LAB # 01

Introduction to magnetic circuits

★ MAIN PARAMETERS OF MAGNETIC CIRCUITS :-

1 MAGNETIC FLUX :-

Magnetic flux are the number of lines of force surrounding a permanent magnet. It is measured in wb represented by ϕ.

2 MAGNETIC FLUX DENSITY :-

It is the flux per unit area. It is the amount of magnetic flux in a unit area perpendicular to the direction of force.

3 MAGNETOMOTIVE FORCE :-

The ~~per~~ property of certain substance or phenomenon that give rise to magnetic field. Represented by I. $F = NI$

4 MAGNETIC STRENGTH :-

Magnetomotive force per unit length.

$$H = \frac{F}{l}$$

5 RELUCTANCE :-

The property of magnetic circuit of opposing the passage of magnetic flux lines. $\sigma = F/\phi$

TASKS

1 Magnetic field around a current carring conductor can be detected using compass when current flow through it. Magnetic field generated around conductor and such magnetic field can be detected through compass. Deflection was minute.

2 Effect of no of turns may produce magnetic field and we can use compass for detecting magnetic field. This time deflection was more as compared to case 1

3 When we kept the compass near a coil without core. It's magnetic field was weak because, of small deflection of plate / needle.

4 when we insert a core in coil and provide Voltage. Hence after energizing. The coil produce magnetic field and detected

by compass. Strong magnetic field as compared to case 3.

5 RESIDUAL MAGNETISM :-

It is the magnetization left behind in ferromagnetic material after an external magnetic field source is removed.

→ LAB # 02

Introduction to different parts of DC machine

→ MAIN SYSTEM :-

We have two main systems.

1) Field system (Stationary part)
2) Armature System (Rotatory part)

1 FIELD SYSTEM :-

The main purpose of this system is to generate magnetic field. This system is further divided as:

a) YOKE :-

It is the external covering of machine. It strengthen the magnetic field also provide support and protection to the other components.

b) POLE :-

The main component of DC machine is pole. It has the stationary windings wounded. It has two parts :-

i) POLE CORE :-

It acts as a core for stationary

windings and thus strengthen the magnetic field.

ii) POLE SHOE :-

It is an arc type, its main purpose is that it provides low resistance air and also covers maximum area

2 ARMATURE SYSTEM :-

It is also called rotatory system. It consists of :-

i ARMATURE CORE :-

It provides a path of very low reluctance to the flux through armature from N to S-pole.

ii ARMATURE WINDING :-

Two types of windings are used :-

① Lap winding ② wave winding

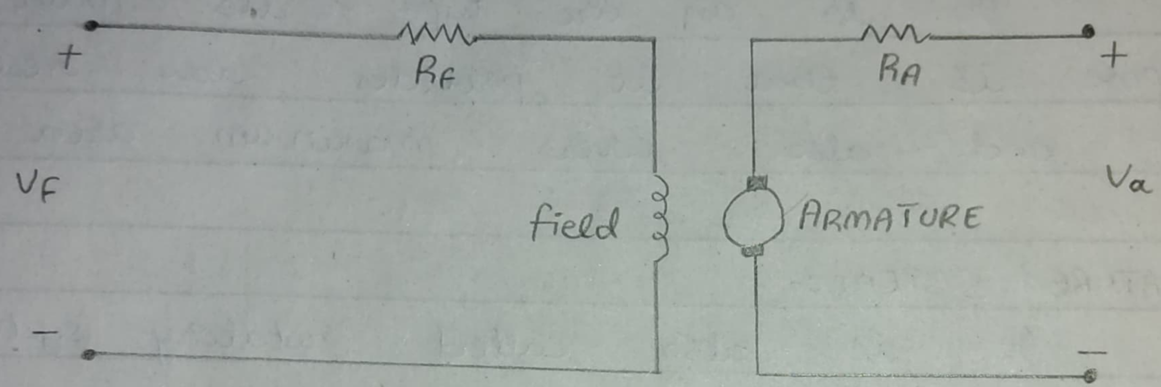
iii COMMUTATOR :-

It is a mechanical rectifier and consists of split rings.

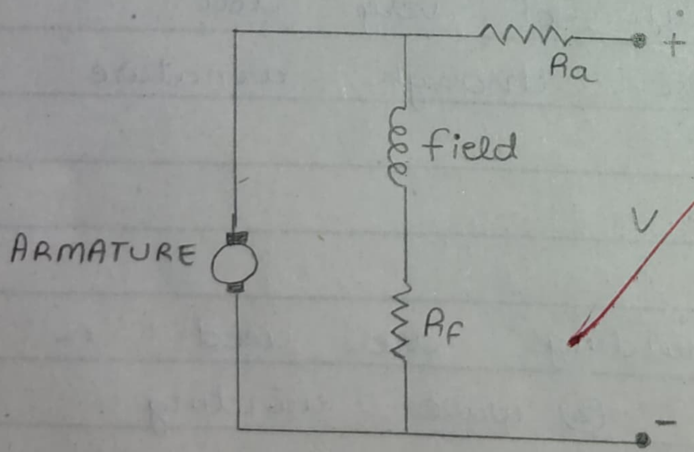
iv CARBON BRUSHES :-

They are used for electrical connections.

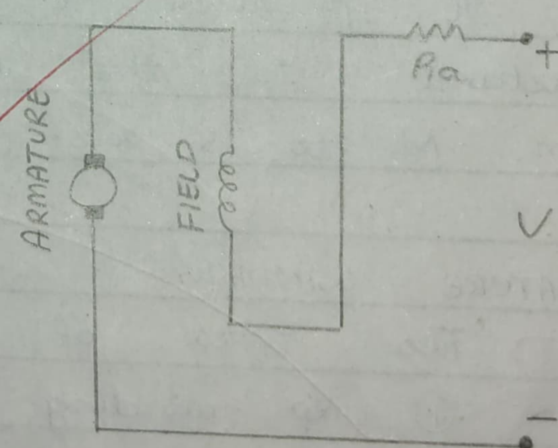
SEPARATLY EXCITED DC MACHINE



DC SHUNT WOUND



DC SERIES WOUND



LAB # 03

Terminal designation circuit diagram and connections of :

1- Separately exited DC machine
2- Self excited DC machine.
   a) DC series wound
   b) DC shunt wound
3- Compound wound
   a) long shunt
   b) short shunt
4- universal motors

