صلاح الدين حوراني

0100431

MACHINES LAB.

تلخيص

Experiment ①

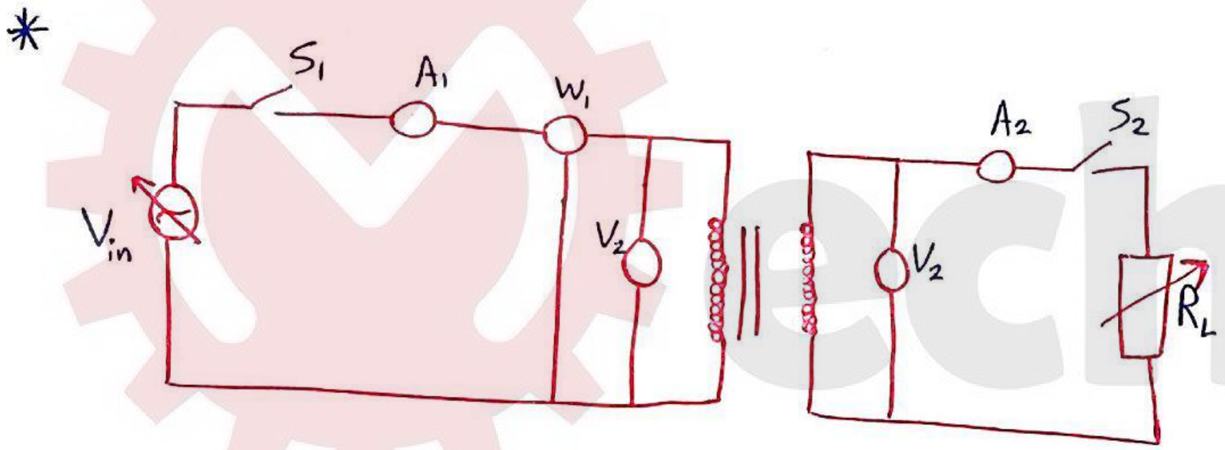
صلاح الدين الحوراني

* transformer ⟶ AC
* watts = (deflection) (range A) (range V)

* in the second part, read V_{sc} from the primary side

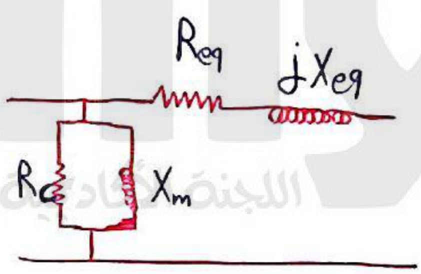
$$(V_1 = V_{sc})$$

*



* turns ratio (a) $= \dfrac{V_1}{V_2} = \dfrac{N_1}{N_2} = \dfrac{I_2}{I_1}$

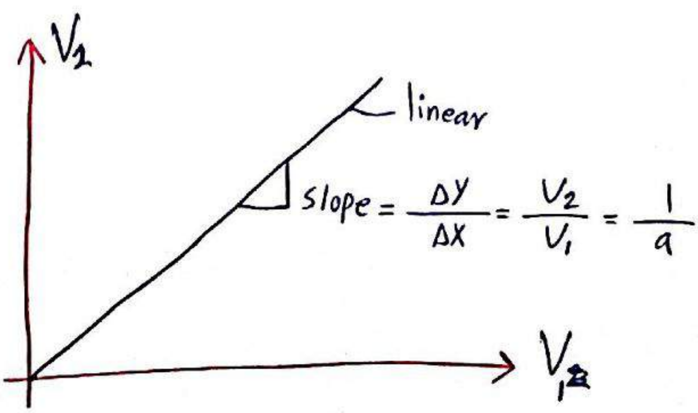
* R_c and X_m ⟶ from OCT



* R_1, R_2, X_1 and X_2 ⟶ from SCT

(R_{eq} and X_{eq})

