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

Electrical Machine Laboratory . (EE2174) **3rd Semester Mining students**

Expt.No: 1

THREE PHASE CONNECTIONS OF TRANSFORMERS

Objective : (i) To make polarities on the winding terminals of single phase transformer by (a) d.c. Kick test, (b) 'Polarity test' (A. C. Methods).

(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 : 1 KVA, 220/110V, 50 Hz.

PROCEDURE : (for object I (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 terminar (say) A1 of the primary winding as shown in the fig. 1 and positive terminal of the voltmeter is connected to terminar (say) a1 of the secondary winding as shown in fig. 1.
3. Suddenly close the switch and open the switch and each time note the instantaneous 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 Objective 1b) Polarity Test (A.C. METHOD)

1. Take one of the three transformers.
2. Connect the primary and secondary windings as shown in fig. 1.
3. Make Polarities arbitrarily on its primary winding terminals.
4. Switch on single phase a.c. supply to its primary winding and measure voltages across primary winding (AB) secondary winding (ab) and Aa.

If the voltage across Aa is equal to the sum of the voltage across AB and ab, the terminals 'A' and 'a' are of 'OPPOSITE' polarity. If it is 'A' and 'a' are of same polarity.

5. Mark polarities on the secondary winding terminals w.r.t. the polarities, marked on the terminals of primary winding.

6. Repeating the same procedure, mark polarities on the winding terminals of other two transformers.

Procedure : (for object (ii) – 'CONFECTIONS')

1. Using proper seqtuency connect the three transformers in Delta/Star (shown in fig. 1) switch on the three phase 220V a.c. supply to the primary and measure line and phase voltages of primary and secondary. Note them in delta-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 reading 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 points 'a' and 'b' (fig. 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 connections.

Connection diagrams :