1- SEPARATELY EXITED DC MACHINE :-

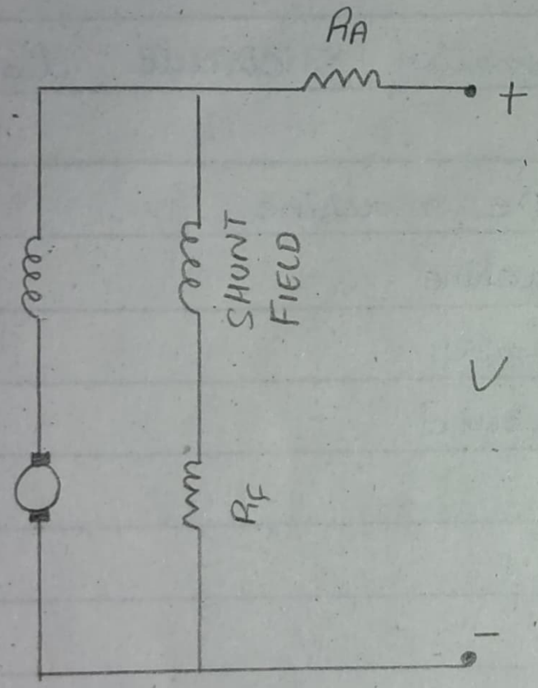
In separately excited DC machine there is two separate supplies to armature and field system. We can reverse the motion of armature by changing polarities of either the armature or field system. In case of generation the field winding and armature is electrically isolated.

2- SELF EXCITED DC MACHINE :-

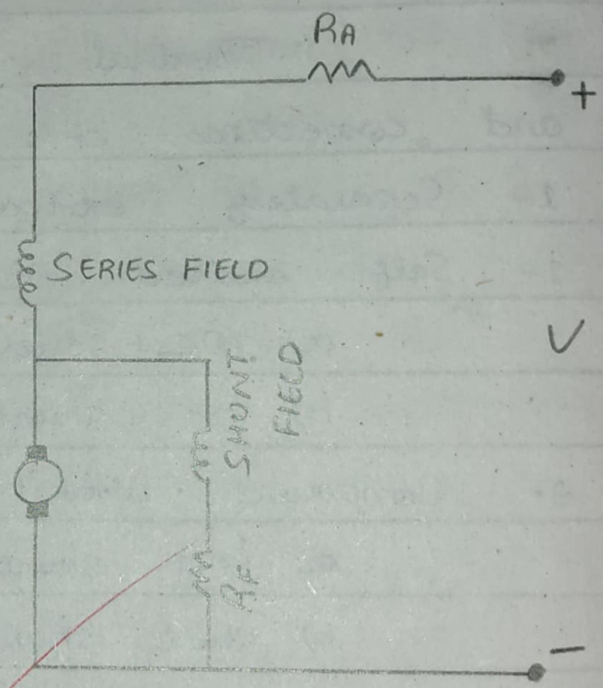
In self excited DC machine there is same voltage source for field and armature.

It has two arrangment types :-

(P.T.O)



LONG SHUNT



SHORT SHUNT

a) DC series Wound :-

The speed regulation of DC series wound is not good and its Stationary torque is high.

b) DC Shunt wound :-

Its speed regulation is good but its Stationary torque is low.

3 COMPOUND WOUND :-

This kind of Connection have both quality of DC series and DC shunt wound, it have good speed regulation and high Stationary torque. They are of two types :-

a) Long shunt motor :-

In such arrangement, field windings are connected in parallel with compination of armature of series resistance.

b) Short shunt motor :-

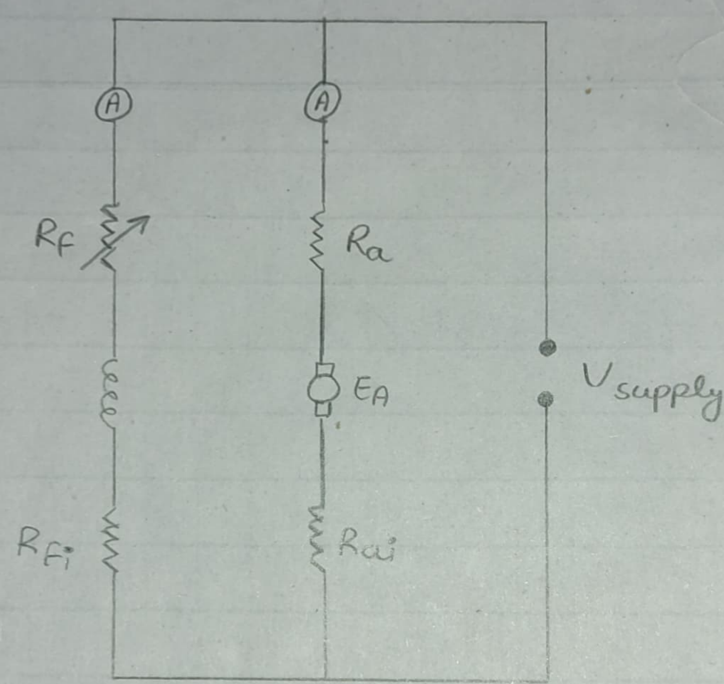
In this motor, field windings are parallel to the armature and not to the series resistance.

(P.T.O)

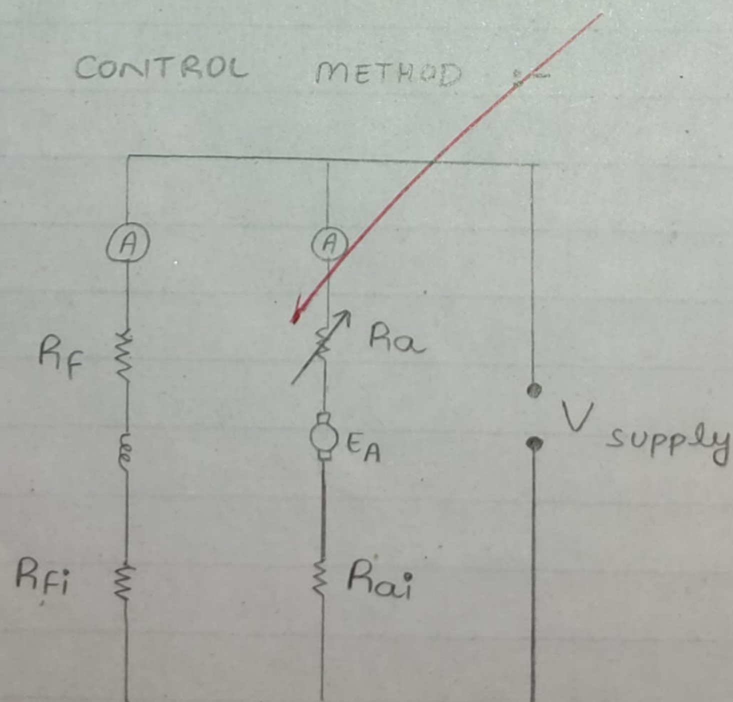
4- UNIVERSAL MOTOR :-

It is a special type of motor which is designed to run on either DC or single phase AC.