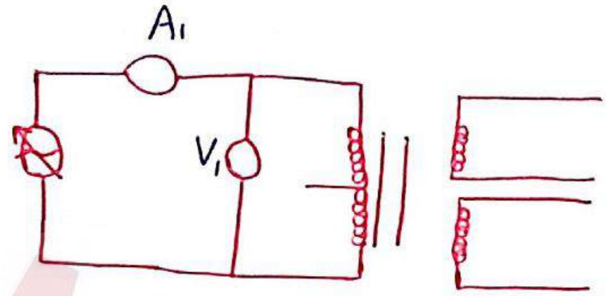
*



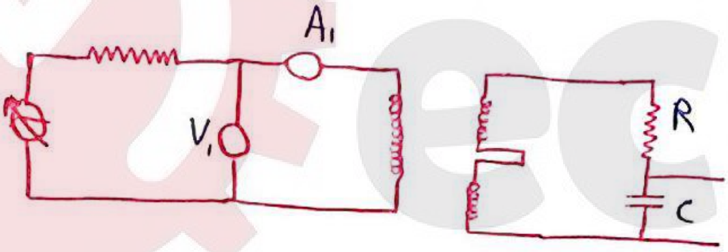
صلاح الدين الحوراني

Experiment ②

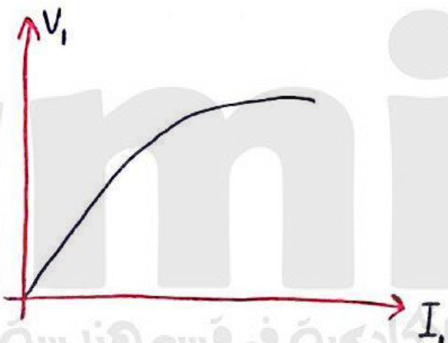
* 1st Part



* 2nd and 3rd parts



* magnetization curve



* read the notes from ① to ③ provided in the manual

* 2^{nd} part :-

① changing the voltage changes the width of the loop. This is related to when voltage is decreased, the current that is directly proportional to $\underbrace{\text{the magnetic intensity (H)}}_{\text{this represents the width of the graph}}$ will decrease

② iron losses can't be calculated accurately from the hysteris loop, this is because:-

- B-H relationship is not linear
- there is no simple mathematical expression that can describe the loop
- eddy current losses

* approximate relation to calculate the area of the hysterisis loop

$A = K B_{max}^{n}$

where, K is a constant

n varies from 1.5 - 2.5

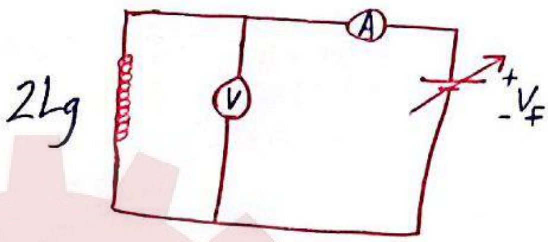
B_{max} is maximum flux density

* the loop of air gap behaves similar to the loop without air gap, the width of air gap loop is larger than the width of the loop without air gap

Experiment ③

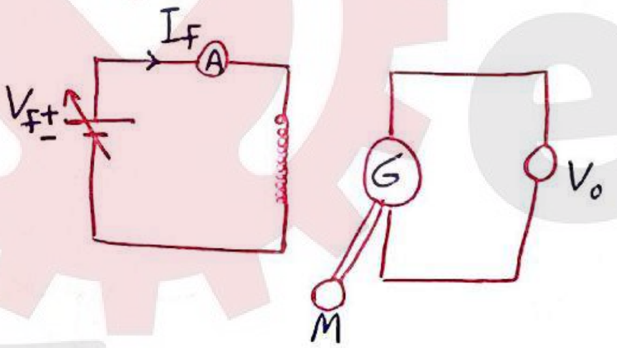
صلاح الدين حوراني

* 1^{st} Part



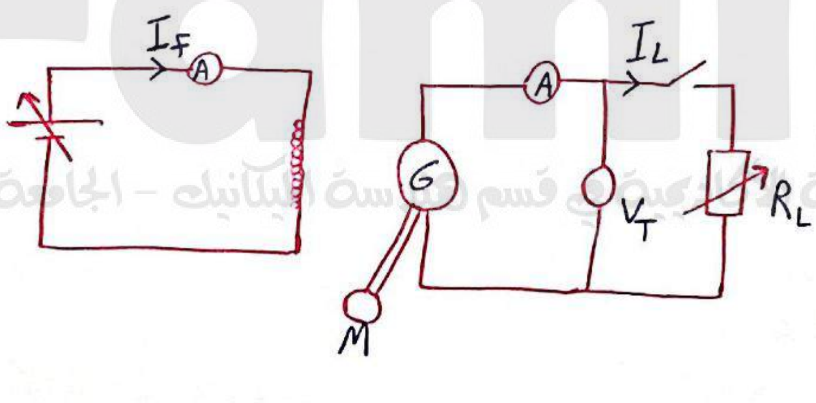
measurement of field resistance

* 2^{nd} Part



no-load test

* 3^{rd} part



load test

* field current ⟶ stationary part

armature current ⟶ moving part

* $E = \underbrace{k}_{\text{Constant}}\,\underbrace{\phi}_{\text{Flux}}\,\underbrace{w}_{\text{angular velocity}}$

* in DC, motor and generator are identical

* for very small machines, there are two small permenant magnets

* for large machines → electrical poles

* tachogenerator → the device used to measure the motor speed

* 0.2 mA = 1000 RPM

* all generators are AC, to convert to DC we connect a commutator (mechanical rectifier)

How to control the speed of DC motor ?

