provides emf as its output.

Basic requirements:-

- * set of conductors
- * Magnetic field
- * Time variation (or) Space variation b/w set of conductors and Magnetic field.

Types:-

- $\Rightarrow$ statically induced emf
- $\Rightarrow$ Dynamically induced emf

statically induced emf:- when the stationary conductor is kept in the time varying magnetic field.

ex:- transformer

magnitude by faraday's law^{2nd}

direction by lenz's law

Dynamically induced emf:- when a rotating set of conductors placed in a stationary magnetic field.

direction by Fleming's righthand rule.

ex:- Motors, Generator.

Fleming's Right hand rule:-

It shows the direction of induced current when a conductor attached to a circuit moves in a magnetic field.

→ Thumb is pointed in the direction of the motion of the conductor relative to the magnetic field.

→ Middle finger represents the direction of induced current with in the conductor. (Induced e.m.f)

→ the fore finger is pointed in the direction of the magnetic field.

Lenz's Law:-

The direction of the Current induced in a conductor by a changing magnetic field such that the magnetic field created by the induced current opposes the initial changing magnetic field.

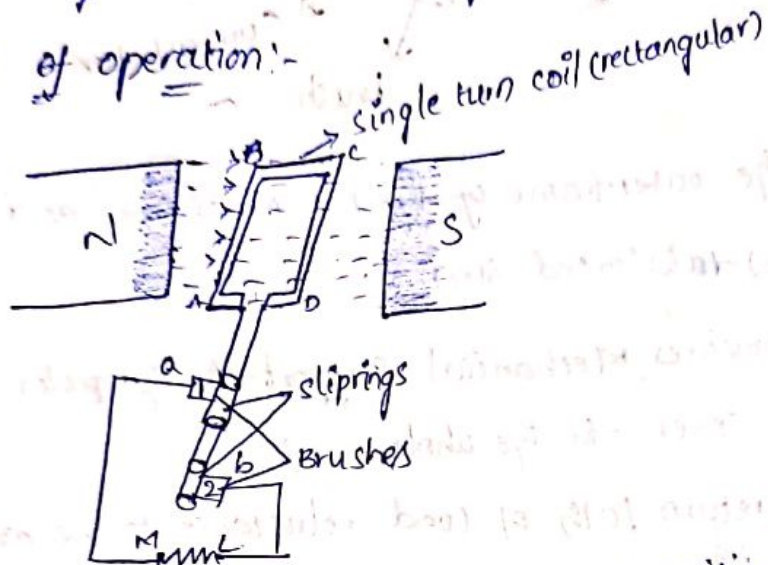
* Lenz's law defined as direction of electromagnetically induced emf is such as to oppose very cause of producing it.

* flux cutting law: $\mathcal{E} = Blv \sin \theta$



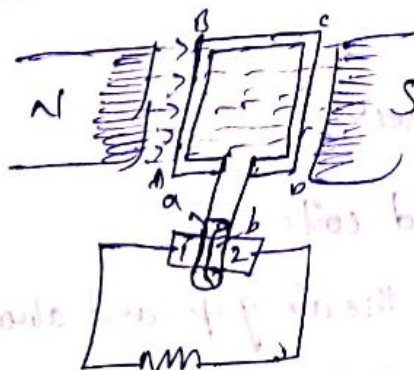
B = flux density
 l = length of conductor
 v = velocity

* principle of operation:-

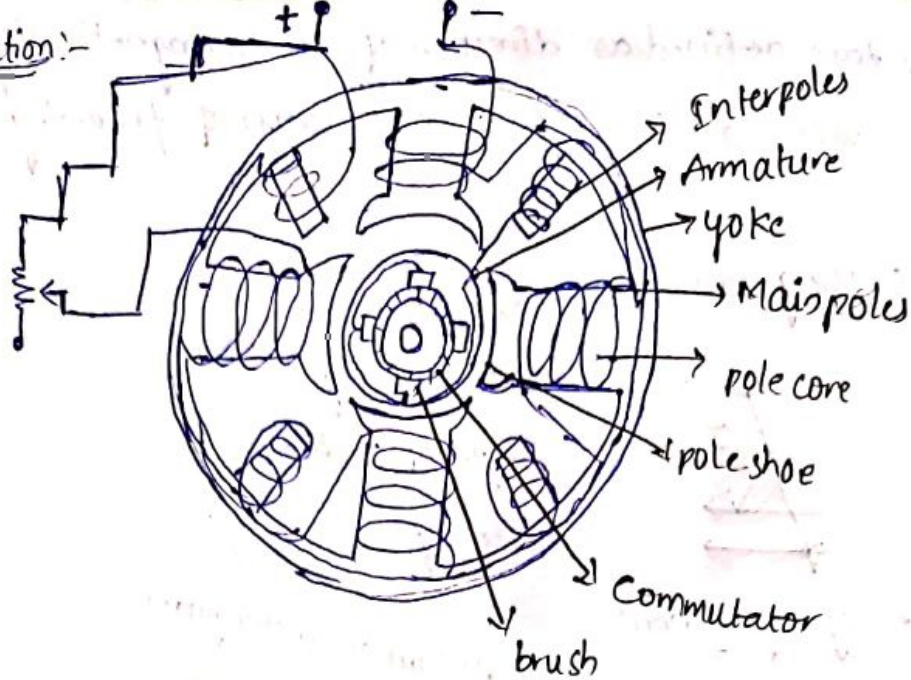


when it is rectangular coil is in vertical position ^{passing} total flux ϕ from N to S is maximum and rate of change of flux is minimum.
brushes $\Rightarrow$ collect current from the circuit and convey it to the external load.

commutator: converts AC supply to DC supply.
 also called as mechanical rectifier.



Construction:-



yoke:-

Yoke is the outer-frame of the D.C Machine and is generally made of Iron (or) fabricated steel.

Purpose:- 1. It provides Mechanical support for the poles and acts as a protective cover for the whole machine.

2. It provides a return path of low reluctance to the magnetic flux produced by poles.

field coils (or) main poles:-

There are 2 types of pole construction. The pole core itself maybe a solid piece made out of either cast iron or cast steel. The pole is laminated.

In modern design the pole core and pole shoe are of thin laminations of annealed steel.

The pole shoe serves 2 purposes:-

1. It acts as a support to field coils
2. To spread out the flux in the air gap and also being of large construction reduced the reluctance of magnetic path.

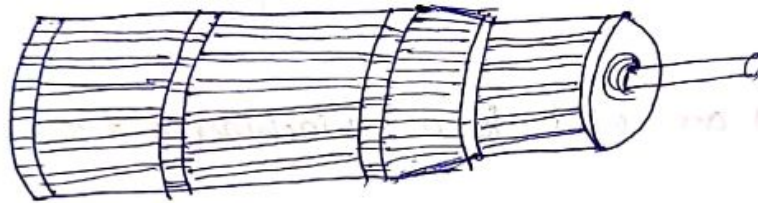
Interpoles:- (or) Commutating poles:-

* It is used to reduce the disturbances in the armature winding and field winding.