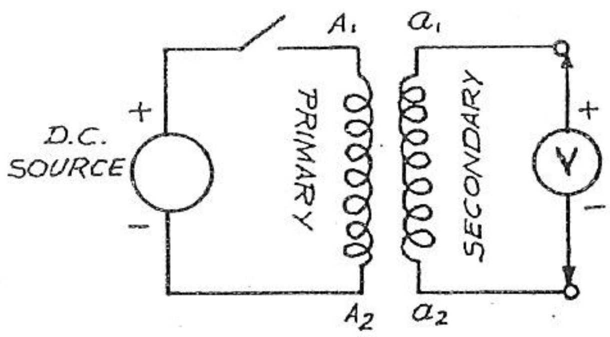

FIG. 1 : **DC Kick Test**

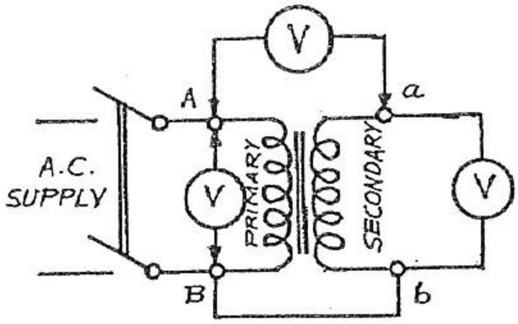

FIG. 2 : **Polarity Test AC Method**

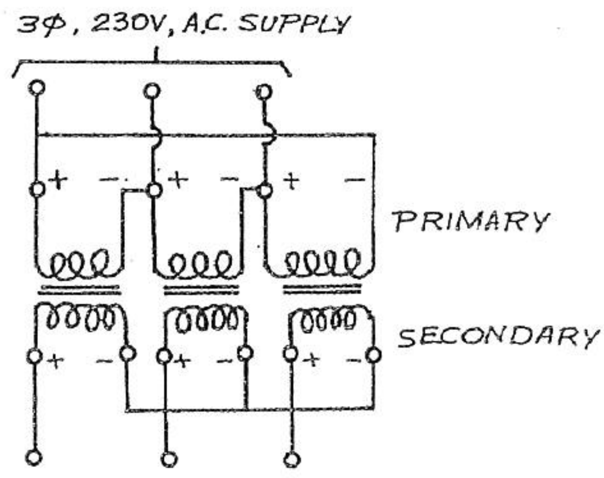

FIG. 3 : **Delta / Star Connection**

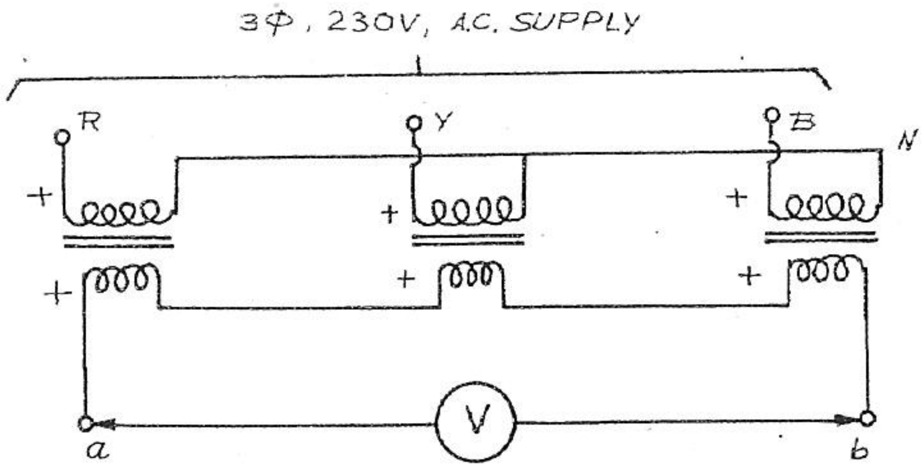

FIG. 4 : **STAR / DELTA CONNECTION**

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					

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Electrical Machine Laboratory (EE2174) **3rd Semester Mining students**

Expt.No: 2

LOAD TEST OF D.C.SHUNT MOTOR BY GENERATOR LOADING METHOD

OBJECT : To study the nature of verification of (a) Efficiency, (b) Torque and (c) Speed with power output of a d.c. shunt motor at constant rated voltage and field excitation.

PROCEDURE :

(1) Make connections as shown in the figure-3.

(2) Start the motor with armature rheostat (M.A.R.) in the ~~minimum~~ maximum resistance position and field rheostat (M.F.R.) in the minimum resistance position.

(3) Gradually cut off 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 table given.

REPORT :

1. Draw curves of – (i) Percentage efficiency

(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.

I_g = Generator output current in amperes.

V_g = Generator output voltage in volts.

R_g =Generator armature resistance in ohms

M = Speed in rpm

P_L = Constant loss (corresponding to speed N and field excitation of 0.12 amp.

The value of P_L for constant field excitation is dependent on speed and its value at any speed can be known From the 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.