1) FIELD CONTROL METHOD :-



2) ARMATURE CONTROL METHOD :-



LAB # 04

To study Speed Control of DC shunt motor:

1) Using field control method
2) using armature control method

1 USING FIELD CONTROL METHOD :-

In this method, resistor is connected in series with field winding. As we know that : $N \propto \frac{E_b}{\phi}$.

when resistance increases, flux decreases and ultimately speed of motor increases. This speed control is used in applications where high speed is required generally speed increases 3 to 4 times.

2 USING ARMATURE CONTROL :-

In this method, variable resistor is connected in series with armature. As a result, Ra increase so ratio of IaRa will also increase then by formula

$$N \propto \frac{V - I_a R_a}{\phi}$$

when IaRa increase, speed decrease because V-IaRa decreases.

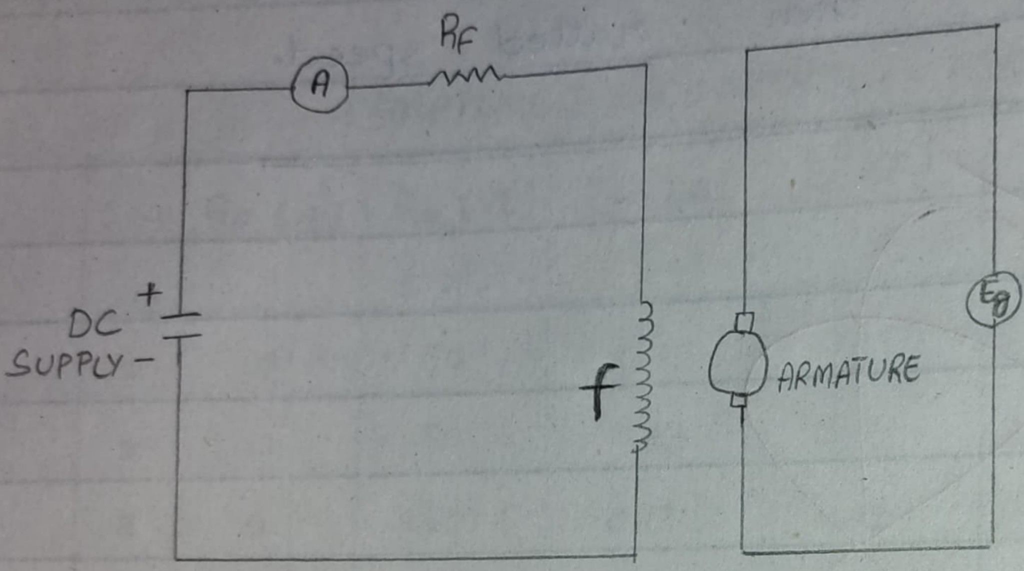
ARMATURE CONTROL METHOD

S.NO	R_f (Ω)	R_a (Ω)	I_f (A)	I_a (A)	N (rpm)
1	0	10	0.13	0.15	2400
2	0	50	0.13	0.14	2300
3	0	150	0.13	0.14	2100
4	0	5000	0.13	0.13	1400
5	0	1000	0.13	0.12	1000

FIELD CONTROL METHOD

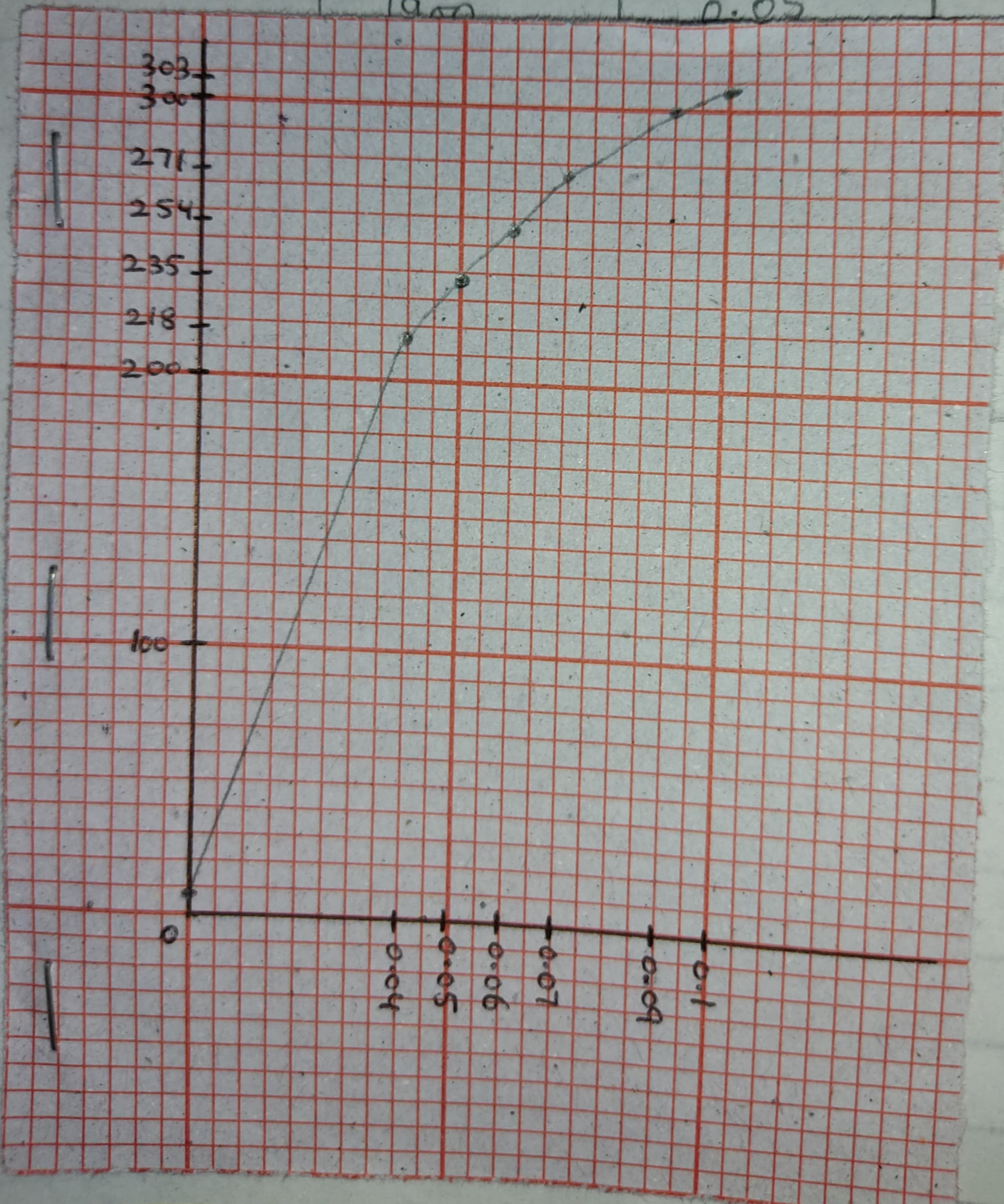
S.No	R_f (Ω)	R_a (Ω)	I_f (A)	I_a (Ω)	N (rpm)
1	0	0	0.13	0.15	2500
2	400	0	0.11	0.15	2600
3	900	0	0.09	0.15	2800
4	1600	0	0.07	0.15	3000
5	2000	0	0.06	0.15	3200