* To minimise the sparks in the DC Motor.

Armature core:-

Armature core houses the armature conductors or coils and causes them to rotate and hence cut the magnetic field flux of the field magnets.



Armature is the rotating part of the D.C. Machine, armature core is cylindrical in construction it is made up of high grade silicon steel to reduce power loss.

Armature winding:-

The armature winding of a DC Machine is a closed circuit winding. The armature winding is made up of copper. There are

2 types of armature windings

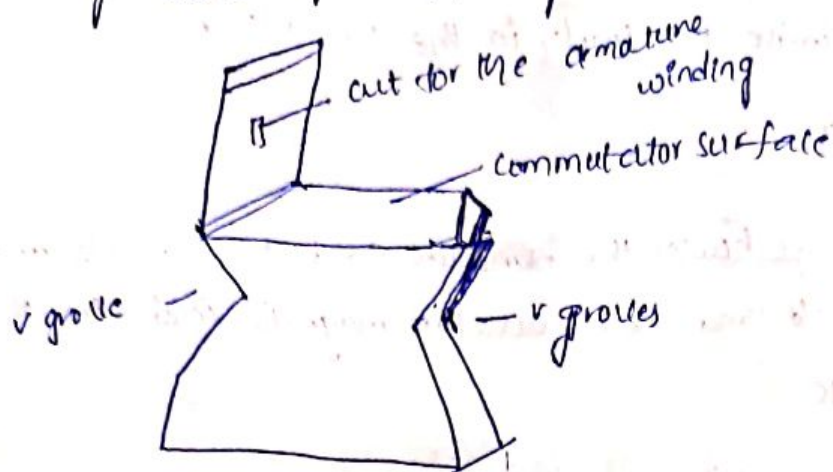
1. Lap winding $\rightarrow$ parallel connection of winding 

2. Wave winding $\Rightarrow$ series connection of winding 

Commutator:-

It is a mechanical rectifier which converts alternating voltage which generated in the armature winding into direct voltage across the brushes. This is made up of copper segments insulated from each other.

the no. of commutator segments can be decided by no. of coils.
each commutator segment is connected to the armature conductor by means of a copper lug or strip



Brushes:-

The brushes are used for DC machines and are divided into 5 classes.

1. Metal Graphite
2. Copper Graphite
3. Electro Graphite
4. Graphite
5. Carbon

It collects the current from the commutator and conveys it to external load.

A flexible copper pigtail mounted at the top of the brush to carry the current

pigtail

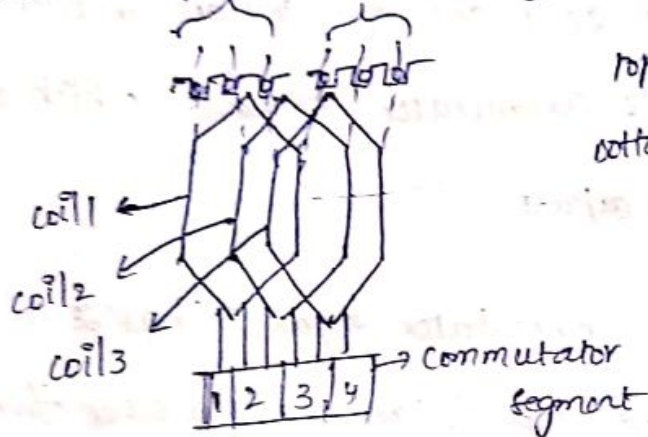


Brushes are made with carbon and used for small DC machines.

Electro Graphite carbon's are used for all types of DC machines.

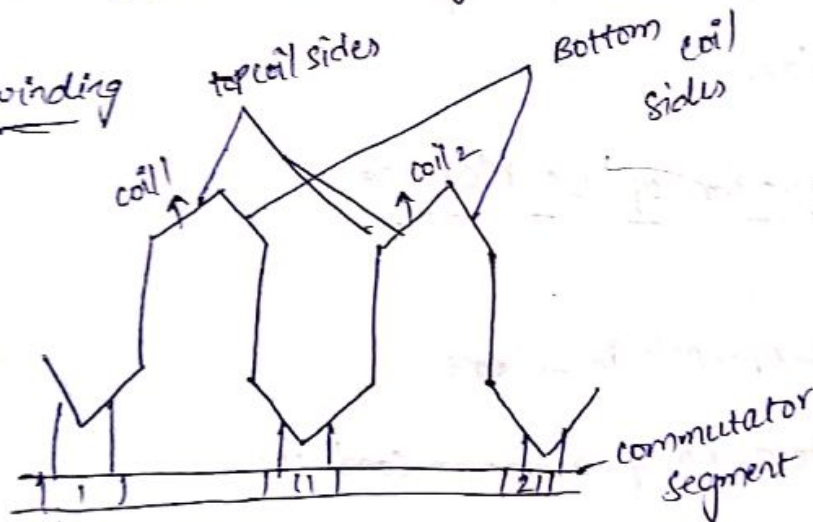
Armature Winding:

Lap winding: top coil sides bottom coil sides



top coil sides - odd number
bottom " " - even number

Wave winding



Lap winding:

In lap winding the 2 ends coil ends of the coil are connected to 2 adjacent commutator segments as shown in the above figure i.e., one ^{top} coil side of the - and the other from the bottom coil - sides are connected to adjacent commutator segment.

the above figure shows that bottom coil side of coil 1 and top coil side of coil 2 are connected to segment 2, Bottom coil side of coil 2 and top coil side of coil 3 are connected to segment 3 and so on.

Wave Winding:-

In wave winding the 2 coil ends of a coil are bent in opposite directions and connected to commutator segments which are approximately 2 pole pitches apart.

- In wave winding each commutator segment has 2 coil ends connected to it one from the top coil side and the other from the bottom coil side.

* Emf equation of DC Machine

- let $\phi \rightarrow$ flux per pole in webers

$Z \rightarrow$ total no. of armature conductors

$P \rightarrow$ no. of Generator poles

$A \rightarrow$ no. of parallel paths in Armature

$N \rightarrow$ Armature rotation in revolution's per minute (speed)

$E \rightarrow$ Emf induced in any parallel path in Armature

$E_g \rightarrow$ Generated Emf in any one of the parallel paths

Average emf generated/conductor $= \frac{d\phi}{dt}$ volt

flux cut by one conductor in one revolution of the

Armature $= d\phi = \phi p$ webers

no. of revolutions per second $= N/60$

time for one revolution $dt = \frac{60}{N}$ sec

Hence According to Faraday's law of electromagnetic induction,

emf generated per conductor $E = \frac{d\phi}{dt} = \frac{\phi p N}{60}$ volts

for wave windings,

No. of parallel paths $= 2$

no. of conductor's in one path $= \frac{Z}{2}$

emf Generated per path $= \frac{\phi p N}{60} \times \frac{Z}{2}$ volts

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

for lap winding:-

No. of parallel paths $= A$

No. of conductor's in one path $= \frac{Z}{A}$

emf Generated per path $= \frac{\phi p N}{60} \times \frac{Z}{A}$

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

✱ for wave winding $A = 2$

for lap winding $A = P$

* The lap wound Armature of a 4-pole Generator Armature has 51 slots. each slot contains 20 conductors. what will be the emf generated in machine when driven 1500 rpm.