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

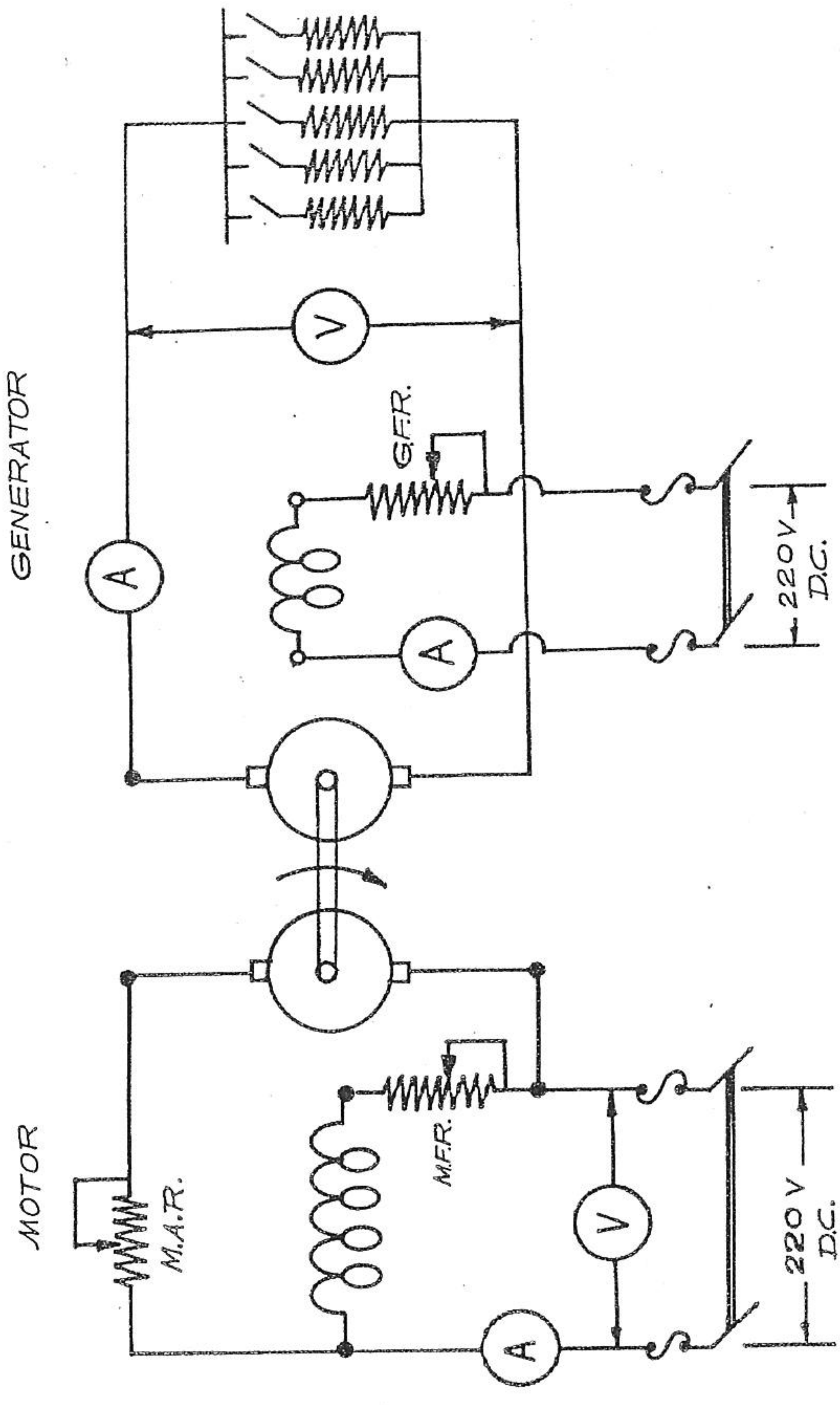
Power input to the motor (P_i) = V_m x I_m Watts