This method is used to operate machine on low speed then ratted speed.



R_F (Ω)	I_f (Ω)	E_g (V)
2200	0	9.55
2200	0.04	218
1900	0.05	235
1400	0.06	254
900	0.07	271
400	0.09	292
100	0.1	303

	2200	0
	2200	0.04
	1900	0.05



LAB # 05

To obtain magnetization curve of Separately excited DC generator.

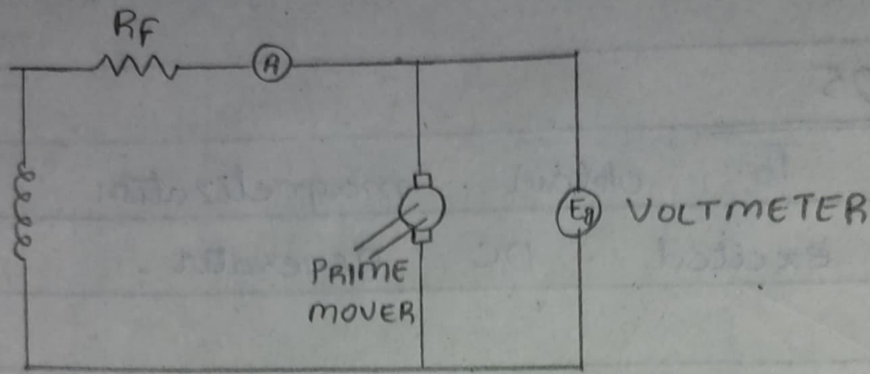
→ SEPARATELY EXCITED DC GENERATOR :-

In Separately excited DC generator we have separate supply for field and armature winding.

→ NO LOAD MAGNETIZING CURVE :-

In no load magnetizing curve we cheak the behaviour of field current and induced emf by changing the field resistance.

Graph?



E_o (V)	R_F (Ω)	I_F (A)
223	2200	0.05
260	1900	0.07
284	1400	0.09
301	900	0.1
320	400	0.14
330	100	0.16

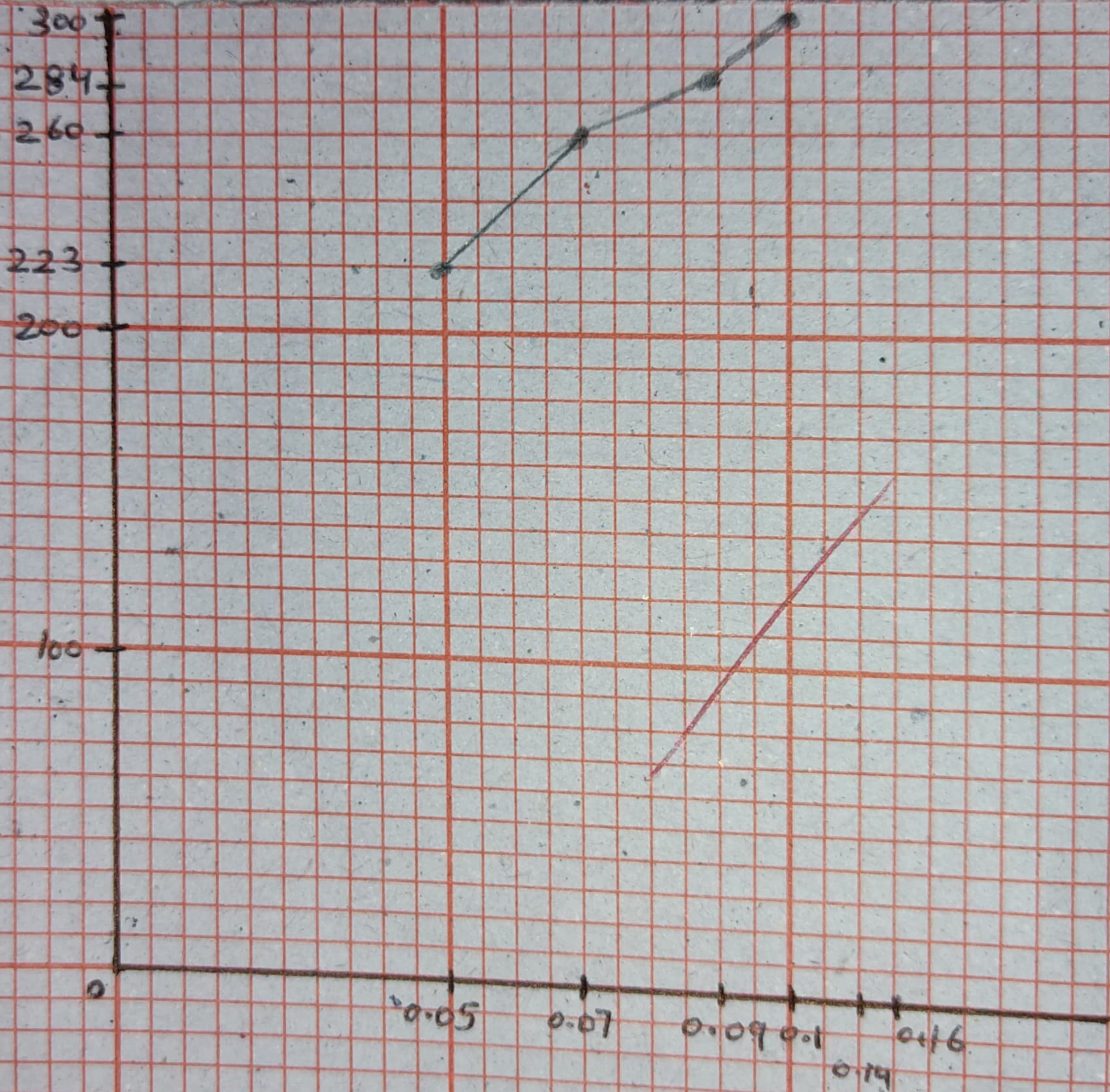
SCALE

X– Axis :