Voltage, current, ______

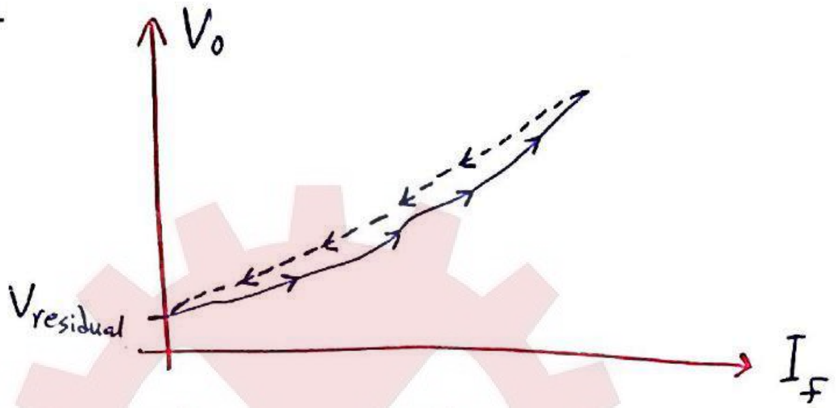
* controlling DC machines is easier than controlling AC machines, AC controlling requires controlling frequency and poles which are so hard

* magnetic flux (ϕ) is supplied from external source, thats why it is called separately excited

* for motors, we must feed both field and armature circuits

* for generators, we feed the field circuit only

*



* the residual voltage has no importance for separately-excited generator, but it is important for self-excited generator

* forward and backward characteristics are not ~~ext~~ exactly the same, this is related to hysterisis losses

Voltage regulation:- measure of change in ~~magnitude~~ the voltage magnitude between the sending and receiving ends of a component
or may be defined as the change in magnitude of the secondary voltage as the load current changes from no-load to loaded conditions

* $$VR = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$

$NL \equiv$ no-load

$FL \equiv$ full load

*

$$V_T = E_a - I_a R_a$$

* at no-load, the terminal voltage (V_T) is equal to the generated voltage (E_a)

$I_L = 0 = I_a$

* drop voltage is due to armature resistance which includes:- brushes resistance, commutator resistance and the effect of armature reaction

$$V_T = E_a - I_a R_a$$

Cause of drop voltage

Experiment (4)

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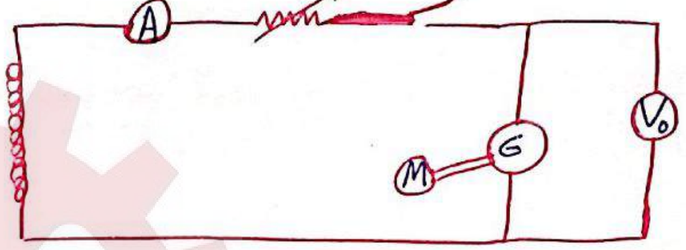
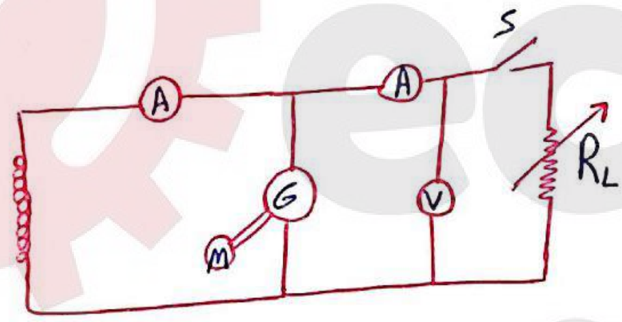
* DC shunt generator sometimes called self-excited generator

* 1st Part



no-load test

* 2nd part



~~load test~~
external characteristics

* OCC

* For a given speed, increasing the current increases the voltage

* For a given field current, increasing the speed increases the voltage

* For a given I_f, ϕ will remain constant

and from $E_a = k\phi w$, k and ϕ are constants and increasing ϕ would increase E_a $\longrightarrow$ increasing in E_a will increase V_o

$$V_o = E_a - I_a R_a$$

* conditions where emf may Fail to build up:-

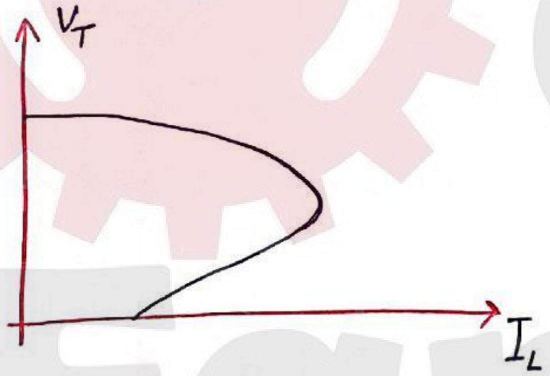
① when there is no residual magnetic Flux