If the useful flux per pole is 0.01 wb

Solⁿ Given that

$$P = 4$$

$$\text{no. of slots} = 51$$

$$\text{no. of conductors in each slot} = 20$$

$$\phi = 0.01 \text{ wb}$$

$$\text{Total no. of conductor} = 51 \times 20 = 1020$$

$$E_g = \frac{\phi Z N}{60} [P/A] = \frac{0.01 \times 1020 \times 1500}{60} \times \left[\frac{4}{2} \right]$$

$$= 255 \text{ volts}$$

* A 6-pole of lap wound Generator Armature has 720 conductors, a flux of 30 milliwebers and a speed of 600 rpm. calculate the emf generated. If the same armature is wave wound at what speed it be driven to generate 600 volts.

Solⁿ Given that

$$P = 6$$

$$A = 6$$

$$\phi = 30 \times 10^{-3}$$

$$N = 600$$

$$Z = 720$$

$$E_g = \frac{\phi Z N}{60} \times [P/A]$$

$$= \frac{30 \times 10^{-3} \times 720 \times 600}{60} \times \left[\frac{6}{6} \right]$$

$$= 216 \text{ volts.}$$

* Given $E_g = 600$
 $N = ?$

$$E_g = \frac{\phi Z N}{60} \times \left[\frac{P}{A} \right]$$

$$600 = \frac{720 \times 30 \times 10^{-3} \times N}{60} \times \left[\frac{6}{2} \right]$$

$$N = 555$$

* The Armature of a 2 pole 220V Generator has 400 conductors and runs at 300 rpm. calculate the useful flux per pole the no. of turns in each field coil is 1200, what is the average value of the emf induced in each coil on breaking the field, if the flux dies away completely in 0.10 sec.

sol:-

$$E = 220 \text{ V}$$

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

$$Z = 400$$

$$P = 2, A = 2$$

$$E = \frac{\phi Z N}{60} \left[\frac{P}{A} \right]$$

$$\phi = \frac{E \times 60 \times A}{P \times Z \times N} = \frac{220 \times 60 \times 2}{2 \times 400 \times 300} = 0.1 \text{ wb}$$

$$\varepsilon \propto \frac{d\phi}{dt}$$

$$\varepsilon = -N \frac{d\phi}{dt}$$

$$= -1200 \times \frac{0.11}{0.10} = -1320 \text{ Vt}$$

* An 8-pole D.C Generator has per pole flux of 40 mill wb and winding is connected in lap with 960 conductors. Calculate the Generated emf on open circuit when it runs at 400 rpm. If the Armature is wave wound at what speed must the machine be driven to generate the same voltage.

solⁿ:-

$$\phi = 40 \times 10^{-3}$$

$$Z = 960$$

$$P = 8$$

$$A = 8$$

$$N = 400$$

$$\varepsilon = \frac{\phi Z N}{60} \times \frac{P}{A} = \frac{40 \times 10^{-3} \times 960 \times 400}{60} \times \frac{8}{8}$$

$$= 256 \text{ Vot}$$

$$\varepsilon = \frac{\phi Z N}{60} \times \frac{P}{A} = N \Rightarrow \frac{256 \times 60 \times 2}{40 \times 10^{-3} \times 960 \times 8}$$

$$= 100 \text{ rpm}$$

* The Armature of a DC Generator is wave wound with 2 poles

There are 40 slots on the armature surface and 10 turns per coil. The armature winding is double layer winding. The resistance of each conductor is 10 milliohm. Find the resistance of the Armature and emf. generated, if flux per pole is 45 milli weber and generator is rotated at 350 rpm. repeat the calculation for lap winding.

Sol:

$P = 2$ wave winding

$A = 2$

$r = 10 \times 10^{-3} \Omega$

$Z = 40 \times 12 \times 2$ (Total of conductors)

$\phi = 45 \times 10^{-3}$

$\phi = 45 \times 10^{-3}$

$N = 350$

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

$$= \frac{45 \times 10^{-3} \times 40 \times 12 \times 2 \times 350}{60} \times \frac{2}{2}$$

$$= 252 \text{ volts}$$

Lap winding: resistance of Armature = 960×10^{-3}
 $= 9.6 \Omega$

Lap winding

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

$$= \frac{45 \times 10^{-3} \times 40 \times 12 \times 2 \times 350}{60} \times \frac{2}{2}$$

$$= 252 \text{ volts}$$

* calculate the armature resistance of 6 pole lap wound armature winding from the following data... [1 turn contains 2 conductors]

$$\text{No. of slots} = 150$$

$$\text{conductors per slot} = 8$$

$$\text{Mean length of 1 turn} = 250 \text{ cm}$$

$$\text{cross section of each conductor} = 10 \text{ mm} \times 2.5 \text{ mm}$$

The resistance of 1 mt of copper wire of 1 mm^2 in cross section is 0.0213Ω

Sol:-

$$Z = 150 \times 8$$

$$P = 6, A = 6$$

$$f = 0.0213 \Omega$$

$$l = 250 \times 10^{-2} = 2.5 \text{ mt}$$

$$\text{area } A = 25 \times 10^{-6} \text{ mt}$$

$$\text{Mean length of conductor} = \frac{250}{2} = 125 \text{ cm} = 1.25 \text{ mt}$$

$$\begin{aligned} \text{resistance of each conductor} &= \frac{f \cdot l}{A} = \frac{0.0213 \times 1.25}{25 \times 10^{-6}} \\ &= 1.065 \times 10^{-3} \end{aligned}$$

$$\text{no. of conductors in series } Z/A = \frac{150 \times 8}{6} = 200$$

$$\begin{aligned} \text{resistance of each parallel path} &= 200 \times 1.065 \times 10^{-3} \\ &= 213 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} \text{Armature resistance} &= \frac{0.213}{6} \\ &= 0.0355 \Omega \end{aligned}$$

Types of D.C. Machines (Based on Excitation)

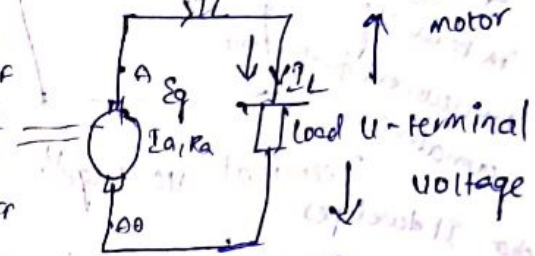
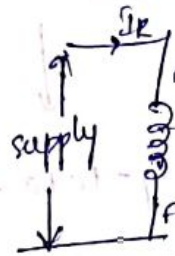
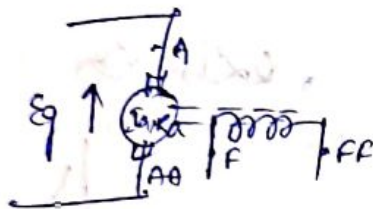
The method of providing the field current is called excitation of a DC Machine.