2 boxes = 0.01

Y– Axis :

1 box = 10


300
284
260
223
200
100
0
0.05
0.07
0.09
0.1
0.14
0.16

LAB # 06

To obtain no load magnetization curve of self excited DC generator

→ APPARATUS :-

→ Two DC motors → Ammeter

→ Voltmeter → Connecting leads

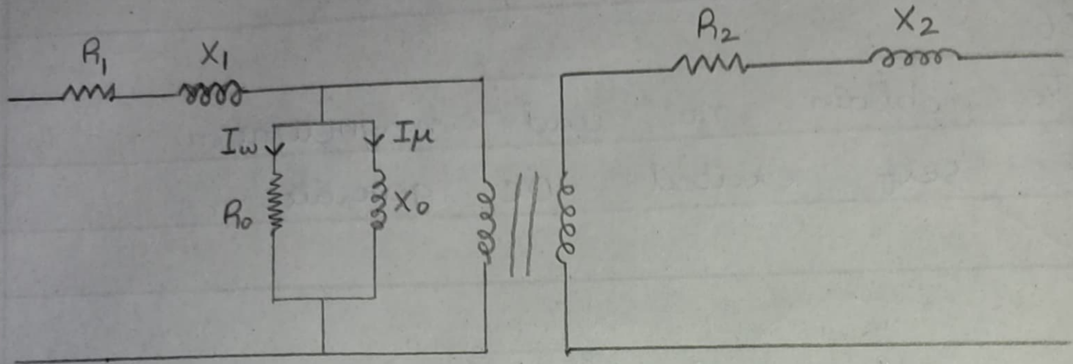
→ THEORY :-

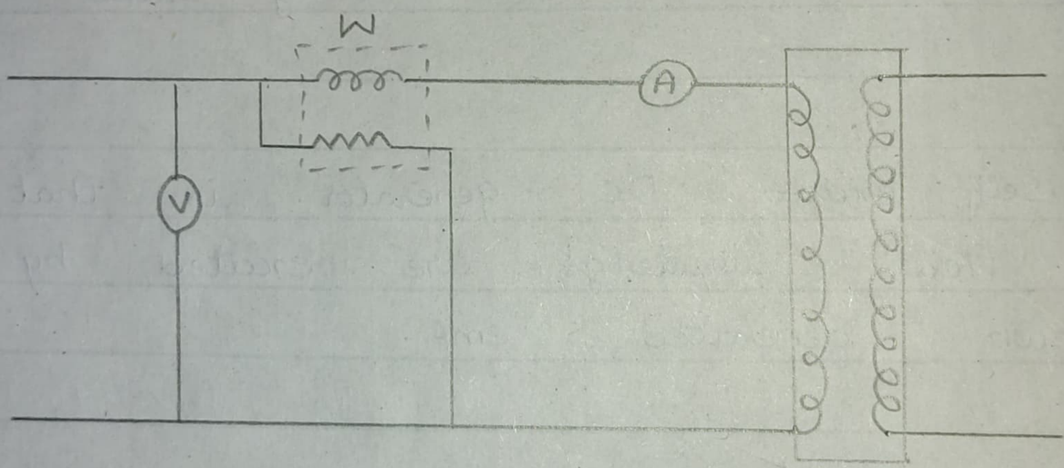
Self excited DC generator is that whose field windings are excited by it's own generated emf.

→ PROCEDURE :-

* Make connections according to the circuit diagram.
* Now change the resistance of field windings external resistance in decreasing sense.
* Note the voltmeter and ammeter readings
* Observe the relation between I_g and E_g due to self excitation.

OPEN CIRCUIT TEST





$W = VI \cos\phi$ $\cos\phi = \frac{W}{VI}$ $\phi = \cos^{-1}\left(\frac{W}{VI}\right)$

$I_\mu = I \sin\phi$ $I_W = I \cos\phi$

$X_0 = \frac{V}{I_\mu}$ $R_0 = \frac{V}{I_W}$

$V = 235V$ $P = 5W$ $I = 40mA$

→ LAB # 07

Open circuit and short circuit test for single phase transformers

→ OPEN CIRCUIT TEST

This method is used to determine core losses. when the transformer is on no load, the primary input current is not wholly reactive. The primary current under no load has to supply i) Iron losses in core ii) negligible copper loss in primary. Hence no load primary current is not at 90° phase difference. So primary current has two components, I_w and I_μ.