② the direction of rotation of generator may ~~be~~ have been reversed, or the

connections of windings may have been reversed

③ Field circuit resistance is larger than the critical Field resistance

*



* short circuit ⟶ minimum resistance

DC shunt generator may operate at S.C. with no danger

* armature resistance $(R_a) = \dfrac{V_{residual}}{I_{s.c.}}$

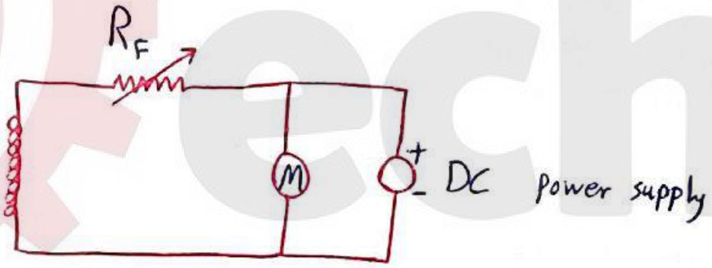
Experiment 5

صلاح الدين حوراني

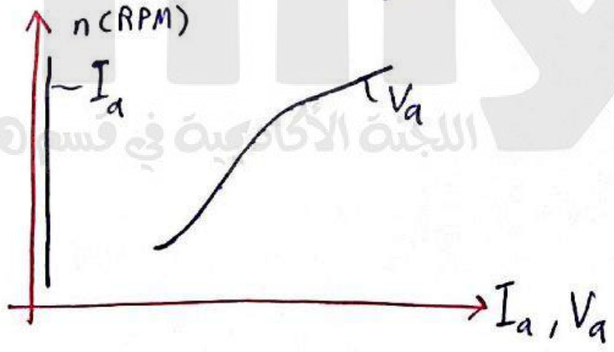
* DC shunt motor is widely used as a variable speed drive and in automatic speed regulation systems because of the simplicity of its requirements

* in DC shunt motor the field coils are connected to the DC supply terminals and are in parallel with the armature circuit

*

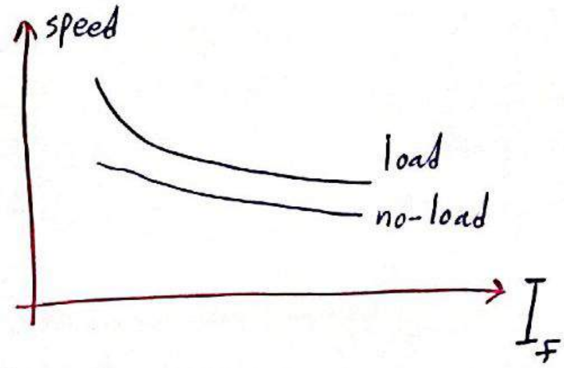


* controlling the speed by changing armature voltage



the armature voltage is increasing with speed while the armature current remains constant. The reason why I_a remains constant is that the the I_{input} is constant and there is no disturbance. $E_a = K\phi w$, k and ϕ are constants and increasing w would increase E_a

* controlling the speed by varying the field current



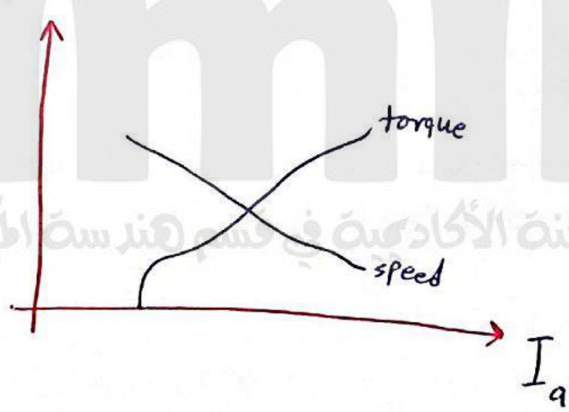
ϕ has direct relation to I_f , consider the next two equations

$V_T = E_a + I_a R_a$ and $T = K \phi R_a$

$$w = \frac{V_T}{\phi k} - \frac{R_a T}{(k\phi)^2}$$

increasing (ϕ), which will increase I_f, will decrease the speed (w)

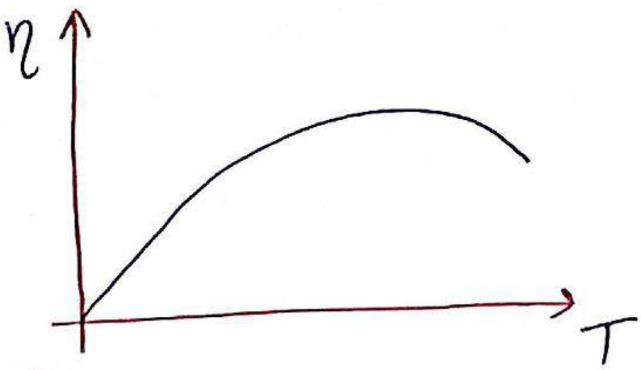
* motor under load



rotational losses, armature circuit losses, shunt winding losses and series field winding losses all can be considered as system's resistance even when there is no resisting torque. torque curve doesn't pass through origin because there must be an armature current so the system can be operated.