There are two types of Excitations:

1. Separately Excited DC Machine

2. Self excited DC Machine

Separately excited DC Machine:-



Armature Current ($I_a = I_L$)

we will get constant supply in separately

terminal ~~is~~ voltage, $V = E_g - I_a R_a$ excited machine, becz flux depends of ϕ .

Electric power developed $P = E_g I_a$

power delivered to load $P = V I_a = (E_g - I_a R_a) I_a$

2. Self excited DC Machine:-

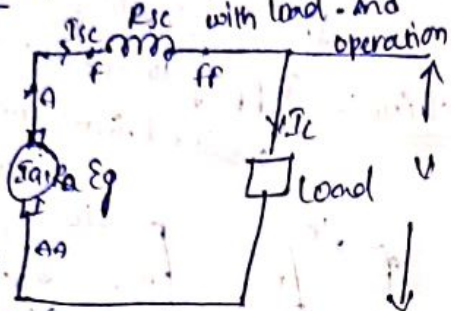
By residual magnetism self voltage was developed. so self excitation, ~~is~~ held in the machine. the field poles must have residual magnetism. so that when the armature rotates a residual voltage appears across the brushes. this residual voltage should establish a current in the field winding. so as to reinforce the residual flux.

Based on self excitation the field winding is connected to the armature in the manner of 3-different types.

1. Series Generator
2. Shunt Generator
3. Compound Generator

Series Generator:-

few turns of large wire in to carry total current from armature



On a series wound dc motor, the speed varies with load and operation wise this is its main difference series with armature from a shunt wound dc motor.

$$T_{avg} = k_a \phi \omega$$

It develops

large amount of starting torque

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

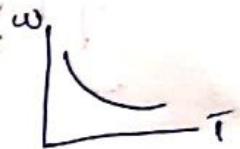
Armature current $I_a = I_{sc} = I_L$

Electrical power generated $P = E_g I_a$ (in armature)

Power delivered to load $P = V I_a$

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

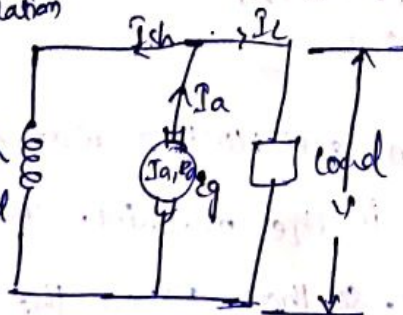
$$T \propto I_a I_{sc}$$



Shunt Generator:-

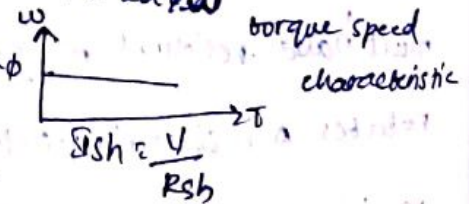
field winding in parallel with armature winding

* good speed regulation
* the shunt connected motor offers simplified control for reversing, this is especially beneficial in regenerative drives



The torque equation of dc motor resembles

$$T = k_a \phi \omega$$



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

Terminal voltage $V = E_g - I_a R_a$

Here $I_{sh} \cdot R_{sh} = V$

parallel connection
If constant b.t. $V_{supply} \text{ and } V_{sc}$

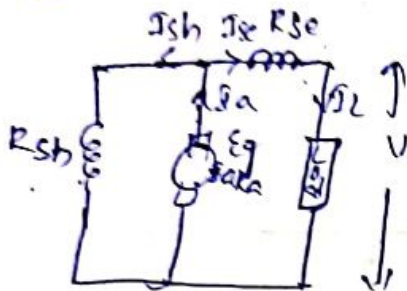
power developed = $E_g I_a$

power delivered to load = $V I_L$

Compound Generator:-

compound winding $\rightarrow$ series winding + ^{shunt} parallel winding

2 types $\rightarrow$ short shunt winding, long shunt winding
Generators.



shunt field winding is parallel with only armature winding

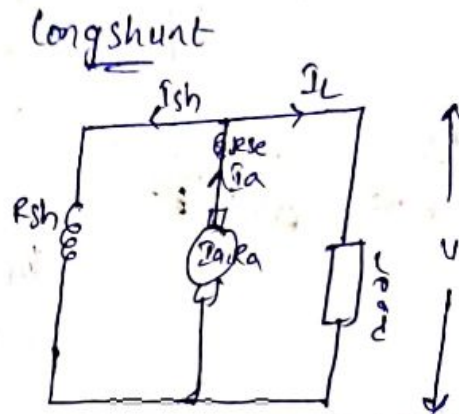
Armature current $I_a = I_{sh} + I_{sc}$
 $I_{sh} + I_L$