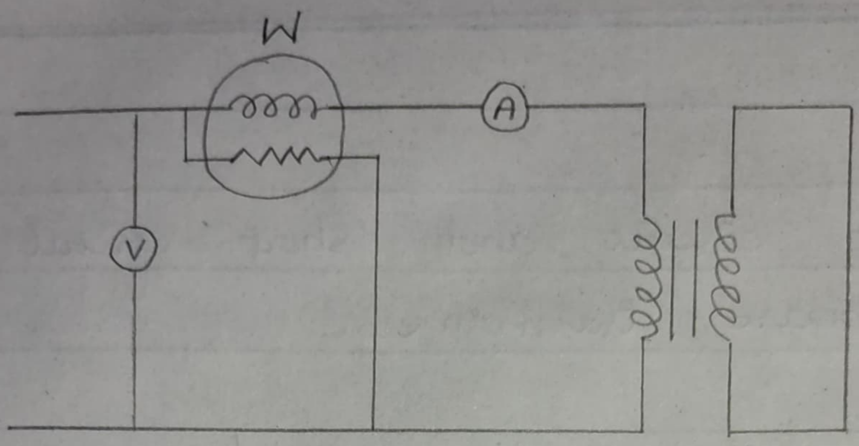
$$I_w = I_o \cos \theta_o$$

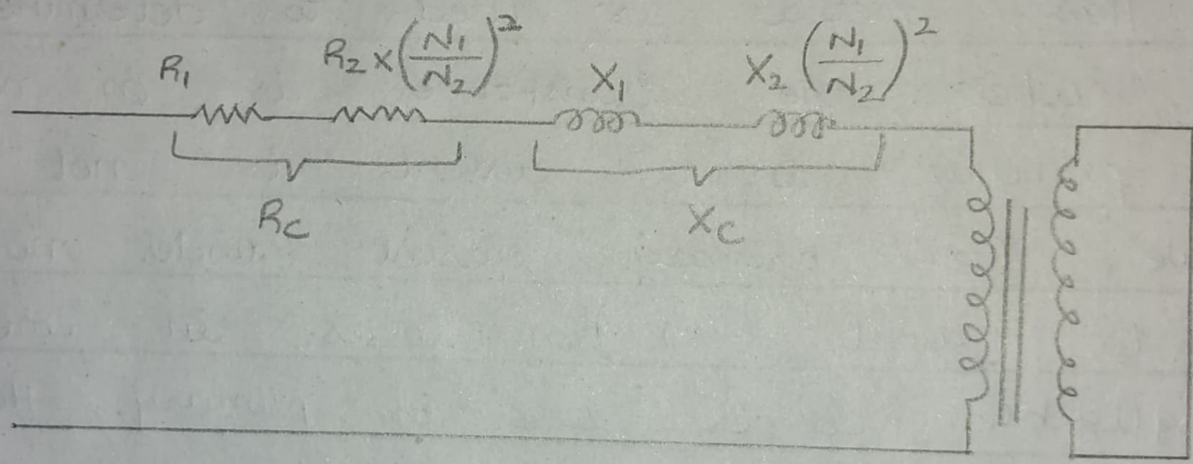
$$I_\mu = I_o \sin \theta_o$$

→ SHORT CIRCUIT TEST

This method is used to determine copper losses or equivalent impedence. In this test, one winding, usually low voltage winding is solidly short circuited and low voltage (5-10) % of normal primary Voltage at correct frequency is applied at primary voltage at correct frequency is applied at primary side and is increased Since

SHORT CIRCUIT TEST





$W = I^2 R_c$

$$R_c = \frac{W}{I^2}$$

$$Z_c = \frac{V}{I}$$

$$X_c = \sqrt{Z_c^2 - R_c^2}$$

$I = 1A$ $V = 55V$ $P = 42W$

full load current starts flowing in both primary and secondary.

→ PROCEDURE :-

- Make connections for open circuit and connect voltmeter, ammeter and wattmeter on primary side.
- Turn ON the power.

Note down the readings and then turn OFF the power again.

- Now make connections for short circuit.
- Turn ON the power and note down the readings.

LAB # 08

Introduction to Induction Motor

→ **AC MACHINE :-**

Those machines which take or give alternating current are called AC machines. They are divided into two types on the basis of their principle of operation :-

1. Synchronous motor
2. Asynchronous motor

→ **ASYNCHRONOUS MOTORS :-**

It is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of stator winding. Induction motor is basically the asynchronous motor which is classified into two types :

1. Squirrel cage
2. Slip - ring

1 **SQUIRREL - CAGE MOTOR :-**

In this induction motor. rotor is basically the squirrel cage shape. It has the simplest and rigid construction. Rotor conductors are not wires but heavy bars of copper. Aluminium or alloy. These bars are placed in slots. The rotor slots are not quite parallel to the shafts but are purposely given a slight skew.

2 SLIP - RING MOTOR :-

This type of motor has rotor with 3- phase, double - layer distributed winding consisting of coils as used in alternators.

→ STRUCTURE :-

1 FRAME :-

Made of closed grained alloy cast iron.

2 STATOR AND ROTOR CORE :-

Built from high quality low-loss silicon steel laminations.

3 STATOR AND ROTOR WINDINGS :-

Have moisture roof trapical insulation embodying mica and high quality varnishes and are rigidly braced.

4 AIR GAP :-

The stator rabbets and bore are machined carefully to ensure uniformity of air gap.

5 SHAFTS AND BEARINGS :-

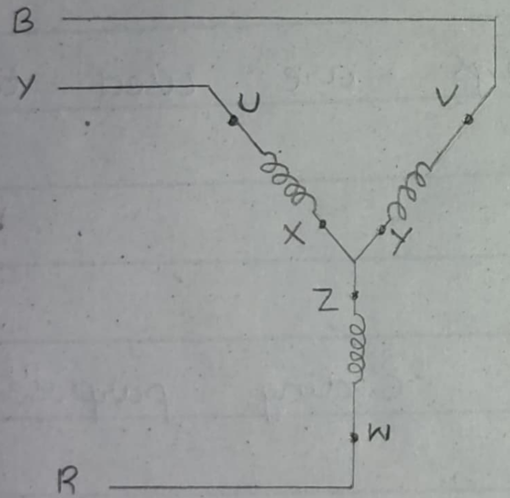
Balls and roller bearings are used to enhance service life.

6 FANS :-

light aluminium fans for cooling purpose.

7 SLIP RINGS AND SLIP RING ENCLOSURES :-

Slip rings are made of high quality phosphor - bronze and are of moulded construction.


B
Y
U
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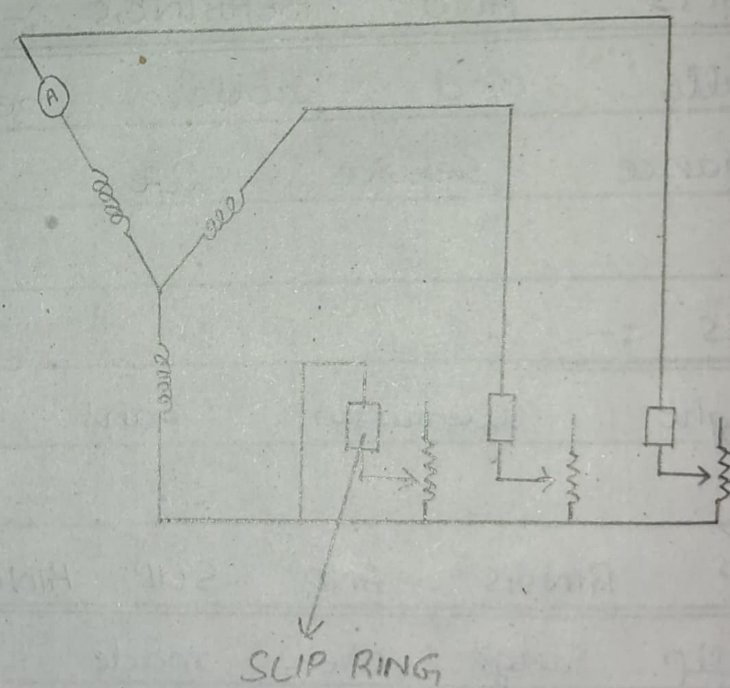
X
Y
Z
W
R


A
SLIP RING

LAB # 09

Starting of induction motor by using 3-ϕ rheostat

APPARATUS :-

- AEG
- Power supply
- Connecting leads

THEORY :-

To compensate with small resistance of conductors of rotor, 3-ϕ rheostat is used on the rotor side. The effect of this increasing resistance is to increase starting current and starting torque of stator. As $\tau \propto \phi I_2 \cos\theta_2$.

