DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 1

TITLE OF THE EXPERIMENT : "NO LOAD, SHORT CIRCUIT AND LOAD TESTS ON SINGLE PHASE TRANSFORMER"

Object : (1) To perform tests to determine the equivalent circuit parameters and

(2) to perform load test at unity power factor on a single phase transformer.

Reference : M.G. SAY, "PERFORMANCE AND DESIGN OF A.C. MACHINES". PP. 109

TRANSFORMER UNDER TEST :

Primary voltage (V_P) : _____, Secondary voltage (V_S) : _____

Voltampere (VA) : _____, Phase : _____ Frequency : 50 Hz

Apparatus used :

Sl. No.	Item	Range	Lab No.
1.	Ammeter	0-1A	MIA
2.	Ammeter	0-5A	MIA
3.	Ammeter	0-10A	MIA
4.	Voltmeter	0-15-150-300V	MIV
5.	Wattmeter	250V. 1A, L.P.F.	W
6.	Wattmeter	250V. 5A, U.P.F.	W
7.	Variae	1-Phase, _____V, _____A, 50Hz	VAR

Procedure :

1. **OPEN CIRCUIT TEST :** With the L.V. side open, supply the primary winding from a single phase auto transformer (variac) through an ammeter (0-1A) and L.P.F. wattmeter as per FIGURE-1; Vary the primary voltage upto the rated value in 4 steps and measure the primary current, power input, voltage impressed and secondary voltage. Record readings in **TABLE-1**.

2. **SHORT CIRCUIT TEST :** Short the L.V. winding terminals through an ammeter (0-10A) as per FIGURE-2. Change the ammeter and wattmeter in the primary side. Increase the impressed gradually from zero value in two steps such that 11% of rated current flows in the H.V. windings. Record input power, primary current, voltage and the secondary current. Insert readings in **TABLE-2.**

3. **LOAD TEST :** Connect the load on the secondary side as per FIGURE-3 Adjust the variac so that rated voltage is impressed across the primary. Note the primary voltage, current, input power and secondary voltage. Load the transformer by putting on the load switches and take the readings as per **TABLE-3** in 5 steps.

NOTE : The primary voltage should be kept constant throughout the load test

Report :

1) Calculate the parameters of the approximate equivalent circuit of the transformer.
2) Plot curves showing no-load current and no-load power against no-load voltage.
3) Plot the efficiency versus load curve.
4) Plot regulation versus load curve.
5) Calculate theoretical efficiency and regulation of the transformer at full load unity power factor from the equivalent circuit parameters compare the values with test results. Give the values in the table.

DATA SHEET

"NO LOAD, SHORT CIRCUIT"

Name : _____ **Roll No. :** _____

Date : _____

OPEN CIRCUIT TEST (TABLE-1) :

No. of Obvs.	Primary Voltage (V_1)	Primary Current (I)	Power Input (P = Red. X M_f)	Secondary Voltage (V_2)	Voltage Ratio (V_1/V_2)
1					
2					
3					
4					
5					

SHORT CIRCUIT TEST (TABLE-2) :

No. of Obvs.	Primary Voltage (V_1)	Primary Current (I)	Power Input	Secondary Current
1.				
2.				
3.				

LOAD TEST (TABLE-3) :

No. of Obvs.	Primary Voltage (V_1)	Primary Current (I_1)	Power Input	Secondary Current (I_2)	Secondary Voltage (V_2)	Power Output	Efficiency	Regulation
1								
2								
3								
4								
5								

* For the load corresponding to the test reading in the table.