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

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

power developed $P = E_g I_a$

power delivered to load $P = V I_L$



shunt field winding is parallel with both armature and series winding

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

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

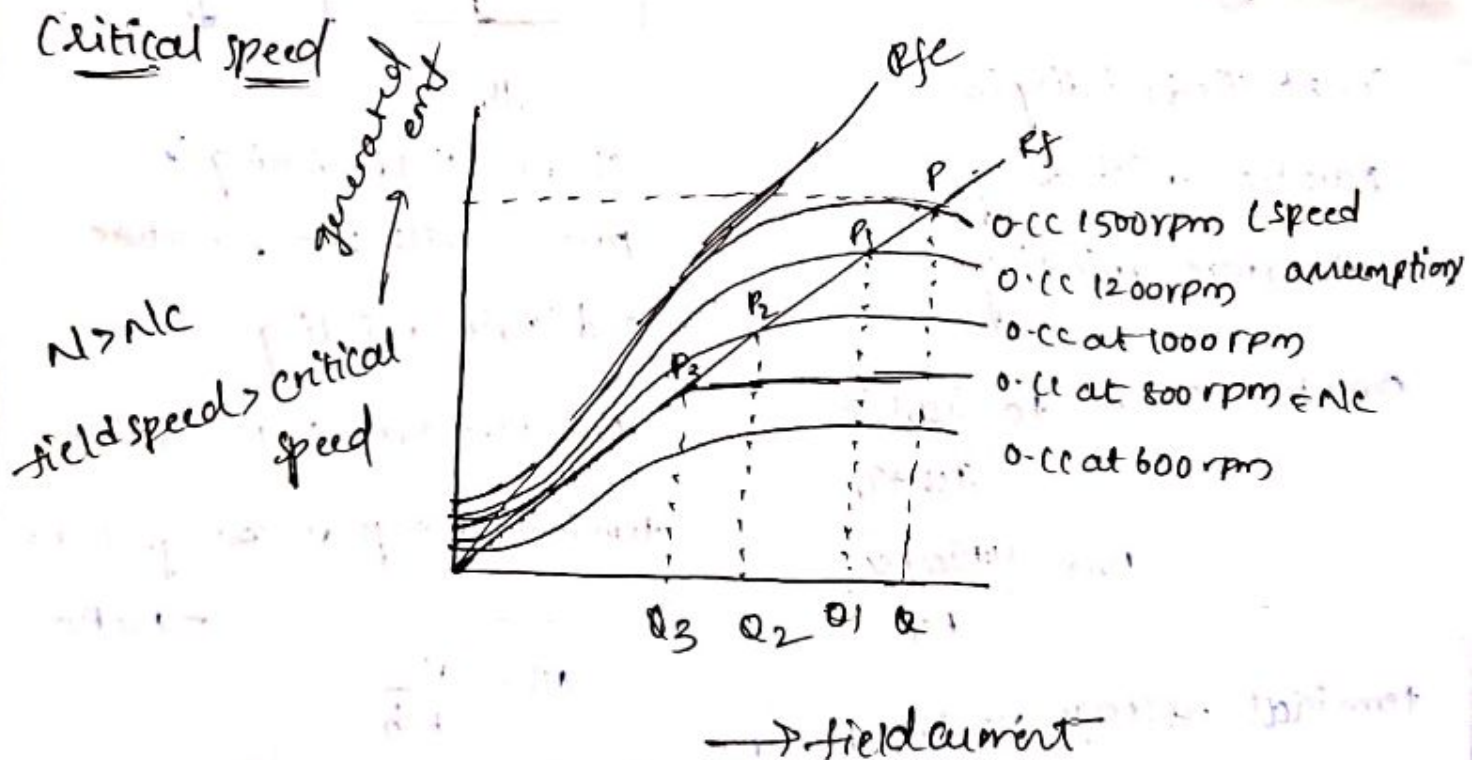
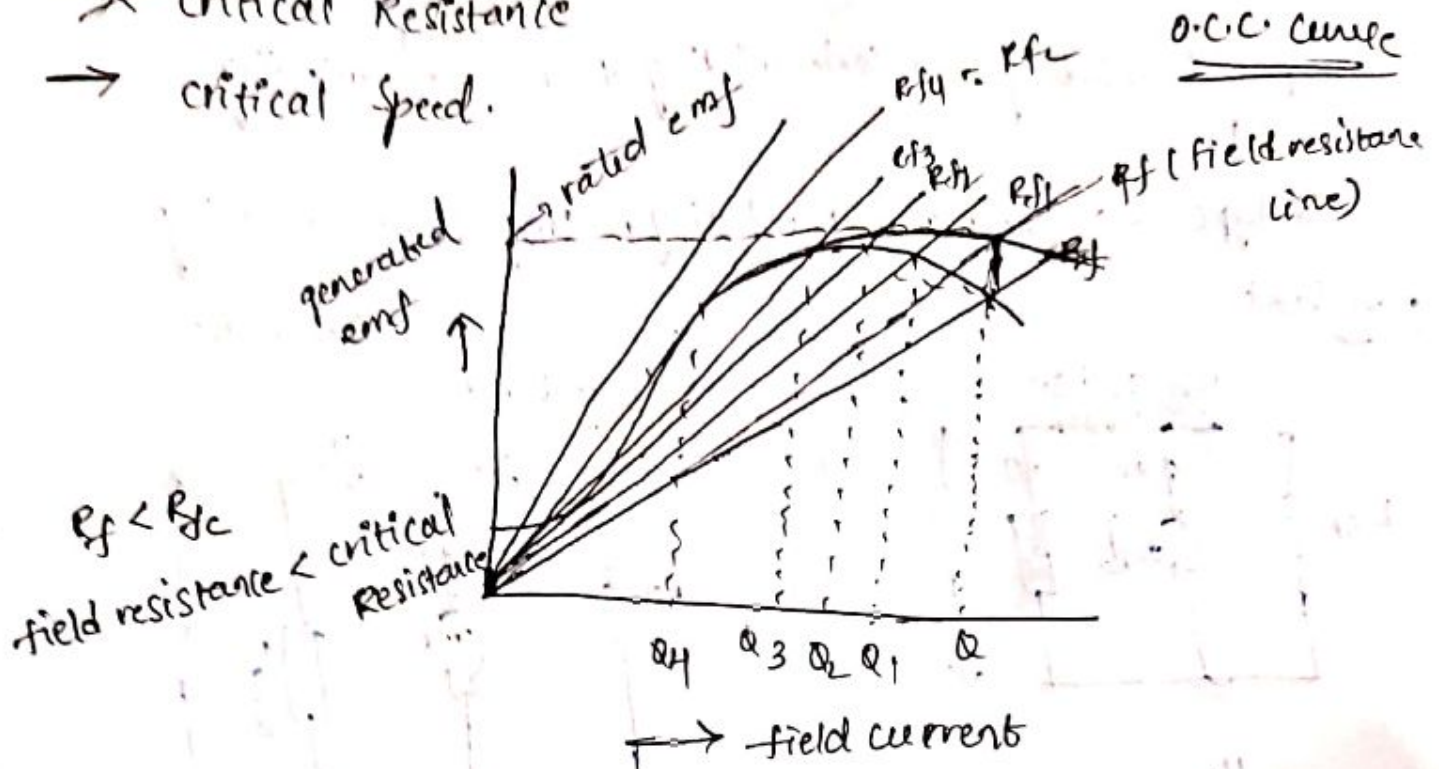
$$I_{sh} = \frac{V}{R_{sh}}$$

power developed $P = E_g I_a$

power delivered to load $P = V I_L$

Building up of the emf:- (Self excitation)

- Residual Magnetism
- connection's of field terminals
- ~~X~~ critical Resistance
- critical speed.



A 100 kva, 240V shunt generator has a field resistance of 55Ω and the armature resistance of 0.067Ω . find the full load generated voltage.