(residual flux in shunt resistance)

*



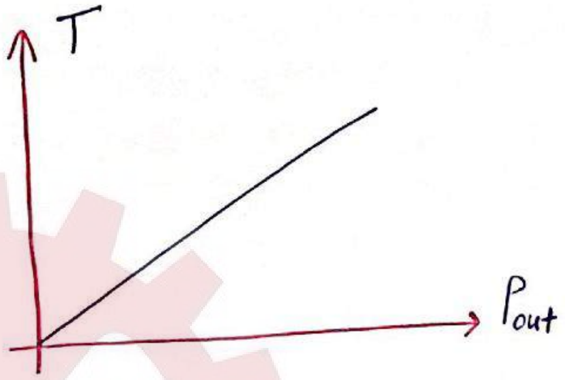
* when output power = 0 ⟶ speed = 0

Power is consumed in shunt resistance

Experiment ⑥

صلاح الدين الحوراني

* $slip(S) = N_{stator} - N_{rotor}$, $n = \frac{N_{stator} - N_{rotor}}{N_{stator}}$
* you can reverse the direction of rotation of an induction motor by simply changing the phase sequence

*


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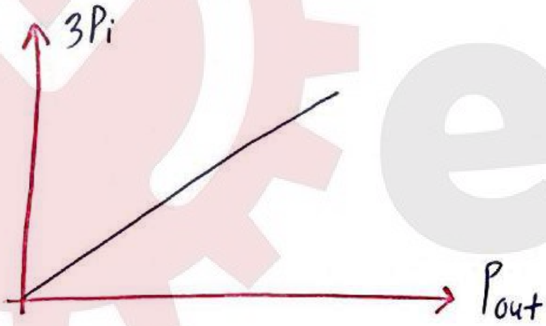

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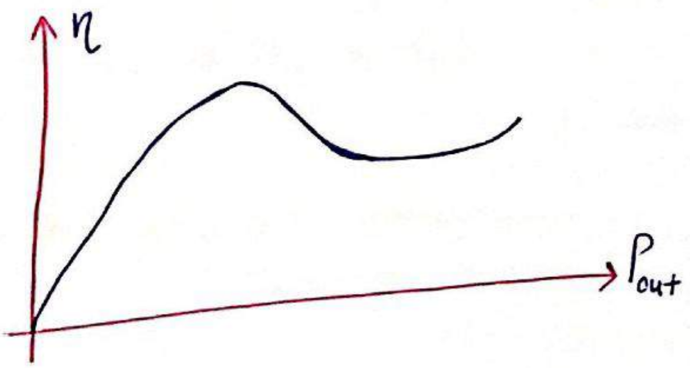

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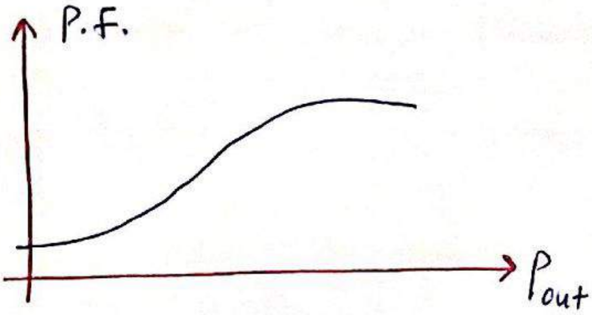

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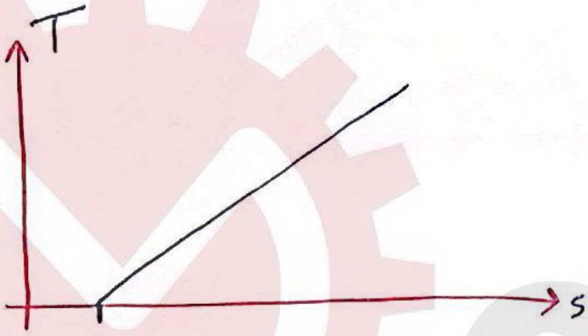


* increasing the torque will increase the slip, and the speed will decrease

* as torque increases, $I_{induction}$ increases
when load (torque) increases, the response of the motor is to increase the $I_{induction}$

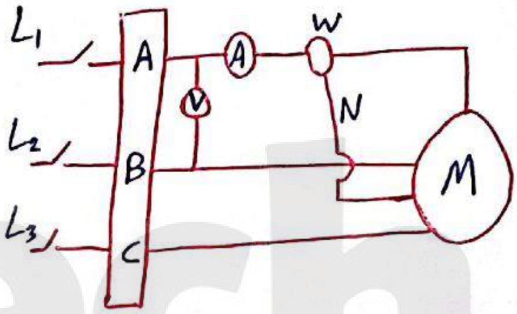
* at no-load conditions, the ratio of $\left(\frac{I_{starting}}{I_{s.s.}}\right)$ is high and this is because of the resistance.
at the beggining the motor has to overcome of itself resistance and the lack of angular momentum

* For 3-phase power supply, never disconnect the wires while power supply is ON

* 1st line → connect the Ammeter → connect the Wattmeter → then connect to phase A