_____

Signature of the teacher

CIRCUIT DIAGRAM

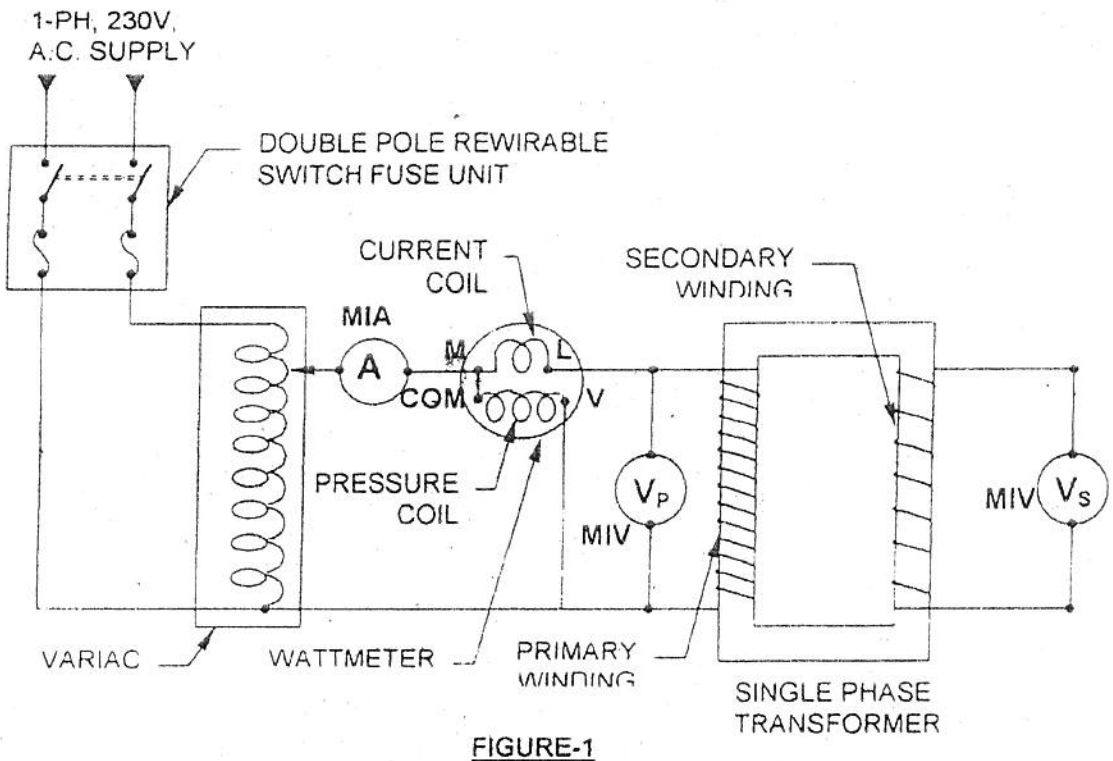

FIGURE-1
OPEN CIRCUIT TEST

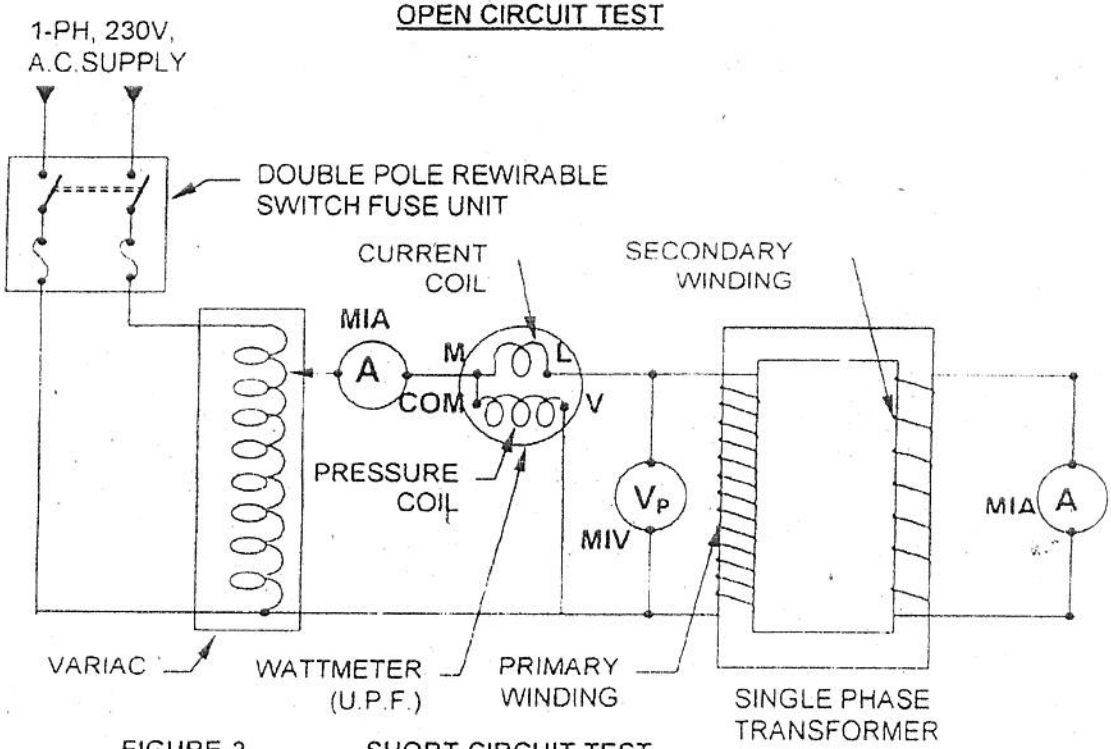

FIGURE-2 SHORT CIRCUIT TEST

CIRCUIT DIAGRAM

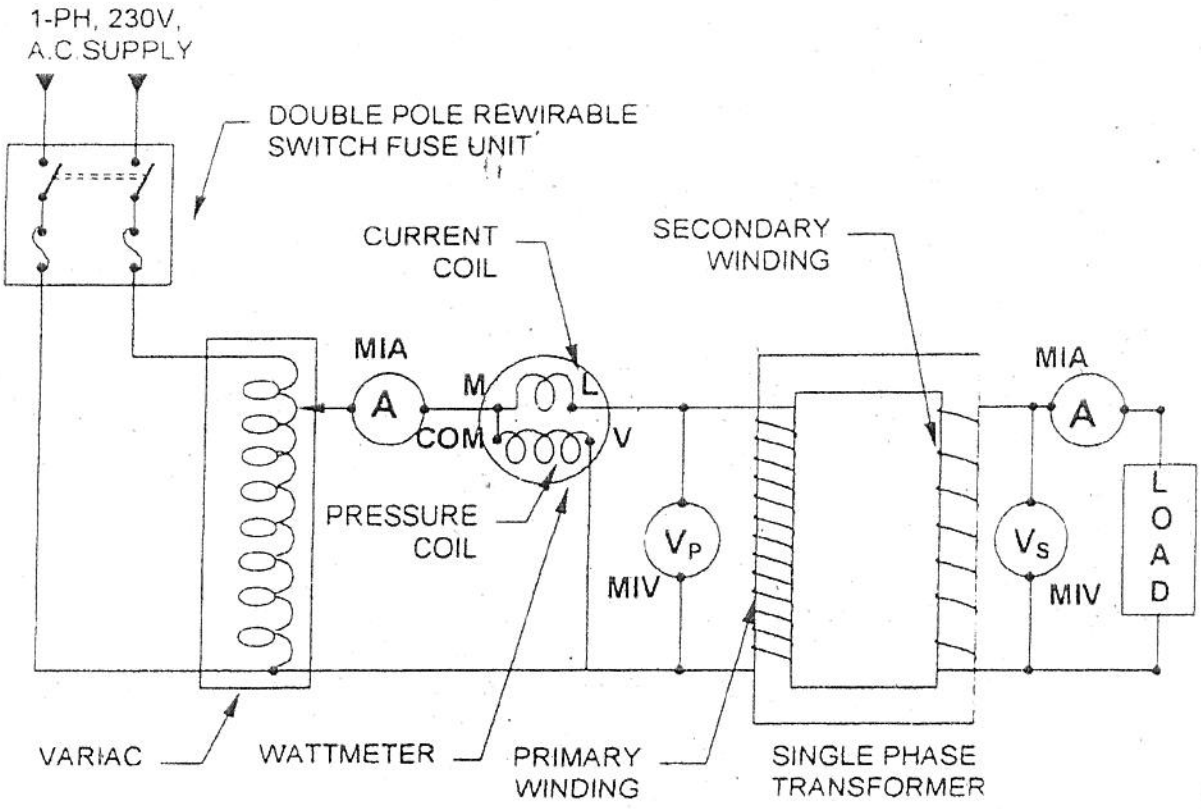

FIGURE-3

LOAD TEST

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Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 2

***TITLE OF THE EXPERIMENT* : "POLARITY TEST AND CONNECTIONS OF THREE TRANSFORMERS"**

Object : (1) To make polarities on the winding terminals of single phase transformer by (a) D.C. Kick test and (b) Polarity test (A. C. Method)

(ii) To connect three single-phase transformers in (a) delta/star (b) Star/star (c) Star/delta and (d) delta/delta.

SET UNDER TEST : Three similar single-phase transformers each rated : 1kVA, 220/110V, 50Hz.

Procedure : [For object 1(a) D.C. Kick test]

1. Take one of the three transformers.
2. Connect the low voltage d.c.source to the primary winding through the switch "s" such that the positive terminal of the voltage source is connected to the terminal of the voltage source is connected to the terminal (say) A1 of the primary winding as shown in the figure-1 and positive terminal of the voltmeter is connected to the terminal (say) a1 of the secondary winding as shown in the figure-1.
3. Suddenly close the switch and open the switch and each time note the instantaneous deflection of the pointer of the voltmeter. If the deflection is positive when the switch is closed and negative when the switch is opened, terminals A1 and a1 are of same polarity. And if the deflection is negative, when the switch is closed and positive when the switch is opened, terminals A1 and a1 are of opposite polarity.
4. Make polarities on the secondary winding terminals w.r.t. the polarities, marked on the terminals of primary winding.
5. Repeating the same procedure, mark polarities on the winding terminals of other two transformers.

Procedure : For object 1b Polarity test (a.c. Method)

1. Take one of the three transformers.
2. Connect the primary and secondary windings as shown in figure-1.
3. Mark polarities arbitrarily on its primary winding terminals.
4. Switch on single-phase a.c. supplies to its primary winding and measure voltages across primary winding (A-B) secondary winding (a-b) and A-a.

If the voltage across A-a is equal to the sum of the voltages across A-B and a-b, the terminals 'A' and 'a' are of 'OPPOSITE' polarity. If it is equal to the difference of the voltages across A-B and a-b, the terminals w.r.t. the polarities, marked on the terminals of primary winding.

5. Mark polarities on the secondary winding terminals w.r.t. the polarities, marked on the terminals of primary winding.
6. Repeat the same procedure, mark polarities on the winding terminals of other two transformers.