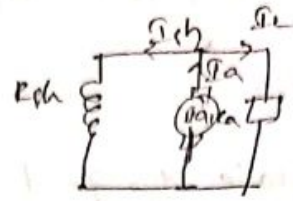
Sol:

power $P = 100 \text{ kW}$

voltage $V = 240 \text{ V}$

$R_{sh} = 55\Omega$

armature resistance $R_a = 0.067\Omega$



$$V = E_g - I_a R_a$$

$$E_g = V + I_a R_a$$

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

$$I_L = \frac{P}{V}, \quad I_{sh} = \frac{V}{R_{sh}}$$

$$= \frac{100 \times 1000}{240} = \frac{240}{55}$$

$$= 416.66 \quad = 4.3636$$

$$\therefore I_a = I_L + I_{sh} = 421.023$$

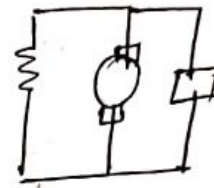
$$E_g = 240 + 421.023 \times 0.067$$

$$= 664.023 \text{ V}$$

$$E_g = 240 + 421.023 \times 0.067$$

$$= 268.208 \text{ Volts}$$

A four pole DC-shunt generator with a wave wound armature has to supply a load of 500 lamps each of 100 W at 250V allowing 10V for the voltage drop in the connecting leads b/w the generator and the load and drop of 1 volt per brush, calculate the speed at which the generator should be driven. The flux per pole is 30 milliw and the armature and shunt field resistances are 0.05Ω and 65Ω respectively. the no. of armature conductors is 390.



sol:- $P = 500 \times 100 \text{ W}$ no. of poles

$V = 250 \text{ V}$

Voltage across shunt $= 250 + 10 = 260$

flux $\phi = 30 \times 10^{-3} \text{ Wb}$

no. of conductors $= 390$

$R_A = 0.05, R_{sh} = 65\Omega$

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

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

$E_g = V + I_a R_A, I_a = I_L + I_{sh}$

$P = 500 \times 100 = 50,000$

$I_a = \frac{P}{V} = \frac{50,000}{250}$

$= 200 \text{ A}$

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

$= \frac{260}{65} = 4 \text{ A}$

$V_{sh} = 250 + 10 = 260$ [10V drop at load and generation]

eg:-

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

$$= 204 \text{ amp}$$

$$E_g = V + I_a R_a + \text{Brush drop}$$

$$= 260 + 204 \times 0.05 \times 2 \times 1$$

$$= 272.2 \text{ V}$$

$$N = \frac{272.2 \times 60 \times 2}{30 \times 10^{-3} \times 390 \times 24}$$

$$= 697.929$$

$$\approx 698 \text{ rpm}$$

generally

[if they not mention the no. of brushes

(for every machine we are taking 2 brushes only)

(1V drop)

* A DC-shunt generator runs at 400 rpm and delivers 500 kW to busbar having a constant voltage of 400 V. Assuming the field excitation to be constant at 5 amp, calculate the speed at which the generator must run if the load on it is to be reduced to 300 kW. The armature resistance is 0.015Ω .

sol:-

$$N_1 = 400 \text{ rpm}$$

$$R_a = 0.015 \Omega$$

$$P_1 = 500 \times 1000 \text{ W}$$

$$P_2 = 300 \text{ kW}$$

$$V = 400 \text{ V}$$

$$I_{sh} = \text{field current} = 5 \text{ A}$$

$$N_2 = ?$$

$$E_g = V + I_a R_a$$

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

$$I_L = \frac{P}{V} = \frac{500 \times 1000}{400}$$

$$= 1250 \text{ amp}$$

$$I_a = 1250 + 5$$

$$= 1255 \text{ Amp}$$

$$E_{g2} = V + I_a R_a$$

$$= 400 + 1255 \times 0.015$$

$$= 418.825 \text{ V}$$

$$E_{g2} = V + I_a R_a$$

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

$$I_L = \frac{P}{V} = \frac{300 \times 1000}{400} = 750 \text{ Amp}$$

$$I_a = 750 + 5 = 755 \text{ Amp}$$

$$E_{g2} = 400 + 755 \times 0.015$$

$$= 411.325 \text{ V}$$

$$\frac{E_{g1}}{E_{g2}} = \frac{N_1}{N_2}$$

$$N_2 = \frac{E_{g2}}{E_{g1}} \times N_1$$

$$= \frac{411.325}{418.825} \times 400$$

$$= 392.8 \approx 393 \text{ rpm}$$

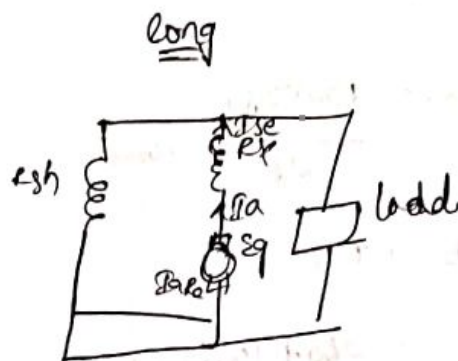
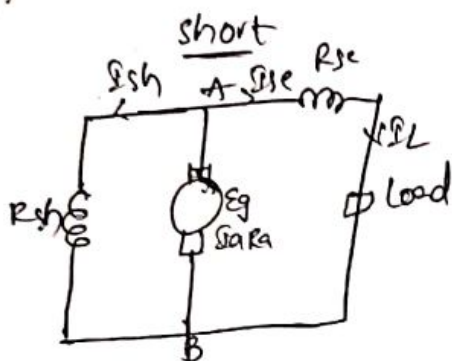
* A compound generator is to supply a load of 250 lamps each rated at 100W at 250V. The armature, series and shunt windings have resistances of 0.06Ω and 0.04Ω and 50Ω respectively. Determine the generated emf when the machine is connected in

1. long shunt

2. short shunt

Take drop per brush as 1V.

Sol:



Given $P = 250 \times 100$

$V = 250$

$R_a = 0.06$

$R_{sh} = 0.04$

$R_{sh} = 50\Omega$

$E_g = V + I_a R_a + I_{sc} R_{sc} + \text{brush drop}$

$I_a = I_L + I_{sh}$

$I_L = \frac{P}{V}$

$= \frac{250 \times 100}{250}$

$= 100$

$I_L = \frac{P}{V}$

$= \frac{250 \times 100}{250}$

$= 100$

$I_a = I_L + I_{sh}$

$E_g = V + I_a R_a + I_{sc} R_{sc} + \text{brush drop}$

$I_a = I_L + I_{sh}$

$I_L = \frac{P}{V}$

$= \frac{250 \times 100}{250} = 100 \text{ AMP}$

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

$= \frac{250}{50} = 5 \text{ AMP}$

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

$$= 100 + 5$$

$$= 105$$

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

$$= 100 + 5$$

$$= 105$$

$$E_g = 250 + 105 \left[0.06 + 100 \times 0.04 \right] + \text{brush drop}$$

$$= 250 + 105 [0.06 + 0.04] + 2 \times 1$$

$$= 262.5 \text{ V}$$

Short shunt:-

$$I_L = \frac{200 \times 250}{250} = 200 \text{ A}$$

$$V_{AB} = V + I_{se} R_{se}$$

$$= 250 + 100 \times 0.04$$

$$= 254 \text{ V}$$

$$I_{sh} = \frac{V_{AB}}{R_{sh}} = \frac{254}{50} = 5.08$$

$$I_a = I_L + I_{sh} = 105.08$$

$$E_g = V_{AB} + I_a R_a + \text{brush drop}$$

$$= 254 + 105.08 \times 0.06 + 2$$

$$= 262.3 \text{ V.}$$

* In a long shunt compound generator the terminal voltage is 230V. when generator delivers 150amp. determine.

- i) Induced Emf ii) total power generated

Given: shunt field, series field, diverter and Armature resistance are 92Ω , 0.015Ω , 0.03Ω , 0.032Ω respectively.