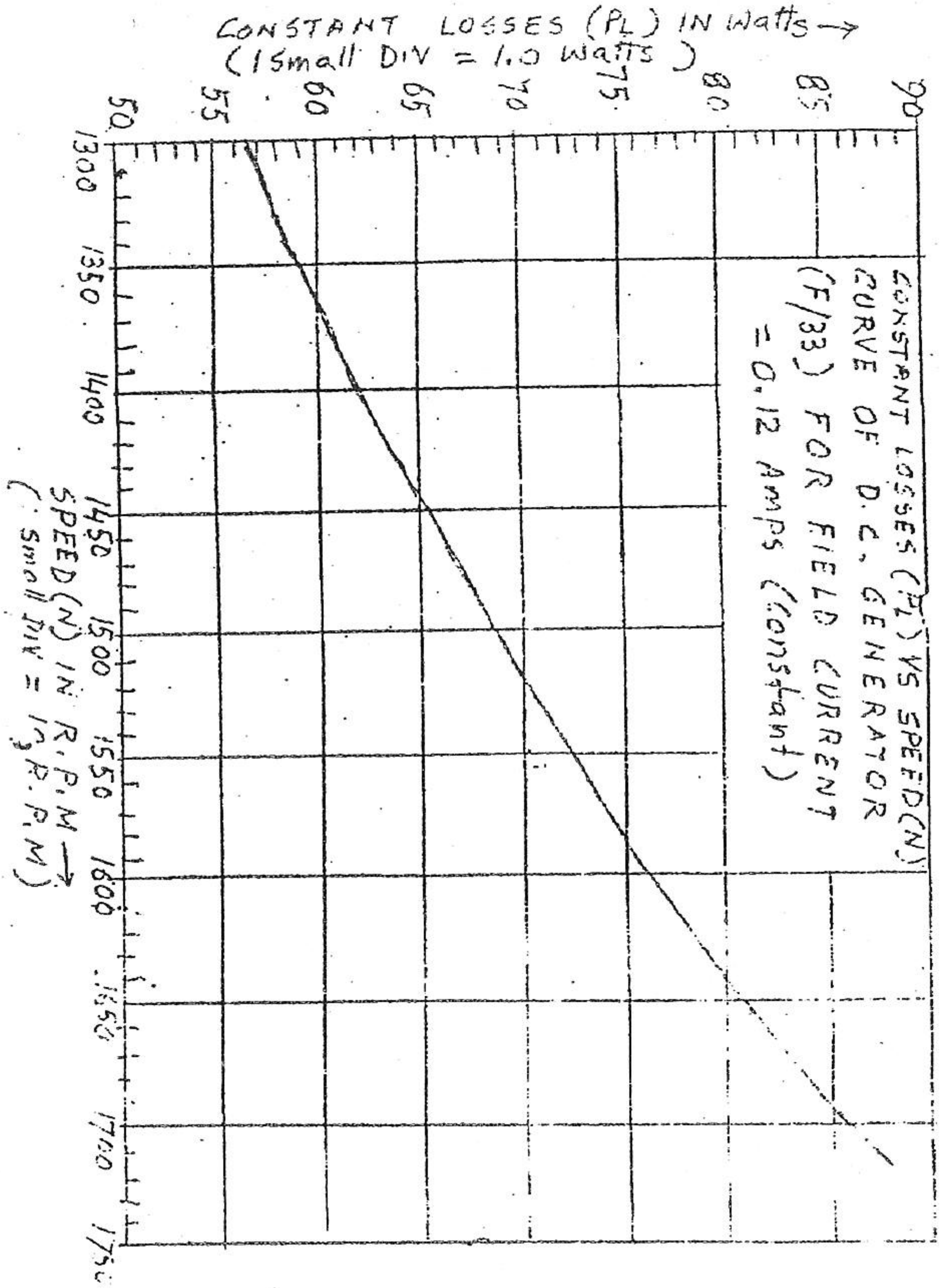
Percentage efficiency

$$(\eta) = \left(\frac{P_O}{P_i}\right) \times 100$$

Load torque

$$(T) = P_O = \frac{V_g I_g + I_g^2 r_g P_L}{\frac{2\pi n}{60}} \text{Nw} - \text{m.}$$


GENERATOR
MOTOR
G.F.R.
M.F.R.
M.A.R.
A
V
220 V D.C.
220 V D.C.


CONSTANT LOSSES (PL) IN Watts →
(1 small DIV = 1.0 Watts)
50
55
60
65
70
75
80
85
90
CONSTANT LOSSES (PL) VS SPEED (N) CURVE OF D.C. GENERATOR (F/33) FOR FIELD CURRENT = 0.12 Amps (constant)
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
SPEED (N) IN R.P.M →
(1 small DIV = 10 R.P.M)

DATA SHEET

LAOD TEST ON D.C. SHUNT MOTOR BY GENERATOR LOADING METHOD.

Name : ________________________________ Roll No. ___________

Date ______________

Motor under test ____________ Volts __________ Amps ___________ H.P.

Lab. No. ______________________ r.p.m. ________________ _____________ Motor,

Apparatus used :

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

DC SHUNT MOTOR UNDER TEST :

________________________________ VOLTS, ________________________________ AMPS,

__________________ H.P., spm ________________ , LAB NO. : ________________________

EXPERIMENTAL RESULTS :

Armature resistance of the generator = 12.00 ohms.

No. Of Obvs.	Applied Voltage (V)	Line Current (I)	Voltage (V)	Load Current (I)	Field Current	Speed In r.p.m.	Torque In Nw-m	Power Output In hp	Efficiency

____

(Signature of the Teacher)

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Electrical Machine Laboratory (EE2174) 3rd Semester Mining students

Expt.No: 3

LAOD TEST ON D.C. SHUNT MOTOR BY BRAKE METHOD.

Object : To study the verification 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 :

(i) Make connections as shown in the figure.

(ii) With maximum resistance in the armature circuit and spring balances in fully loose condition start the d.c. motor.

(iii) Gradually out the armature resistance and apply rated voltage to the machine. Take initial readings of spring balances when they are in loose condition.

(iv) Load the motor by increasing the tension of the springs till the line current reaches 25%, more than its rated value. Note the value of current, voltage, speed and the spring-balance readings.

(v) 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.

2. Show one sample calculation.

Note : if V = Applied Voltage in volts. I = Line current in amps.

W_1 & W_2 = Spring balance readings in kg.

D = Diameter of the pulley in metre. t = Thickness of the belt in metre. N = Speed in r.p.m.

Load torque (T) = $W_1 - W_2 \frac{(D+t)}{2}$ Kgm.