ϕ = magnetic flux

I_2 = rotor current

$\cos\theta_2$ = Power factor on rotor

PROCEDURE :-

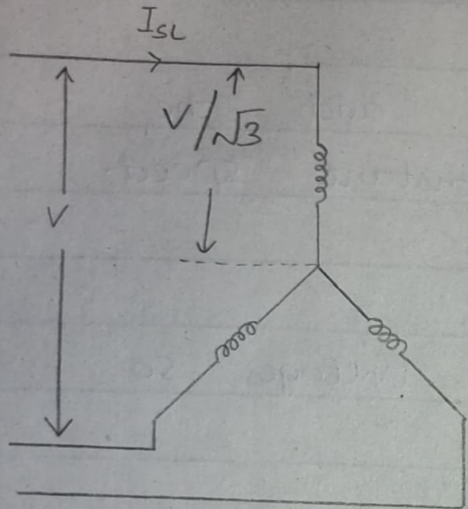
- Make connections as shown in circuit diagram.
- Now turn on power supply.
- Initially when resistance of rheostat is maximum then we observe high starting torque and maximum current on the ammeter.

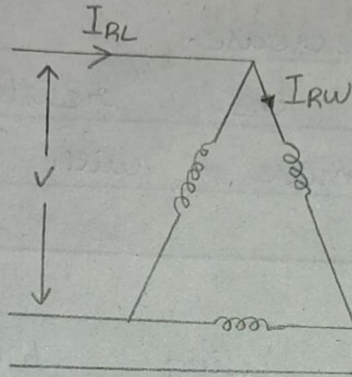
→ This is just for an instance and after that, back emf produces and current and torque decrease.

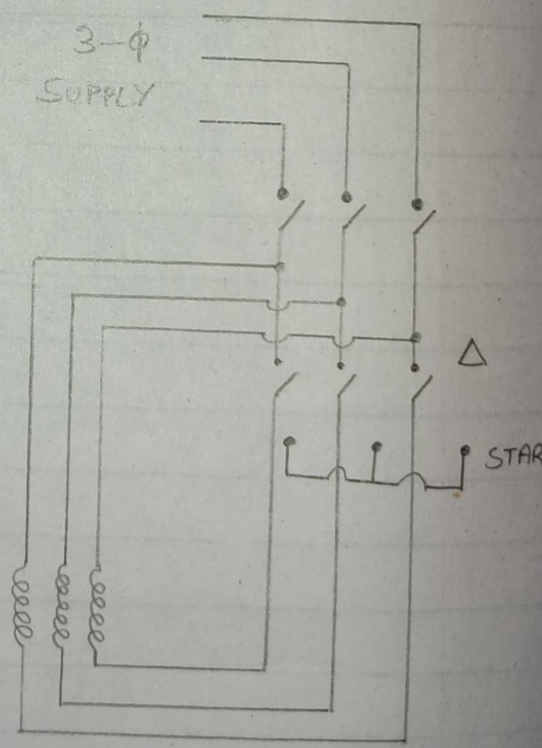
→ Now minimize the resistance and the motor will move with constant speed.

→ **PRECAUTION :-**

As we are using high voltages so care should be takken.







$\rightarrow \frac{I_{st}}{phase} = \frac{I_{st}}{line} = \frac{V}{\sqrt{3}\,Z}$

$\rightarrow I_{st} = \frac{1}{\sqrt{3}} I_{RW}$

$= \frac{I_{RL}}{3}$

$= 0.12\ A$

$I_{RW} = \frac{V}{Z}$

$I_{RL} = \sqrt{3}\,\frac{V}{Z}$

$= \sqrt{3}\, I_{RW}$

$I_{RL} = 0.36\ A$

LAB # 10

To start an induction motor by Y– Δ Starting method

APPARATUS :-

- Induction motor
- Ammeter
- Voltmeter
- Y– Δ switch
- Connecting leads
- 3-ϕ supply

THEORY :-

As Squirrel – cage motor has no system for external rheostat on rotor side so we use Y– Δ Starting method for this for safe start on stator side. In this Y– Δ switch is used to first connect system in Y and then Δ.

PROCEDURE :-

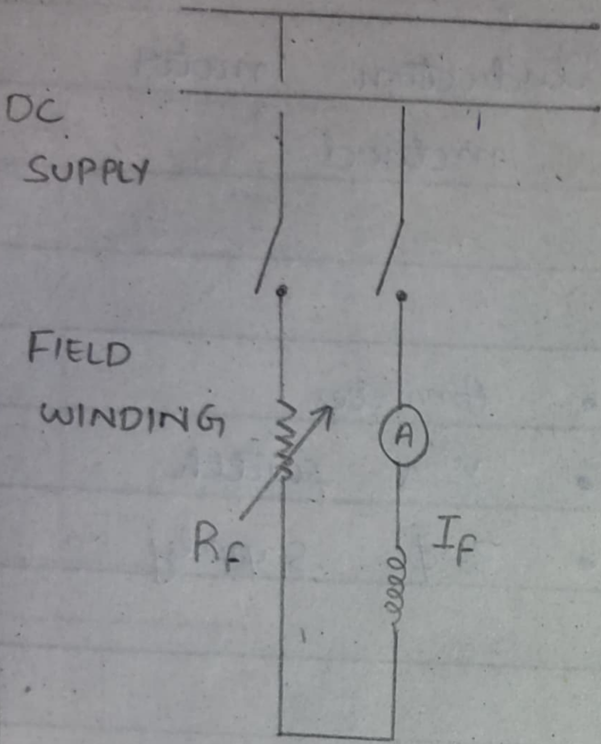
→ Make connections according to the diagram.