Solⁿ

$$V_{ter} = 230V.$$

$$I_L = 150$$

$$R_{sh} = 92\Omega, R_{se} = 0.015\Omega, R_d = 0.03\Omega, R_a = 0.032\Omega$$

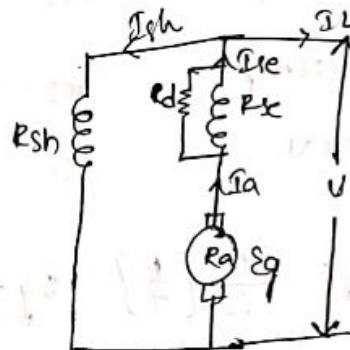
$$E_g = V + I_a R_a$$

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

$$I_L = 150A$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{92} = 2.5A$$

$$I_a = I_L + I_{sh} = 152.5A$$



Since series field resistance and diverter resistance are in parallel. where combined resistance is,

$$= \frac{0.03 \times 0.015}{0.03 + 0.015} = 0.01\Omega$$

$$\text{Total Armature resistance} = 0.032 + 0.01$$

$$R_a = 0.042\Omega$$

$$E_g = 230 + 152.5 \times 0.042$$

$$= 236.4V$$

$$\text{Total power generated} = E_g \times I_a = 236.4 \times 152.5$$

$$= 36051W$$

* A separately excited DC generator has armature circuit resistance of 0.1Ω and total drop at brushes is $2V$. when running at 1000 rpm , it delivers a current of 100 amp at 250 V to a load of constant resistance. If the generator speed drops to 700 rpm , with field current unaltered. find the current delivered to load.

Sol:-

$$R_a = 0.1\Omega$$

$$\text{Drop at Brushes} = 2V$$

$$N_1 = 1000\text{ rpm}$$

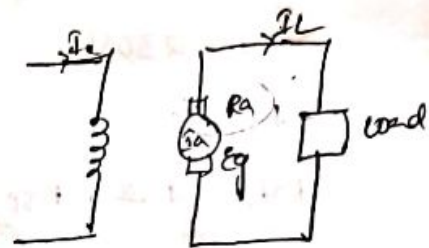
$$N_2 = 700$$

$$I_{a1} = 100\text{ amp}$$

$$I_{a2} = ?$$

$$V = 250\text{ V}$$

$$I_{a2} = ?$$



field current const. means

flux also const.

for separate excitation

$$E_g = \frac{\phi Z N}{60} \left[\frac{P}{A} \right]$$

$$E_g = V + I_a R_a$$

$$E_g \propto N$$

$$E_g \propto V + I_a R_a$$

$$\frac{V_1 + I_{a1} R_{a1} + \text{brush}}{V_2 + I_{a2} R_{a2} + \text{brush}} = \frac{N_1}{N_2}$$

$$I_{a2} = ?$$

$$\frac{250 + 100(0.1) + 2}{250 + I_{a2}(0.1) + 2} = \frac{1000}{700}$$

$$\frac{262}{252 + 0.1 I_{a2}} = 1.428$$

$$252 + 0.1 I_{a2} = 183.473$$

$$0.1 I_{a2} = -68.6$$

$$I_{a2} = -686\text{ A}$$

↑
on
ply
↓

O.C.C. of DC shunt generator:-

characteristics of DC machine:-

1. O.C.C. (Eg vs If)

2. External characteristics (V vs IL)

Load characteristics (Eg vs IL)

3. Internal characteristics.

(Open circuit characteristics / Magnetisation characteristics / no load characteristics)

DC shunt generator:-

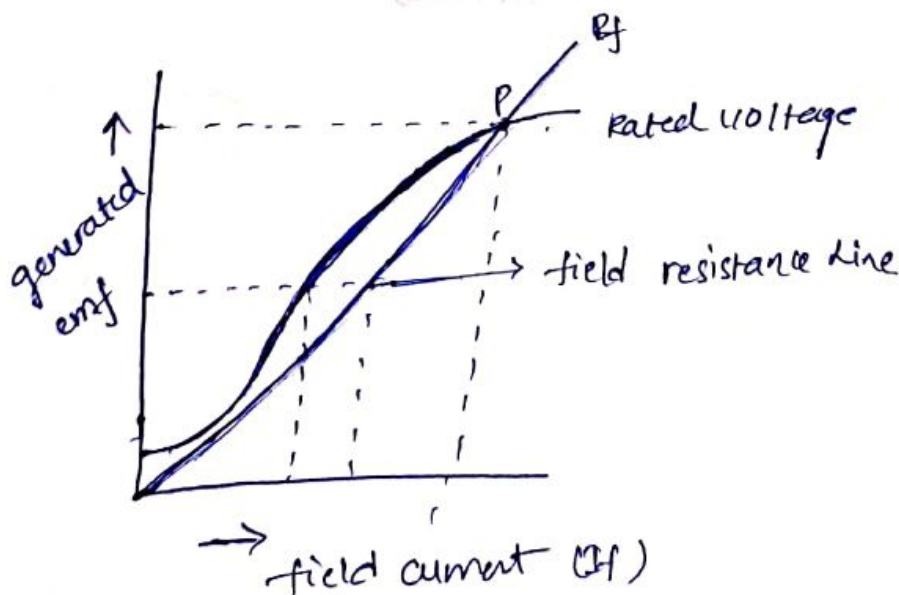
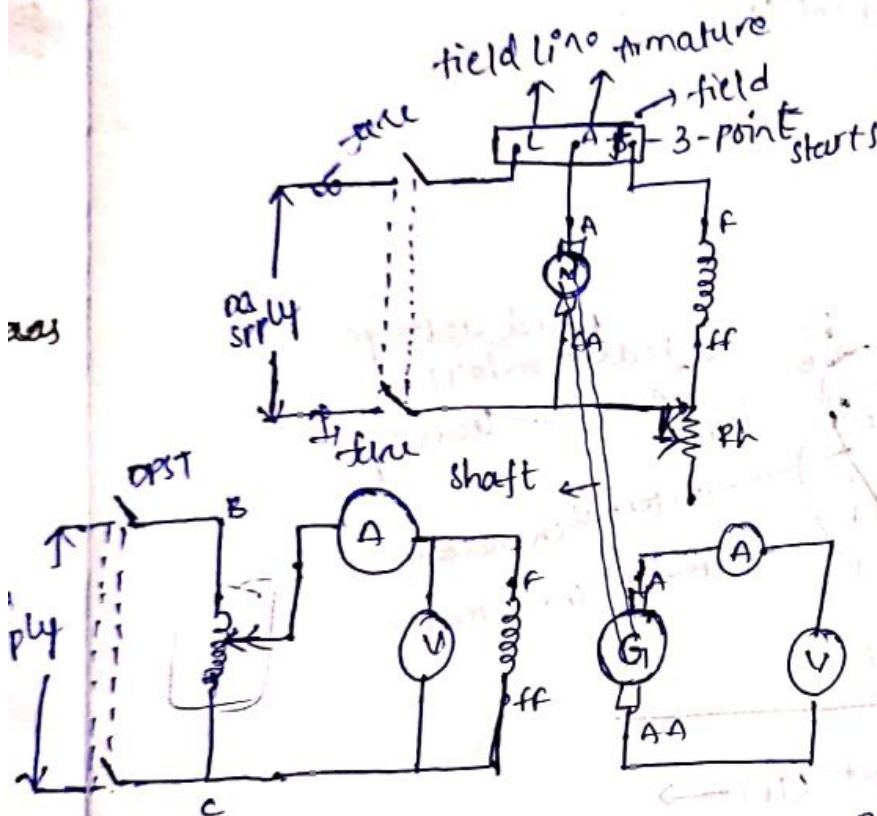
(characteristics of shunt and separated DC are same)