2nd line → connect to phase B

3rd line → connect to phase C



* highest current at $I_{starting}$

* to reverse the direction of rotation, reverse any two phases

* we read the direction of rotation from the newtonmeter

* $I_{starting}$ is an instantenous current and it must be observed the Ammeter gives the highest reading immediately after plugging the power

* we use the movistrob device to measure the speed, this device works when the frequency of the device matches the frequency of the motor

* watts = (deflection) (range A) (range V)

Experiment 7

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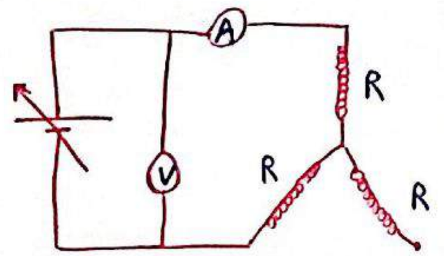
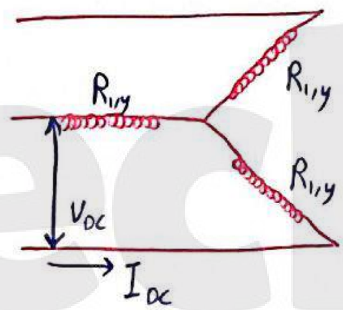
*



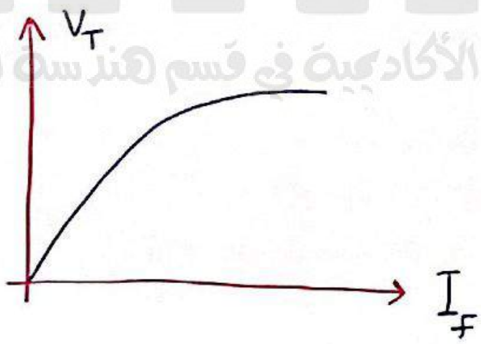
measurement of armature resistance

$$2R_A = \frac{V_{DC}}{A_{DC}}$$



the generator is Y-connected (star connected), the current flows through two windings and the resistance is given by the above relation

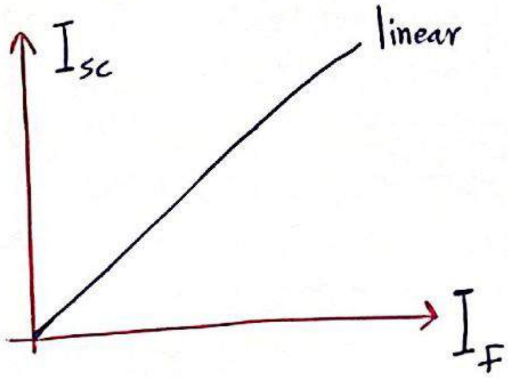
* magnetization curve



* R_{DC} is not equal to R_{AC}, in AC current and voltage have a shift angle between them. The impedance of real and imaginary parts are

$$Z = \sqrt{(R)^2 + (X)^2}$$

* short circuit characteristic curve



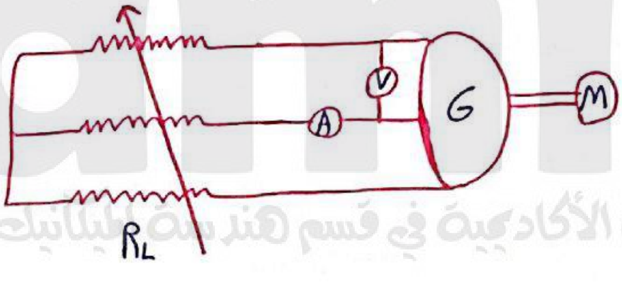
decreasing the speed will decrease the induced Voltage, thus short circuit current decreases

decreasing the short circuit current decreases the speed, this is because decreasing the speed will change the frequency thus current changes

* synchronus impedance $(Z_s) = \dfrac{V_T}{I_{sc}} = \dfrac{\frac{V_L}{\sqrt{3}}}{I_{sc}}$

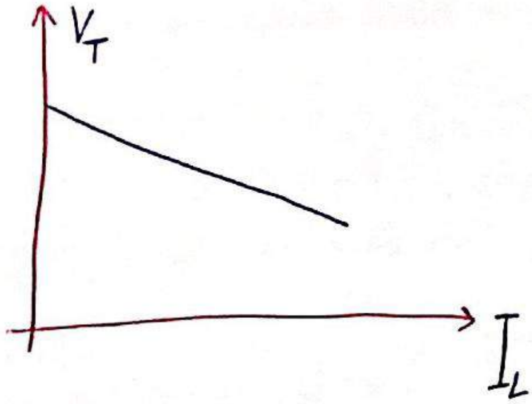
* synchronus reactance $(X_s) = \sqrt{(Z_s)^2 - (R_A)^2}$