To calculate efficiency (n)

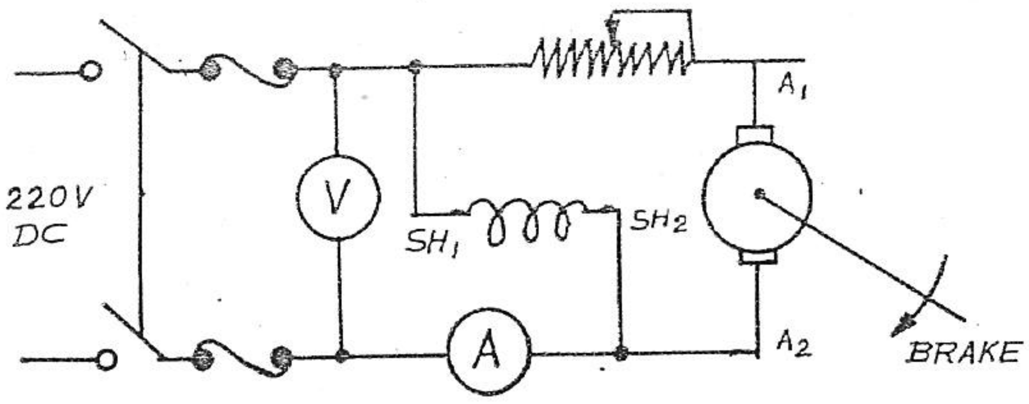
Power input to the motor (P_i) = V x I watts

Power output of the Motor (P_o) =

$$\frac{2\pi N}{60}(W_1 - W_2)(\frac{D+t}{2})\text{Kgm/Sec.}$$

Efficiency

$$(s)\eta = \frac{Po}{P_i} \times 100 = 9.81\left[\frac{2\pi N}{60}(W_1 - W_2)\frac{(D+t)}{2}\right]\text{Nwm/Sec.orwatts.}$$



Connection Diagram

DATA - SHEET

LAOD TEST ON D.C. SHUNT MOTOR BY BRAKE METHOD.

Name : ______________________ Roll No. __________

Date ______________

Machine under test ____________ Volts ____________ Amps ___________ H.P.

Lab. No. ____________________ r.p.m. ______________ ____________ Motor.

Apparatus used :

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

Experimental Data :

Diameter of the pulley (D) : 0.133 metre.
Thickness of the belt (T) : 0.009 metre.

No. Of Obvs.	Applied Voltage	Line current	Speed	Spring balance readings in kg		Torque in kg. m.	Output in watts	Efficiency (%)
				W_1	W_2			
1.								
2.								
3.								
4.								
5.								

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Electrical Machine Laboratory (EE2174) **3rd Semester Mining students**

Expt.No: 4

Starting and reversing of 3-phase squirrel cage Induction Motor

Object : (A) To acquire knowledge of starting 3 phase squirrel cage induction motor using (i) direct on line (D.C.I.) starter (ii) star-delta starter and (iii) Auto-transformer starter.

Object : (B) To study the method of reversing the direction of rotation of 3 phase squirrel cage induction motor.

Procedure (Object A) :

For (i) D.C.L. STARTER :

(a) Study the Induction Motor and note the ratings of the machine in the data sheet given.

(b) Make connections as shown in fig. 1.

(c) Switch on the 3 ph. 400 V a.c. supply and start the machine by pressing 'START' button of the starter.

(d) Take reading of initial starting current (maximum value), final steady current, motor input voltage and speed and note them in the data sheet given.

(e) Stop the machine by pressing the 'STOP' button of the starter.

For (ii) STAR/DELTA STARTER

(6) Make connections as shown in fig. 2.

(7) (Switch on the 3 phase 400 V. a.c. supply.

(8) Press the 'START' button of the starter and move the handle to 'START' position. Observe that the Motor starts.

(9) Take readings of initial starting current (maximum value) and motor input voltage, motor input current and speed under final steady condition. Note the readings in the data sheet given.

(10)Move the handle to 'RUN' (Delta) position and take same readings as in procedure (4). Note them in the data sheet.