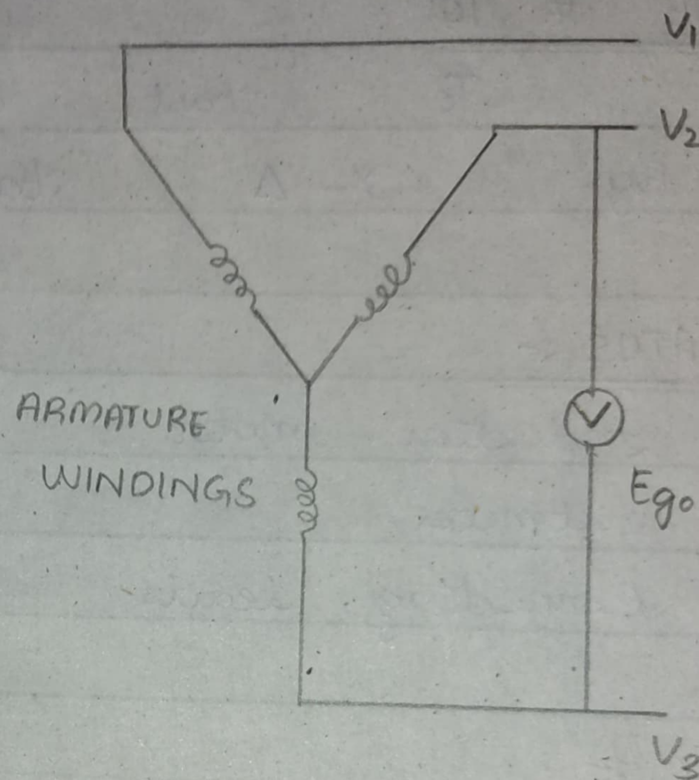
→ First, Y– Δ switch is on Y point to provide Y– Connection at the start.

→ Note I_{SL} and V_{SW}.

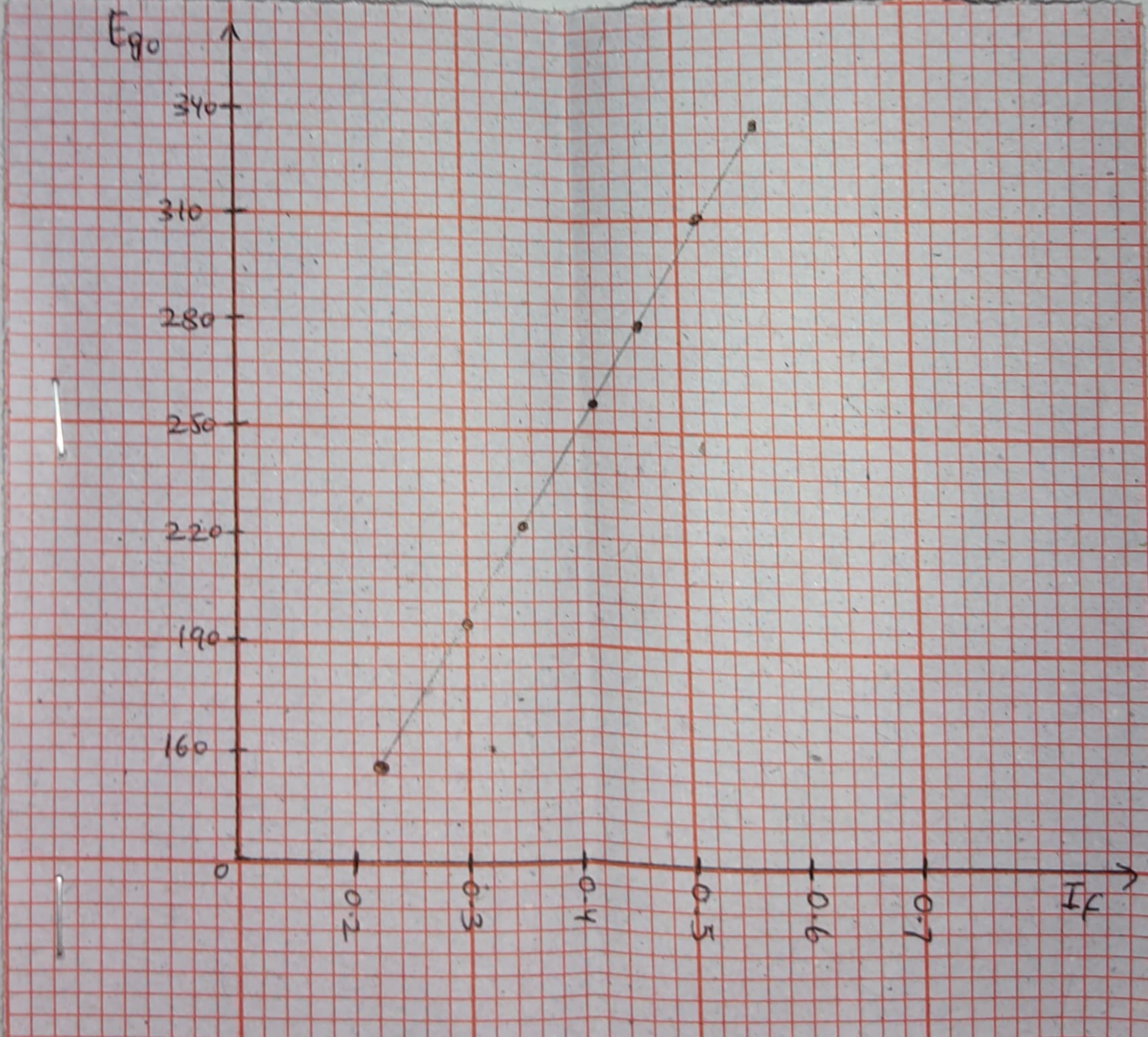
→ Now Y– Δ switch is on Δ– mode.

→ Note down the values and compare it.





I_f (A)	E_{go} (V)
0.23	161.2
0.3	202
0.35	229
0.4	260
0.45	287
0.5	314
0.55	338
0.6	362



E_{g0}
340
310
280
250
220
190
160
0
0.2
0.3
0.4
0.5
0.6
0.7
I_f

LAB # 11

To obtain No load magnetization curve of Synchronous generator

APPARATUS :-

- AEG
- Induction motor
- Synchronous generator
- Ammeter
- Connecting leads
- Voltmeter

THEORY :-

Synchronous machines are those machines which give synchronous frequency or speed. These motors and generators are a major source of commercial energy. DC supply is given to rotor which act as field windings and generated voltage is drawn from stator winding which act as armature winding.

PROCEDURE :-

→ Make connections according to the circuit diagram.

→ Initially R_f is maximum but we will observe the induced emf.

→ Now decrease R_f so I_f increase and hence induced emf will also increase.

→ As you further decrease R_f step by step then you will observe an increase in induced emf (E_{g0}).

→ Note down the readings and draw the graph.