*



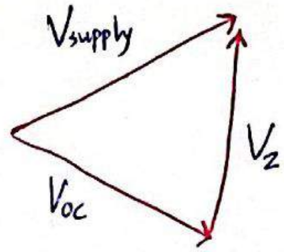
load test

* load test magnetization curve

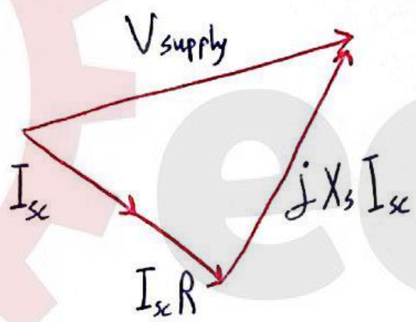


Phasor diagrams:-

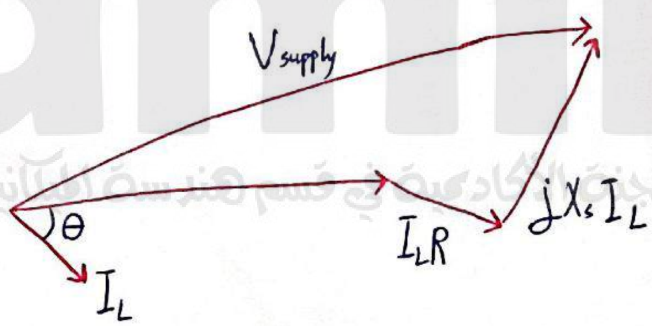
① For open circuit condition



② For short circuit condition



③ For load condition



* synchronus machine rotates at a constant speed in the steady state

* in synchronus machines, both rotor and stator magnetic field rotate with the same speed

* synchronus machine can operate as both generator and motor

* a synchronus machine is a doubly excited machine, the rotor poles are excited by DC current and stator windings are connected to AC supply

Eperiment ⑧

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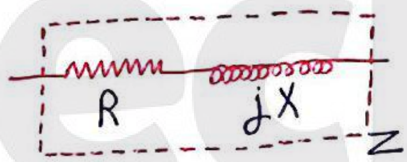
* synchronus motor and synchronus generator are identical

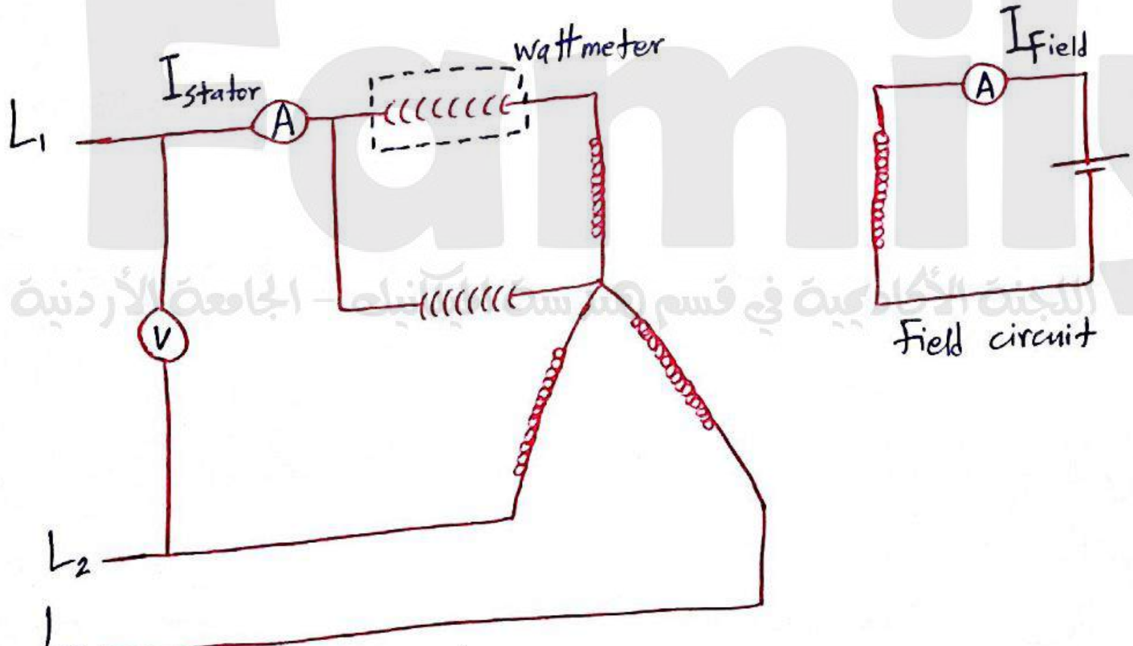
* parameters of synchronus motor to be found ⟶ operate the sync. motor as sync. generator

no-load
load
DC-test
short circuit
open circuit
] tests to Find the parameters

* $Z = \sqrt{(R_{eff})^2 + (X)^2}$



* 3-phase , Y-connection



stator circuit

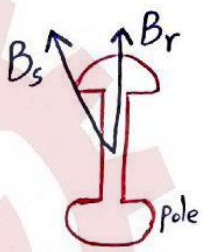
Field circuit

* sync. motor is not self starting type of machines

* Flux rotates with sync. speed

* slip (S) = $\frac{N_s - N_m}{N_s} \times 100$

*



torque (T) = $B_r \times B_s$

* this machine is not "self starting" because the resultant of Fluxes is equal to zero