Procedure : [For object (ii) 'CONNECTION']

1. Using proper sequence connect the three transformers in delta/star (shown in figure-1) switch on the three phase 230V a.c. supply to the primary and measure line and phase voltages of primary and secondary. Note them in the **DATA SHEET** given.
2. Repeat the same procedure connecting the three transformers in star/star, star/delta and delta/delta one by one and note the readings in the **DATA SHEET**. In case of star/delta and delta/delta connections, before closing the delta of the secondary windings, measure the voltage between the closing point 'a' and 'b' (figure-4) of the secondary windings to be sure that the voltage is zero. (Why?)

Report : Draw Connection Diagrams and Phasor Diagrams of induced voltages for all types of connection.

CIRCUIT DIAGRAM
FOR POLARITY TEST OF TRANSFORMERS

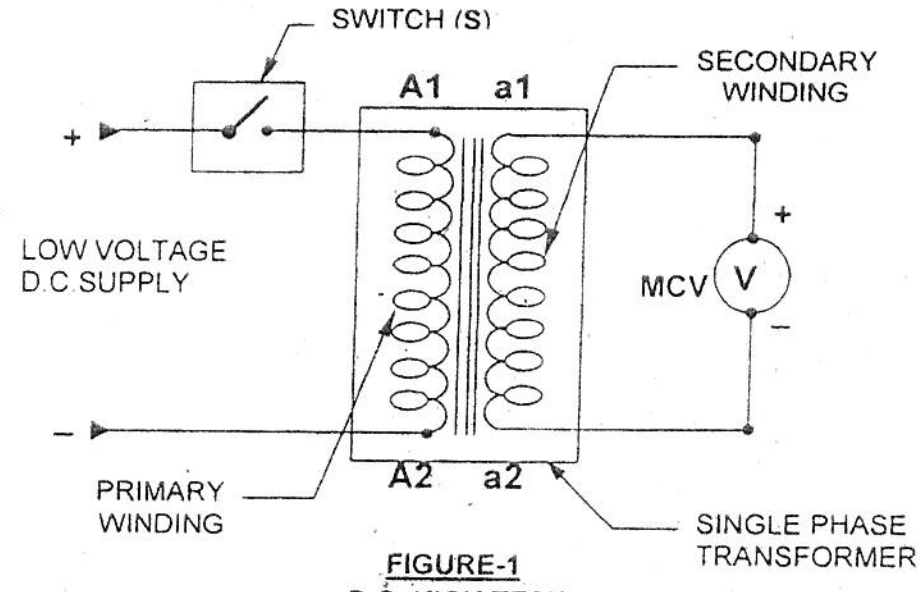


FIGURE-1
D.C. KICK TEST

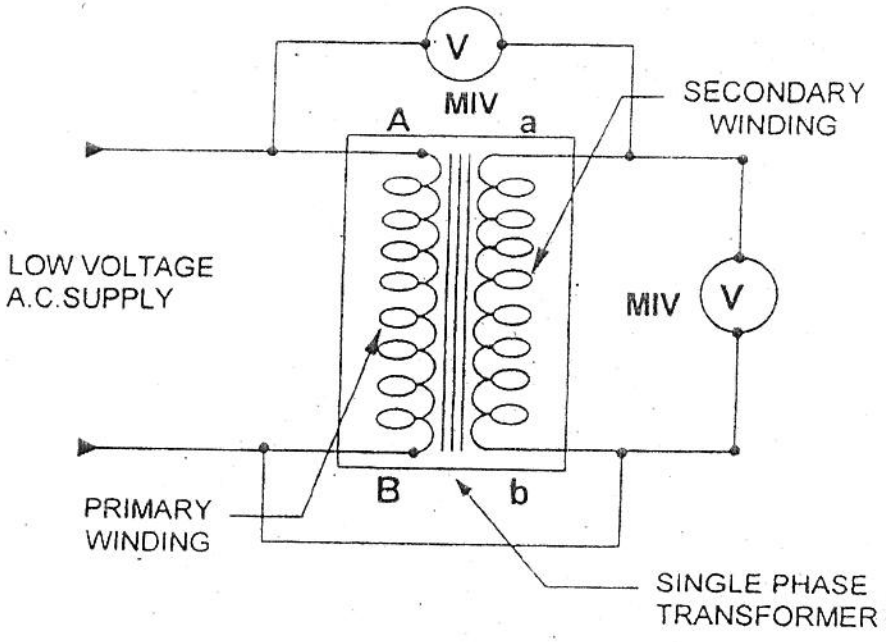


FIGURE-2

A.C METHOD

CIRCUIT DIAGRAM
FOR THREE PHASE CONNECTIONS OF TRANSFORMERS

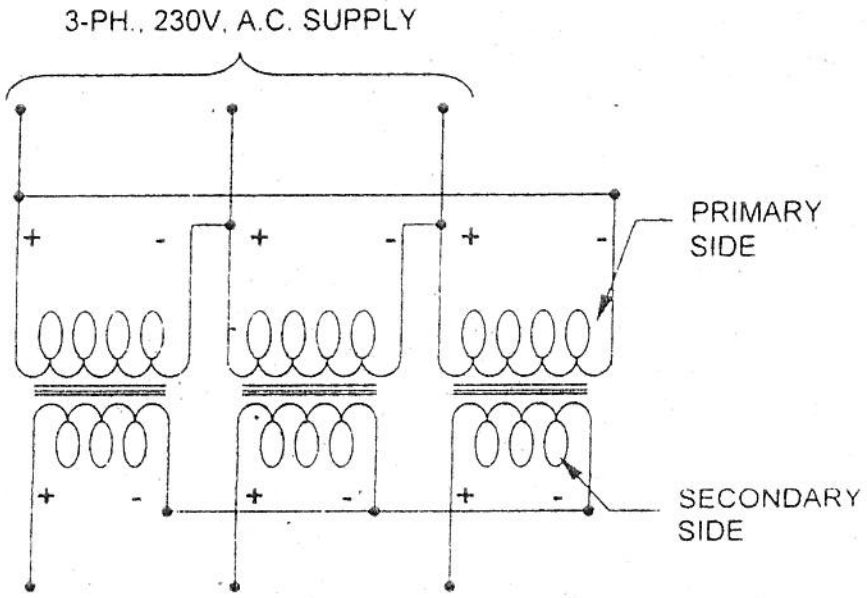


FIGURE-3
DELTA/STAR CONNECTION

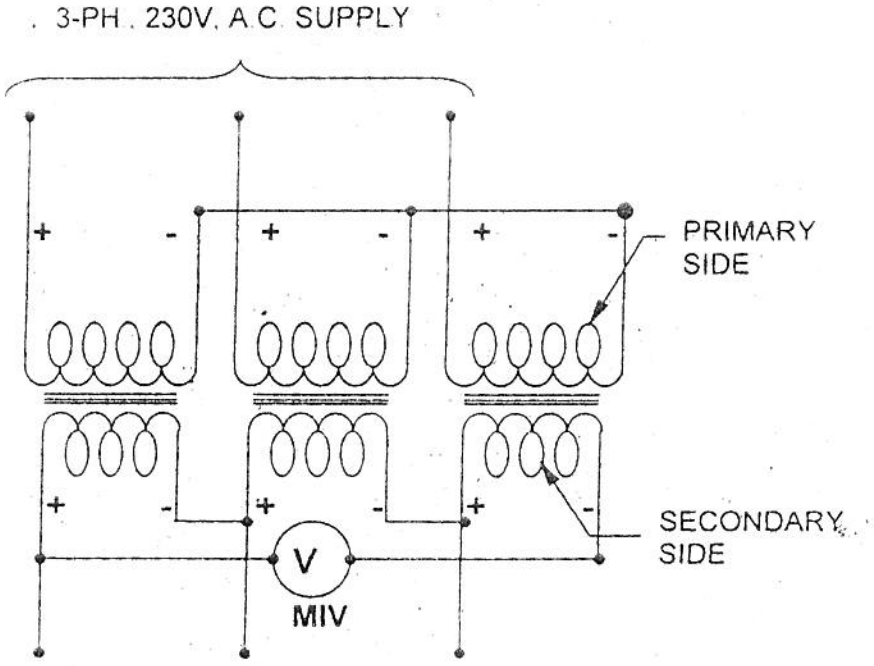


FIGURE-4

STAR/DELTA CONNECTION

DATA - SHEET

THREE PHASE CONNECTIONS OF TRANSFORMERS

Name : _____ **Roll No.** _____

Date _____

M/c. under test : Volts : KVA : amps :

Apparatus used :

Sl. No.	Item	Range	Maker's Name	Lab No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				

Observations :

Type of Connection	Primary Voltage		Secondary Voltage		Voltage Ratio
	Line	Phase	Line	Phase	
Delta / Star					
Star / Star					
Star / Delta					
Delta / Delta					

_____

(Signature of the teacher)

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 3

Title of the Experiment : "Starting and speed control of D.C. Shunt motor"