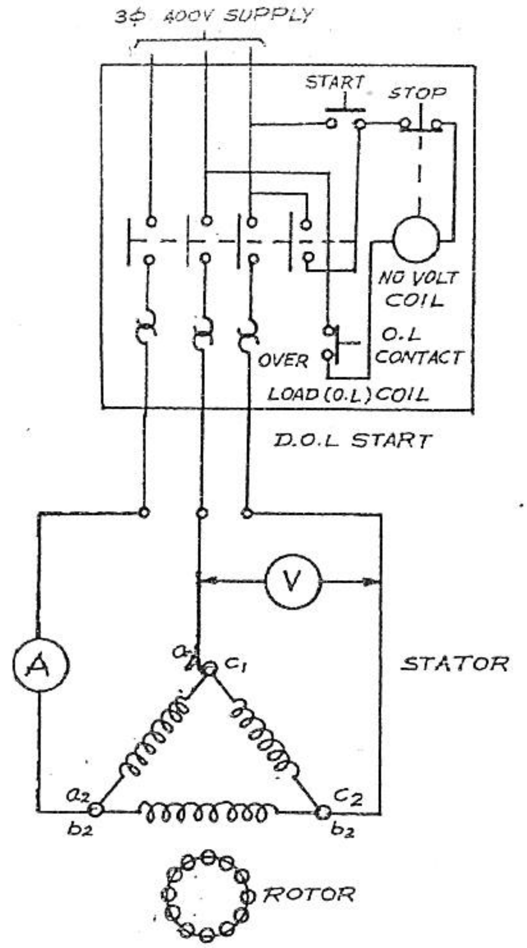

Fig. 1 : DOL Stater

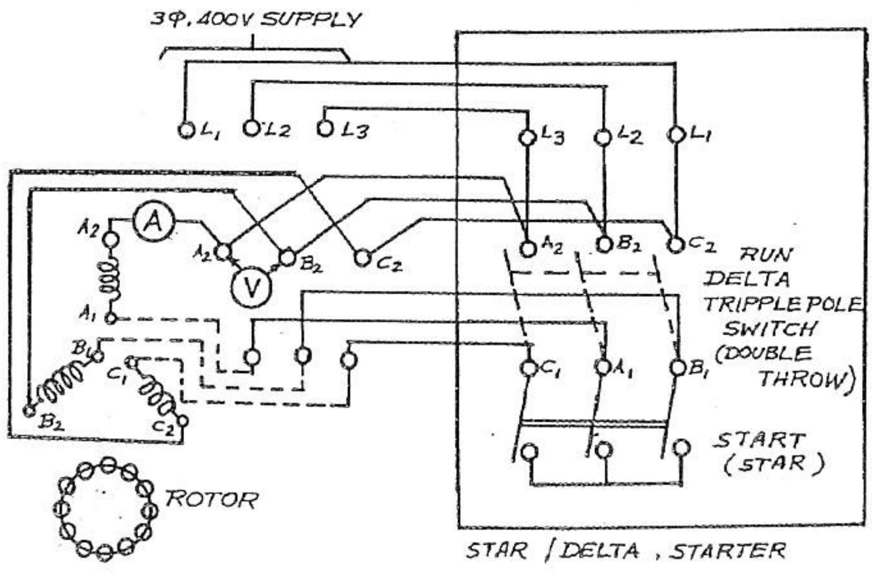

FIG. – 2 : STAR / DELTA STARTER

For (iii) AUTO TRANSFORMER STARTER :

(1) Make connections as shown in fig. 3.

(2) Switch on the 3 phase 400 V a.c. supply.

(3) Move the Tripple pole Switch. First to 'start' position and then to 'RUN' position and take some readings in the data sheet given.