Methods for starting the synchronus motor:- there are three methods:-

① introduce a prime mover untill you reach the sync. speed ($speed_{prime\ mover} \geq speed_{sync.}$), when the required speed is reached we can connect the 3-phase power supply and disconnect the prime mover

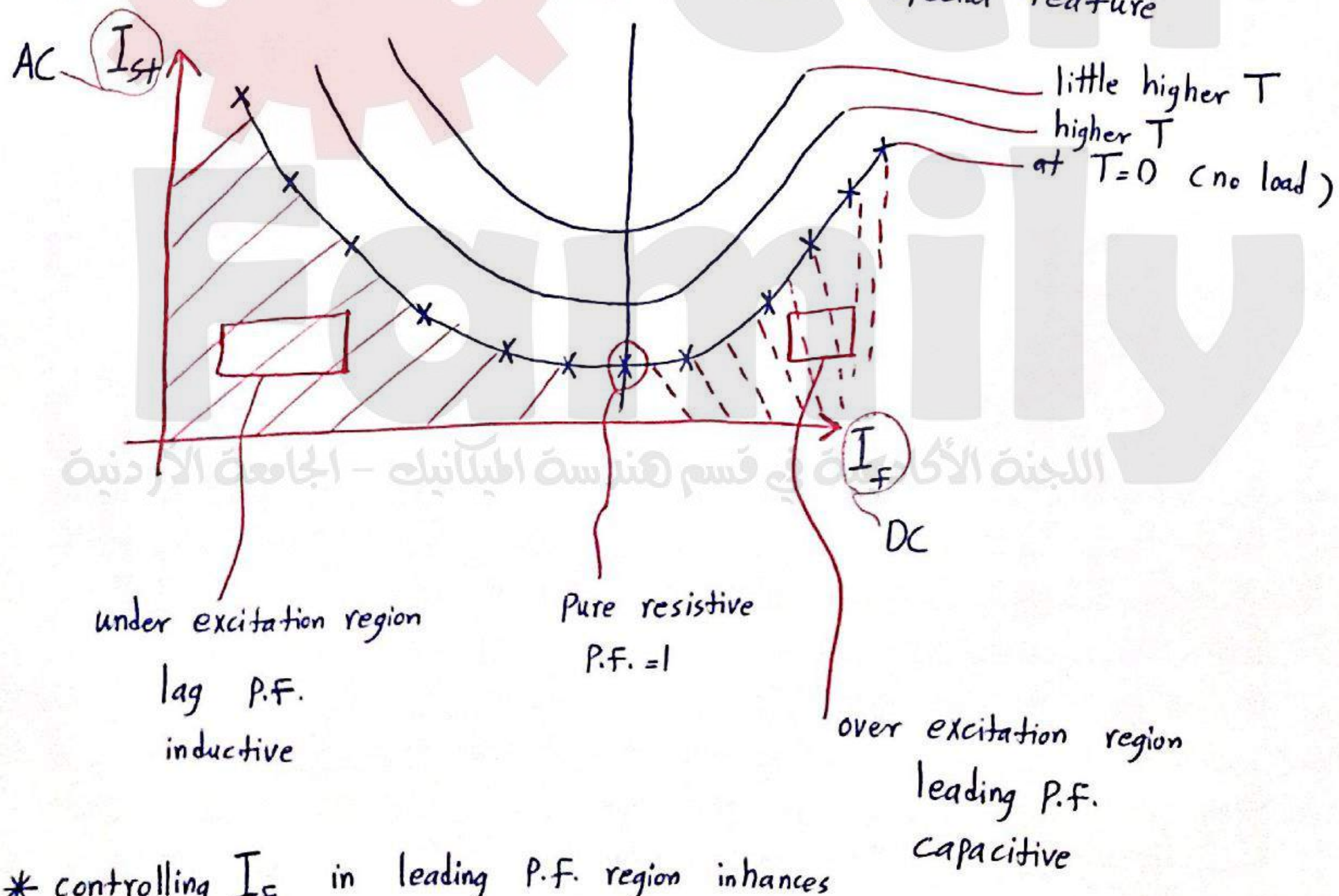
② sync. motor as induction motor ⟶ by adding a damper winding

damper winding ⟶ short circuit

(3) variable frequency voltage source → two sources → when two frequencies matches → sync. motor starts

* sync. motor rotates at —either→ sync. speed
—or→ zero (pull-out)

* the U- curve , sync. motor has this special feature



* controlling I_f in leading P.F. region inhances the P.F. which makes the lost power become less