Object : To acquire a practical knowledge of the procedures & precautions involved in starting, reversing & controlling of the speed a d.c. shunt motor.

Procedure:

Using 3- point starter.

Connect the motor as shown in fig.

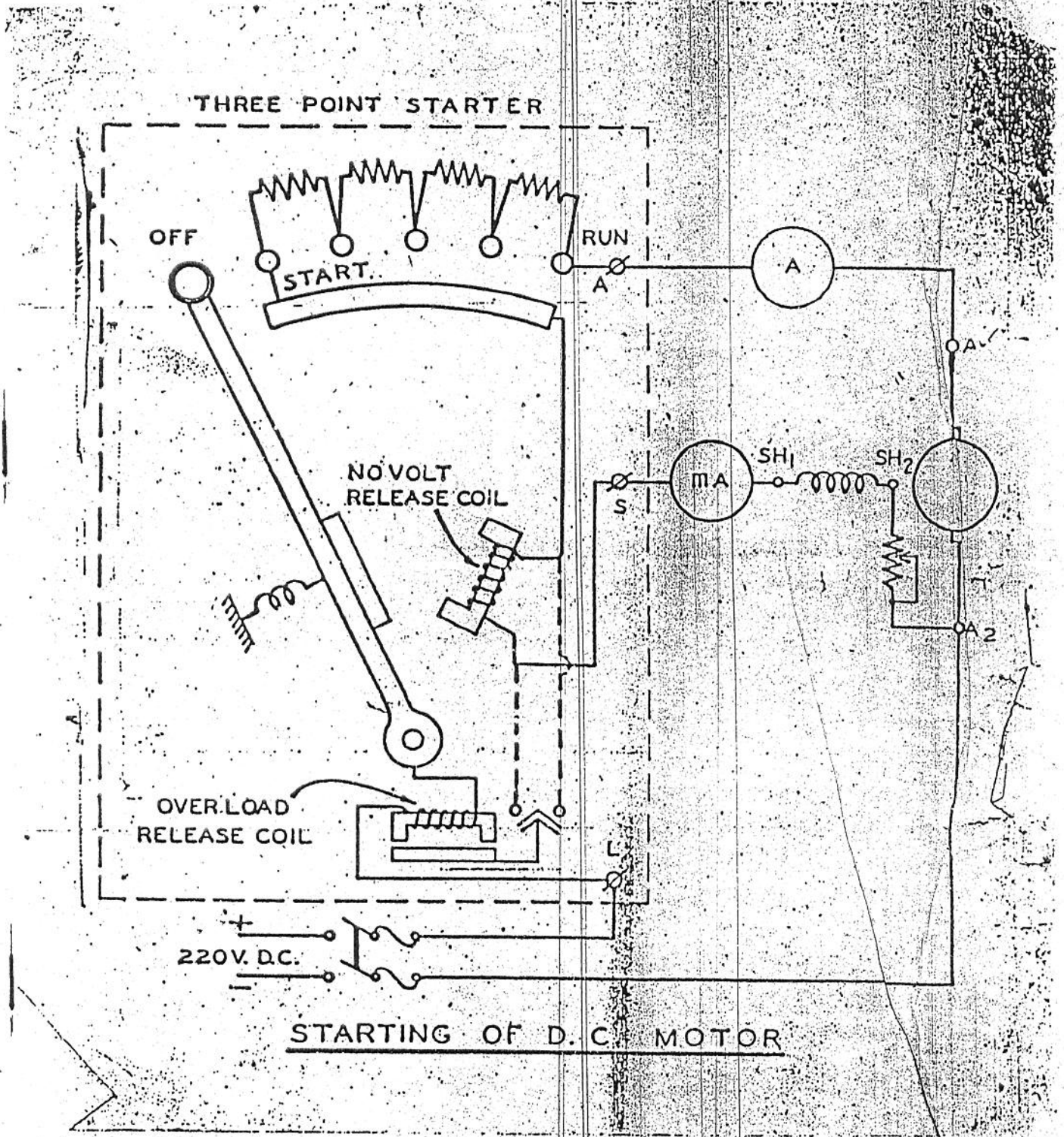
Experimental data:

For 3-point starter

Particulars	Starter handle position	Armature current	Field current	Supply voltage	Speed
Field Rheostat in minimum position	At start				
	At run				

Reversing direction of Rotation

Particulars	Direction of Rotation
Connect as in fig-2	
Reverse field winding terminals only	
Reverse armature winding terminals only	
Reverse both armature &field winding terminals	



STARTING OF D. C. MOTOR

DEPARTMENT OF ELECTRICAL ENGINEERING
BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

Electrical Machine- I Lab. **3RD Semester EE**

Expt. No. 3

TITLE OF THE EXPERIMENT **: "STARTING SPEED CONTROL OF D.C. SHUNT MOTOR"**

Object : To study the two methods of speed control of a d.c. Shunt Motor.

a) Armature voltage control

b) Field current control

Theory : The voltage **"V"** across the armature terminals of a d.c. Shunt Motor is approximately related as :

$V = K\varnothing n$; Where, "$\varnothing$" is the flux per pole and is proportional to field current (I_f).

"n" is the speed of the motor.

"K" is a constant of the motor.

A) By varying the armature voltage (V), keeping the field current (I_f) constant, **"Speed variation from zero to about rated value can be obtained."**

B) By varying the field current (I_f), keeping armature voltage (V) constant, **"Speed variation from rated to above rated value can be obtained."**

Procedure :

1) Make connection as shown in the circuit diagram.

METHOD – A

2) With minimum resistance in the field circuit (that is maximum I_f), and the potential divider in the minimum voltage position (V = 0) switch on the d.c. 220 V mains.