DPST - double pole single through switch

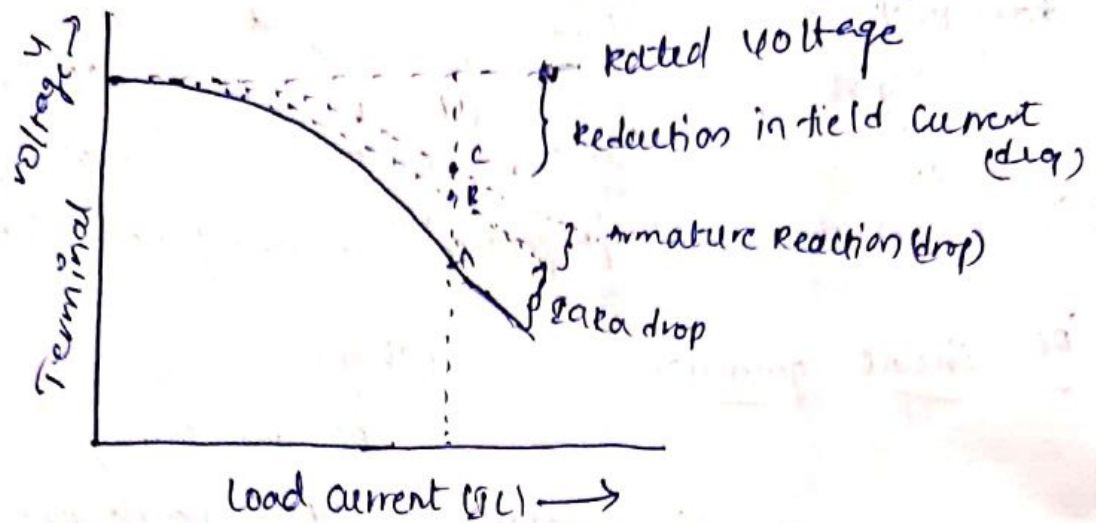
Tachometer - used to measure the speed

potential divider

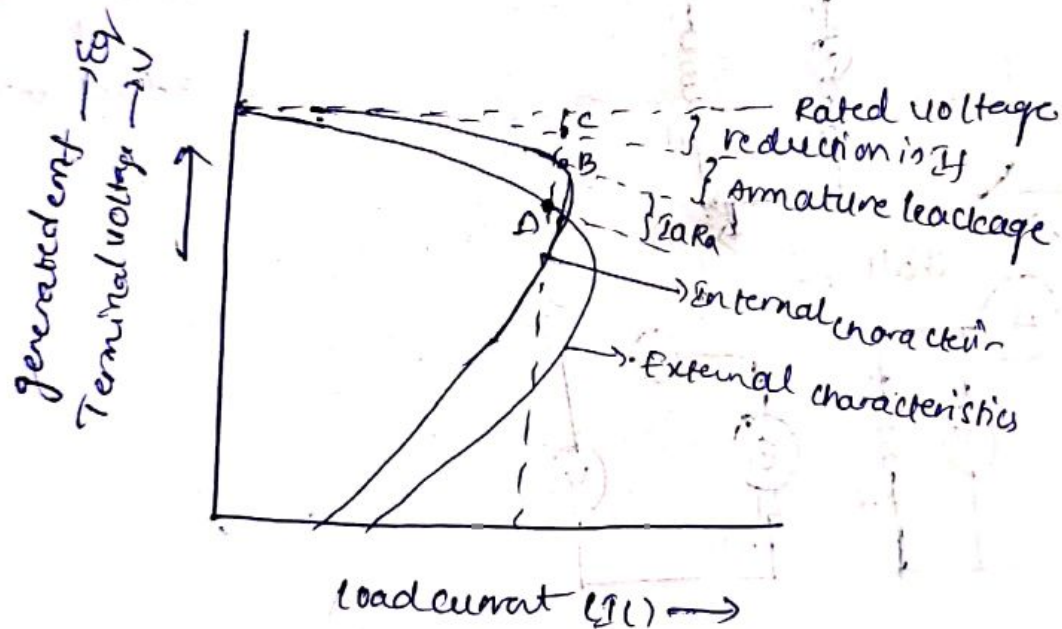
3 fixed ends



External characteristics - Drooping characteristics (dc shunt generator)



Internal characteristics



* A DC shunt generator gives an open circuit voltage of 240V. When loaded the terminal voltage falls to 220V.

Determine the load current in case of Armature circuit and field winding resistances are 0.1Ω and 50Ω respectively.

sol:- $E = 240V$ $V_t = 220$

$R_a = 0.1\Omega$ $R_{sh} = 50\Omega$
 $I_L = ?$

$I_a = I_L + I_{sh} \Rightarrow I_L = I_a - I_{sh}$

$I_{sh} = \frac{V}{R_{sh}} = \frac{220}{50} = 4.4$

$E_g = V + I_a R_a$

$I_a = \frac{E_g - V}{R_a} = \frac{240 - 220}{0.1} = \frac{20}{0.1} = 200 \text{ Amp}$

$I_L = 200 - 4.4$
 $= 195.6 \text{ A}$

* find the resistance of the load which takes a power of 5kW from a DC-shunt generator whose external characteristics is given by the equation $V = 250 - 0.5 I_L$

sol:- $P_{out} = 5 \text{ kW} = 5000 \text{ W}$ $R_L = \frac{V}{I_L} = \text{?}$

$V = 250 - 0.5 I_L$

$I_L = \frac{P}{V} = \frac{5000}{V} \Rightarrow V = 250 - 0.5 \left[\frac{5000}{V} \right]$

$= \frac{5000}{239.56}$ $V = 250 - \frac{2500}{V}$

$= 20.87$ $V^2 - 250V + 2500 = 0$

$$V_1 = 239.564 \text{ (single phase)}$$

$$V_2 = 10.435 \text{ (neglected)}$$

$$R_{eq} \frac{V_1}{I_L} = 20.87$$

$$V = 250 - (0.5)(20.87)$$

$$V = 239.6$$

$$R_L = \frac{V}{I_L} = \frac{239.6}{20.87} = 11.48 \Omega$$