3) Apply small voltage to the armature circuit and observe that the motor runs at a steady speed. Note armature voltage, speed and field current.

4) Increase V to the maximum value in 4 (four) steps and complete DATA SHEET of TABLE – 1.

METHOD – B

5) Keeping the potential divider in the maximum voltage position, decrease field current (I_f). Observe that the speed increases. Note field current (I_f). Observe that the speed increases. Note field current (I_f), speed (n) and armature voltage (V).

6) Decrease field current (I_f) in 4 (four) steps till the motor speed is about 1750 r.p.m. and complete the DATA SHEET of TABLE – 2.

Report : 1) Draw curves showing –

a) Speed (n) versus armature voltage (V), with field current (I_f) constant.

b) Speed (n) versus field current (I_f) with armature voltage (V) constant.

CIRCUIT DIAGRAM
FOR SPEED CONTROL OF D.C. SHUNT MOTOR

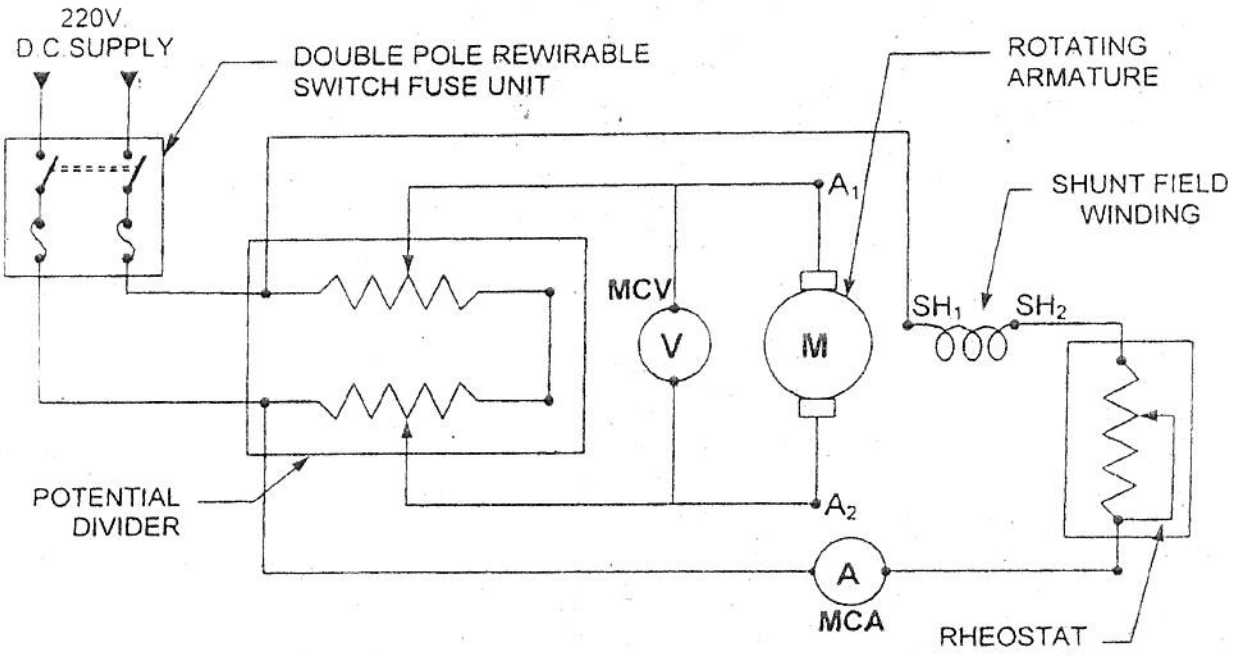


FIGURE-1

DATA SHEET

"SPEED CONTROL OF D.C. SHUNT MOTOR"

Name : _____ Roll No. : _____

Date : _____

Apparatus used :

Sl. No.	Item	Range	Lab No.
1.	Ammeter		
2.	Voltmeter		
3.	Tachometer		

Machine under test : D.C. Shunt Motor

Voltage (V) : _____, Power : _____, Current : _____

Speed : _____, Lab No. _____

Experiment Data :

No. of obvs.	Armature Voltage (V) in volts	Speed (n) In r.p.m.	Field Current (I_f) (Constant) In mA
1			
2			
3			
4			
5			
6			

TABLE – 2

No. of obvs.	Armature Voltage (V) in volts	Speed (n) In r.p.m.	Field Current (I_f) (Constant) In mA
1			
2			
3			
4			
5			
6			

_____

Signature of the teacher

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Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 4

TITLE OF THE EXPERIMENT **: "LOAD TEST ON D.C. SHUNT MOTOR BY BRAKE METHOD"**

Object : To study the variation of (i) speed (ii) input current and (iii) efficiency with power output of a D.C. Shunt motor at constant rated voltage and field excitation.

Procedure :

1. Make connection as shown in the figure.
2. With maximum resistance in the armature circuit and spring balances in fully loose condition start the D.C. Motor.
3. Gradually cut out the armature resistance and apply rated voltage to the machine. Take initial readings of the spring balances when they are in loose condition.
4. Load the motor by increasing the tension of the springs till the current reaches 25% more than its rated value. Note the value of current voltage, speed and the spring balance readings.
5. Gradually decrease the load by decreasing the tension of the springs to initial value in as many steps as possible. In each step take some readings as before and fill up the data sheet.

Report : 1. Draw curves of (i) efficiency in percent (ii) Torque (iii) Line current and (iv) speed against power output in watts.

2. Show one sample calculation

NOTE : If V = Applied voltage in Volts

I = Line currents in amperes

W1 & W2 = spring balance readings in kg

D = Diameter of the pulley in meter

T = Thickness of the belt in meter

N = Speed in r.p.m.

Load torque

$$(T) = (W_1 - W_2)\frac{(D+t)}{2}\text{kgm}$$

To calculate efficiency (η)

Power input to the motor (P_1) = V x I watts

Power output of the motor

$$(P_0) = \frac{2\pi N}{60}(W_1 - W_2)(\frac{D+t}{2})\text{kgm}$$

Efficiency

$$(\eta) = \frac{P_0}{P_1}100 = 9.81[\frac{2\pi N}{60}(W_1 - W_2)(\frac{D+t}{2})]\text{Nm/sec or Watts}$$

DATA SHEET

"LOAD TEST ON D.C. SHUNT MOTOR BY BRAKE METHOD"

Name : _____ **Roll No. :** _____

Date : _____

Apparatus used :

Sl. No.	Item	Range	Lab No.
1.	Ammeter		
2.	Voltmeter		

D.C. Shunt Motor under test :

_____ Volts, _____ Amps, _____ H.P.

r.p.m. _____ Lab No. _____

Experiment Data :

Diameter of the pulley (D) : 0.133 metre.

Thickness of the belt (t) : 0.009 metre.

No. of obvs	Applied voltage in volt	Line current in amp.	Speed in r.p.m.	Spring balance reading in kg		Torque In kg-m	Output in watts	Efficiency in %
				W1	W2			
1								
2								
3								
4								
5								

_____

Signature of the teacher

CIRCUIT DIAGRAM
FOR LOAD TEST ON D.C. SHUNT MOTOR BY BREAK METHOD

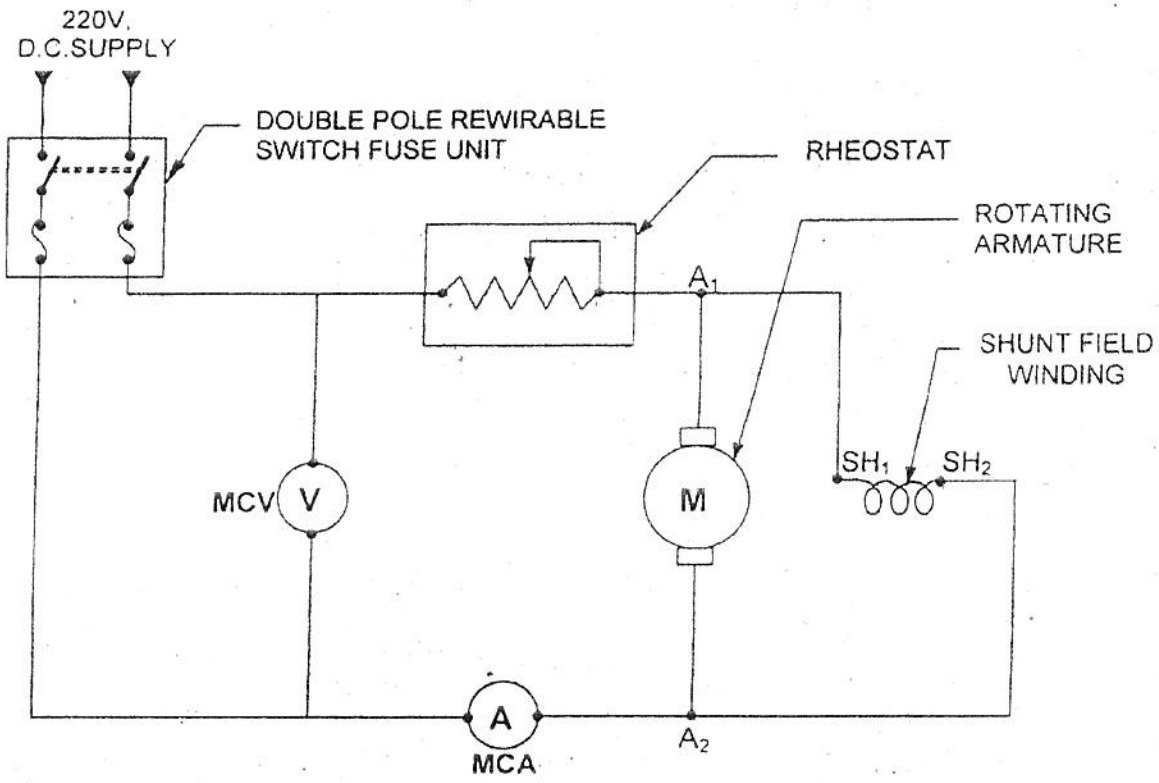


FIGURE-1

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 5

TITLE OF THE EXPERIMENT : **"LOAD TEST ON D.C. SHUNT MOTOR BY GENERATOR LOADING METHOD"**

Object : To study the nature of the variation of (i) speed (ii) torque and (iii) efficiency with power output of a D.C. Shunt motor at constant rated voltage and field excitation.

Procedure :

1. Make connection as shown in the figure.
2. Start the motor with armature rheostat (M.A.R.) in the maximum resistance position and field rheostat (M.F.R.) in the minimum resistance position.
3. Gradually out off the complete resistance of M.A.R.
4. Adjust the generator field rheostat (G.F.R.) to bring the field current to 0.12 amps. (This value should be kept constant throughout the experiment)
5. Put on the load switches and adjust M.F.R. (if necessary) to bring the motor input current to about 1.45 amps. And speed about 1425 r.p.m.; Take readings of motor input voltage, motor input current, generator output voltage, generator output current and speed.
6. Put off the load switches in steps and in each step take same set of readings as done in procedure (5). Tabulate them in the given TABLE.

Report : 1. Draw curves of

(i) efficiency in percent.

(ii) Torque,

(iii) Motor input current and

(iv) Speed against power output in h.p.

2. Show one sample calculation.

NOTE : If V_m = Motor input voltage in Volts.

I_m = Motor input current in amperes.

V_g = Generator output voltage in volts.

I_g = Generator output current in amperes.

R_g = Generator armature resistance in ohms.

N = Speed in r.p.m.

P_L = Constant losses (corresponding to speed 'N' and field excitation of 0.12 amps.) of generator in ohms.

The value of 'P_L' for constant excitation is dependent on speed and its speed at any speed can be known from the calculation curve (P_L Vs. N curve) of the generator given. Power output of the motor (P_O).

= [Power output of the generator + armature copper losses of the generator + constant losses of the generator]

= $(V_g I_g + I_g^2 r_g + P_L)$ Watts

Power input to the motor (P_L) = $V_m I_m$ watts.

Percentage efficiency ( ) =

$$\frac{P_O}{P_I} \times 100$$

Load torque (T) =

$$\frac{P_O}{\frac{2N}{60}} = \frac{(V_g I_g + I_g^2 r_g + P_L)}{\frac{2N}{60}}$$

DATA SHEET

"LOAD TEST ON D.C. SHUNT MOTOR BY GENERATOR LOADING METHOD"

Name : _____ Roll No. : _____

Date : _____

Apparatus used :

Sl. No.	Item	Range	Lab No.
1.	Ammeter		
2.	Voltmeter		
3.	Voltmeter		

D.C. Shunt Motor under test :

_____ Volts, _____ Amps, _____ H.P.

r.p.m. _____ Lab No. _____

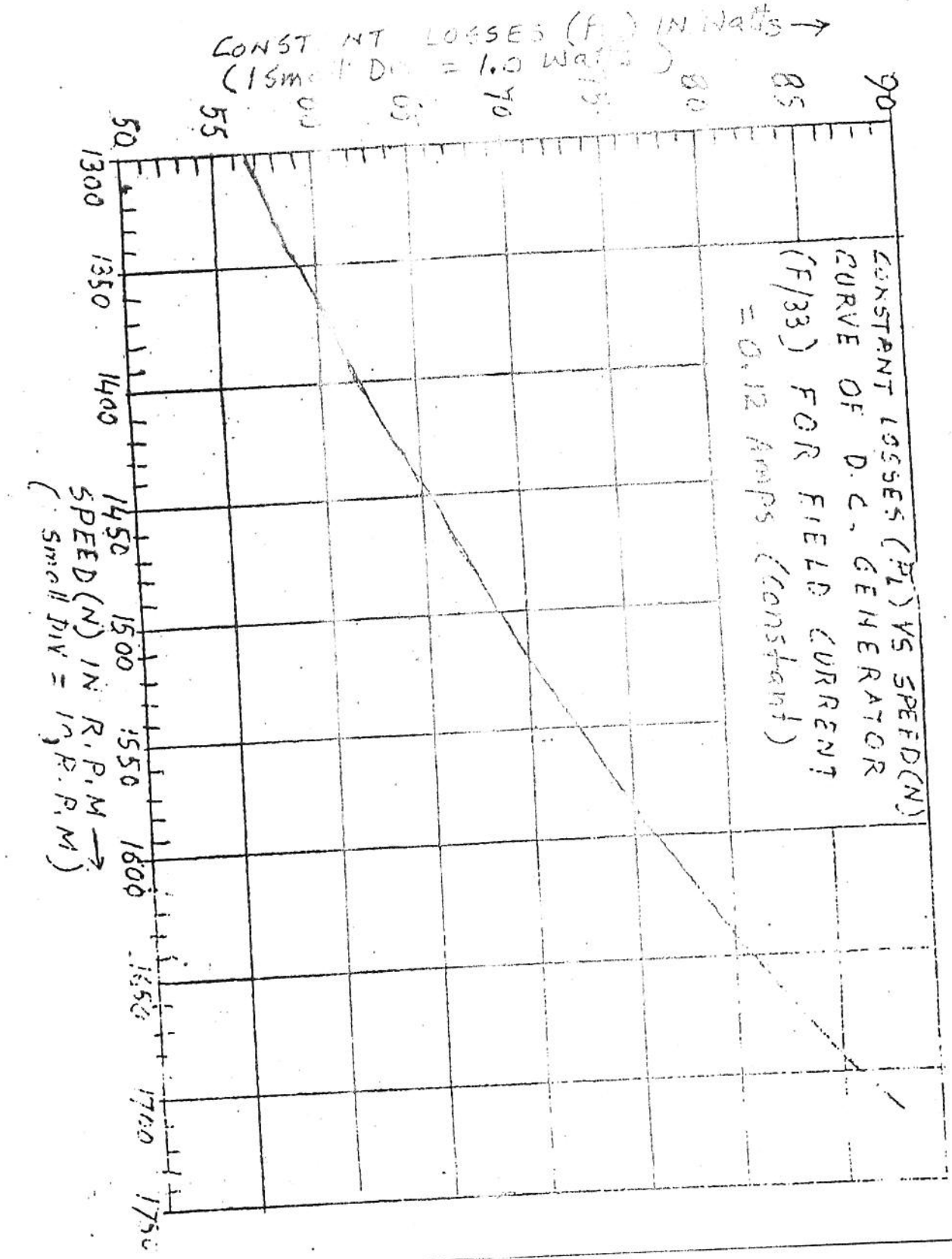
Experiment Data :

Armature resistance of the Generator = 12.00 ohms.

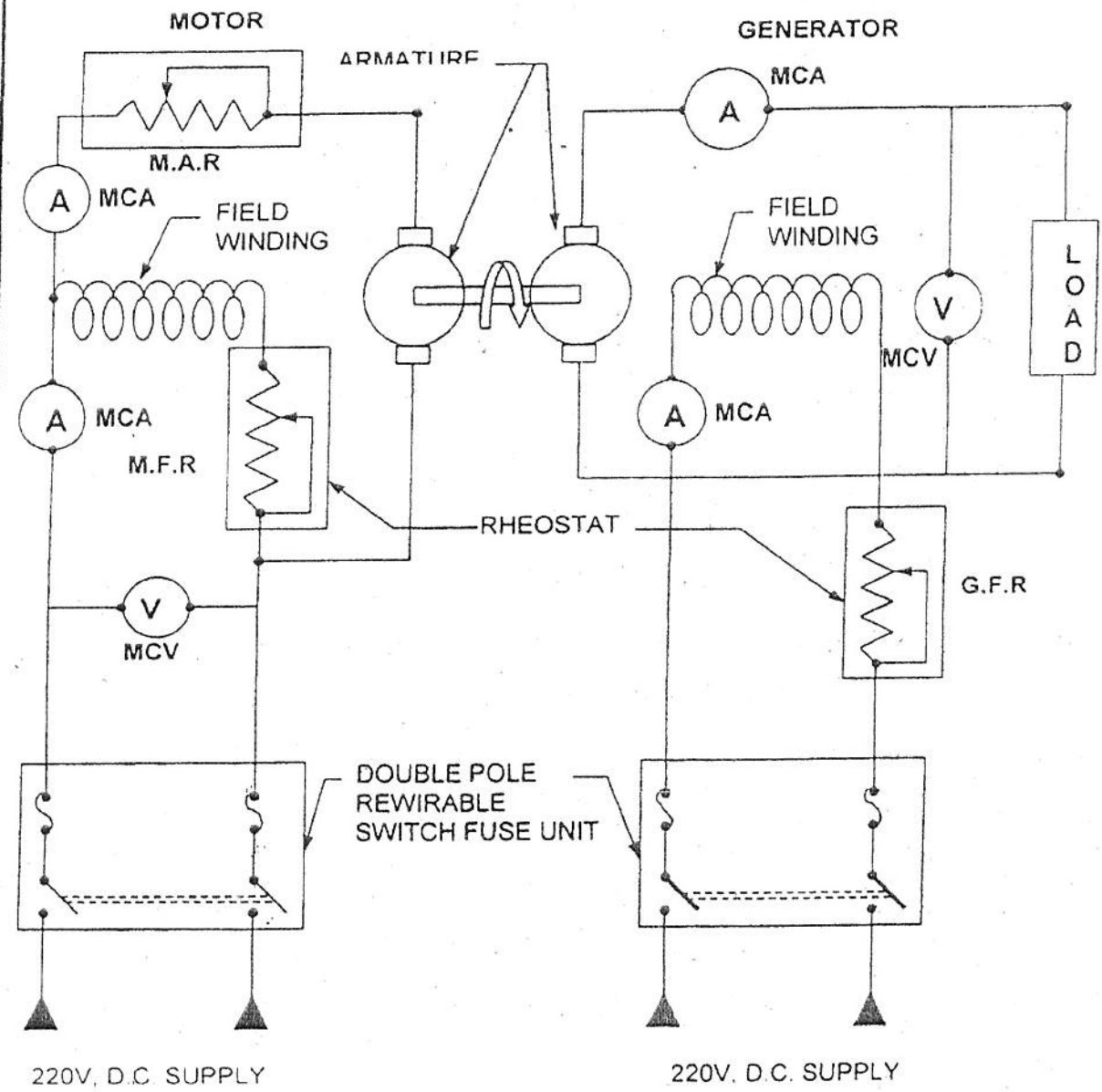
No. of obvs	Applied voltage in volt	Line current in amp.	Voltage	Load current in amp	Field current in amp	Speed in r.p.m.		Output in watts	Efficiency in %
1									
2									
3									
4									
5									
6									
7									

_____

Signature of the teacher


CONSTANT LOSSES (f) IN Watts →
50
55
90
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
SPEED (N) IN R.P.M →
(Since In = 1500 R.P.M)
CONSTANT LOSSES (f) VS SPEED (N)
CURVE OF D.C. GENERATOR
(F/33) FOR FIELD CURRENT
= 0.12 Amps (constant)

CIRCUIT DIAGRAM
FOR LOAD TEST ON D.C. SHUNT MOTOR BY GENERATOR LOADING METHOD



Electrical Machine Laboratory -I (EE2172) **3rd Semester EE students**

Expt.No: 6

CHARACTERISTICS OF D.C. GENERATORS

Set under test : 220 V, 1.35A, 1425 r.p.m. d.c. Generator coupled to a ½ h.p., 220V, 2.5A, 1425 r.p.m. d.c shunt motor.

Reference : The performance and Design of D.C. Machines By A. E. Clayton, p. 163.

1. SEPARATELY EXCITED GENERATOR.

Object : (A) To study the effects of field current and speed on the induced e.m.f. of a d.c. separately excited generator under no-load condition (No-load test).

(B) To study how the terminal voltage varies with load current in a separately excoted generator (Load Test).

Procedure : (A) No Load Test

Connect the driving motor through a starting resistance and field regulator as per fig. 1. Run it at a speed 1700 r.p.m.

Record the generated voltage with a generator field unexcited. Excite the generator field Sh – Sh through a potential divider and increase the field current in 5 steps till the generator field current is maximum. Record the field current, the generated voltage and the speed in Table-I. (The speed should be maintained constant at 1700 r.p.m.)

Repeat the above with the speed = 1800 r.p.m. and complete Table 2.

(B) Load Test

With the generator field winding excited separately (fig. 2), adjust the generator armature terminal voltage on no load at rated value (i.e., 220 volts), at speed 1700 r.p.m. Load the generator in 5 steps till the load current is about 1.5A, keeping the speed and the field excitation constant throughout. Record load current, terminal voltage, field excitation and speed (Table 3).

(C) Measurement of Armature Resistance

Measure armature circuit resistance of the generator armature at the rated armature current by voltage – drop method. The potential divider, Complete Table 4.

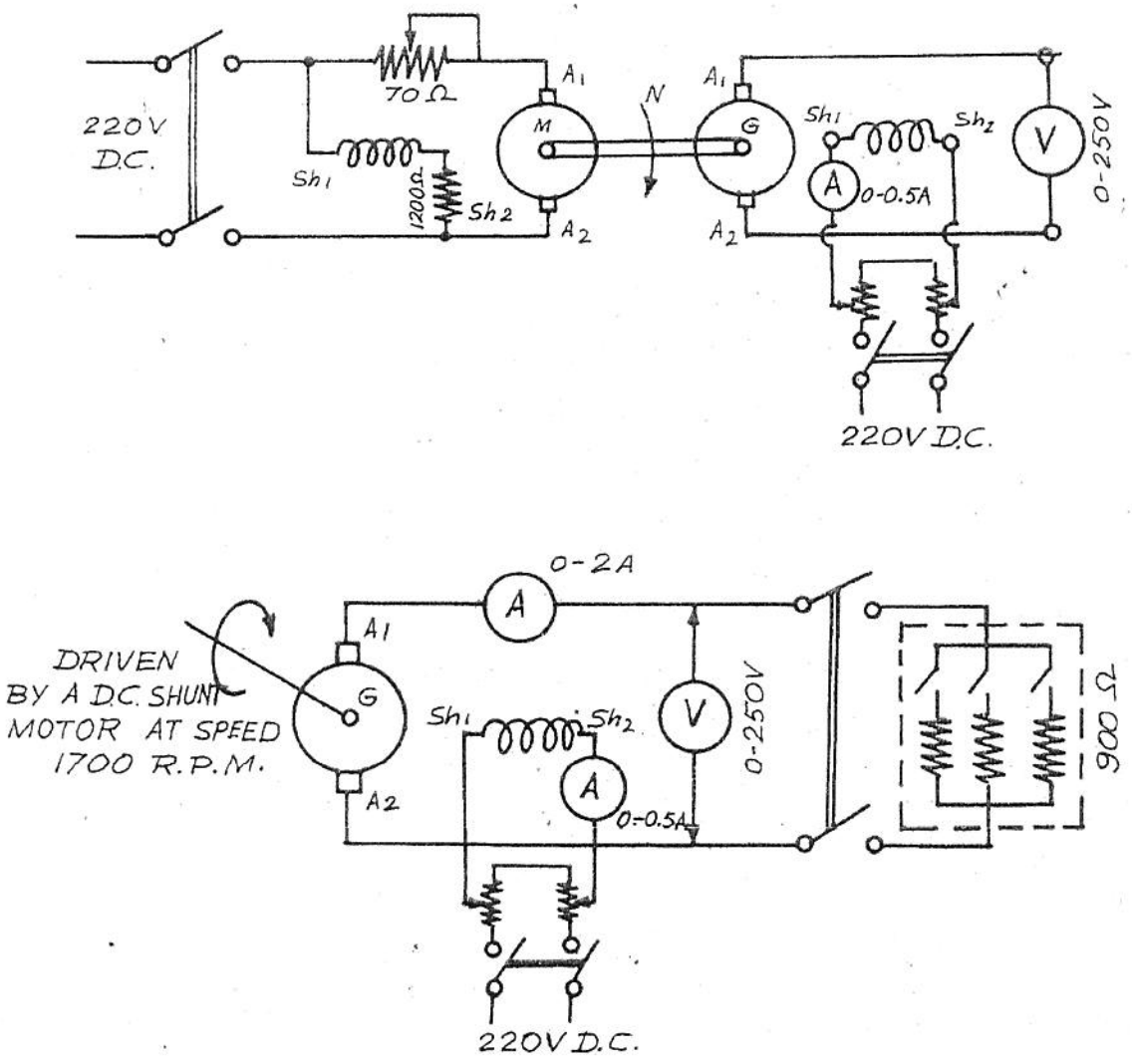


Fig. 1: Connection Diagram

Report :

(1) Draw the curves of the generated voltage vs. field current at both speeds ;

(2) Draw the load characteristics (terminal voltage vs. load current)

(3) Determine the critical resistance at speed 1700 r.p.m.

The separately excited generator which you have tested can be operated as a self-excited generator (shunt connected).

(a) if the field circuit resistance is less than the critical resistance ;

(b) if the connections between armature and field terminals are proper.

Critical resistance is thus defined as the field circuit resistance above which the generator will not build up.

To determine this resistance, draw a straight line through the origin for maximum slope to the generated voltage vs. field curve corresponding to the speed 1700 r.p.m. (is plotted in report I). Write down the value of the critical resistance on the graph of report 1.

(4) Determine the theoretical load characteristic at speed 1700 r.p.m. using the measured value of armature resistance r_a.

At any armature current I_1, the terminal voltage on load is given by :

$$E_t = E_o - I_a \ r_a$$

Where, E_O = generated voltage at speed N, as adjusted on no load,

= 220 volts (in our case).

Plot the characteristic on the graph of Report (2).

(5) Why is the theoretical load characteristic determined in Report (4) different from the experimental curve?

DATA SHEET

CHARACTERISTICS OF D.C. GENERATORS

Name : _____ **Roll No. :** _____

Date : _____

Apparatus used :

Sl. No.	Item	Range	Maker's Name	Lab No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				

TABLE : 1 : NO LOAD CURVE AT SPEED : 1700 r.p.m.

Sl. No.	Field current	Generated Voltage	Speed
1.	0		1700 r.p.m.
2.			
3.			
4.			
5.			
6.			

TABLE : 2 : NO LOAD CURVE AT SPEED : 1800 r.p.m.

Sl. No.	Field current	Generated Voltage	Speed
1.	0		1800 r.p.m.
2.			
3.			
4.			
5.			
6.			

TABLE : 3 : LOAD CHARACTERISTIC

Sl. No.	Load current	Terminal Voltage	Field Current	Speed
1.				
2.				
3.				
4.				
5.				
6.				

TABLE : 4 : ARMATURE RESISTANCE

Armature current	Armature voltage	Armature resistance

Signature of the Teacher