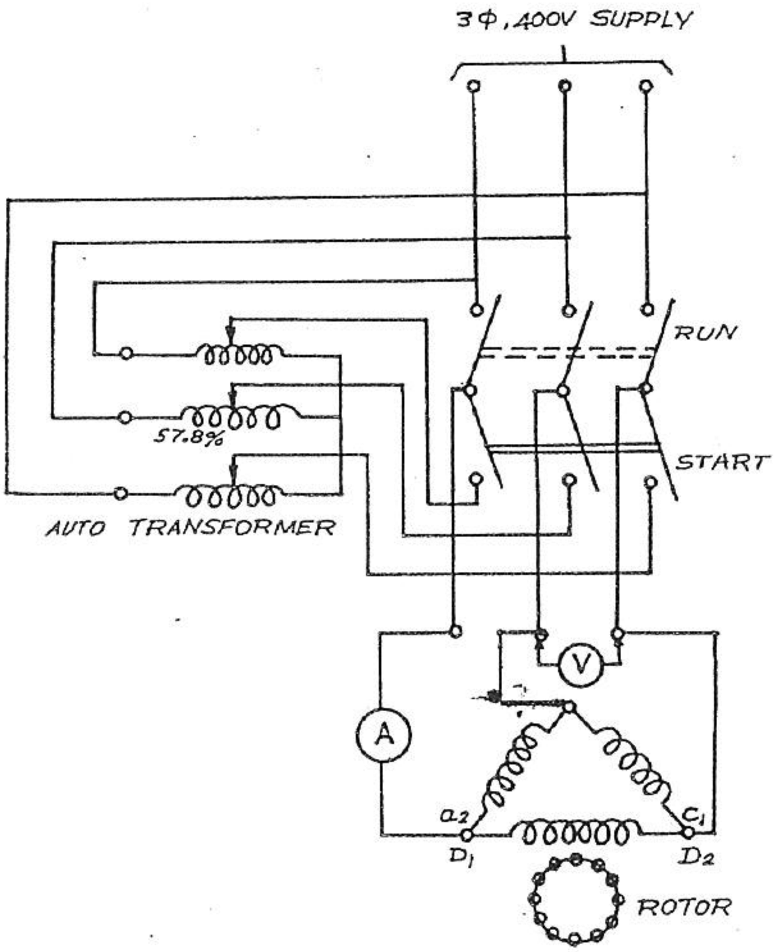

FIG. – 3 : AUTO TRANSFORMER STARTER

(Object B) :

1. Make connections as shown either in fig. 1 or 2 or 3.
2. Switch on the 3 phase 400V a.c. supply and start the motor. Note the phase sequence of the supply and direction of rotation and speed of the motor in the data sheet given.
3. Change the phase sequence (in as many ways as possible) of the supply input to the motor by interchanging any two of the three supply terminals and note same readings as in procedure (2).

DATA - SHEET

Starting and reversing of 3-phase squirrel cage Induction Motor

Name : ______________________________ Roll No. ___________

Date _____________

M/C. under test : Volts KW amps

r.p.m. phase Hz.

Connected Motor.

Apparatus used :

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

TABLE – I

Type of		Input current Max. value Steady value	Input Voltage Speed
D.O.L. Starter			
Star/Delta Starter	Start		
	Run		
Auto-transformer Starter	Start		
	Fun		

TABLE – II

Phase sequence	Direction of rotation	Speed

____

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Electrical Machine Laboratory (EE2174) **3rd Semester Mining students**

Expt.No: 5

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.)

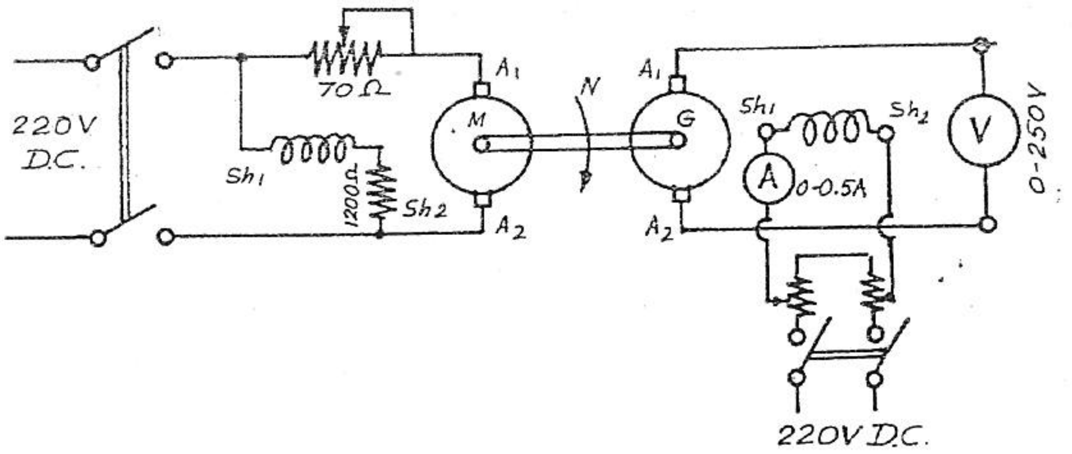
Repeat the above with the speed = 1800 r.p.m. and complete Table 2.

(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.



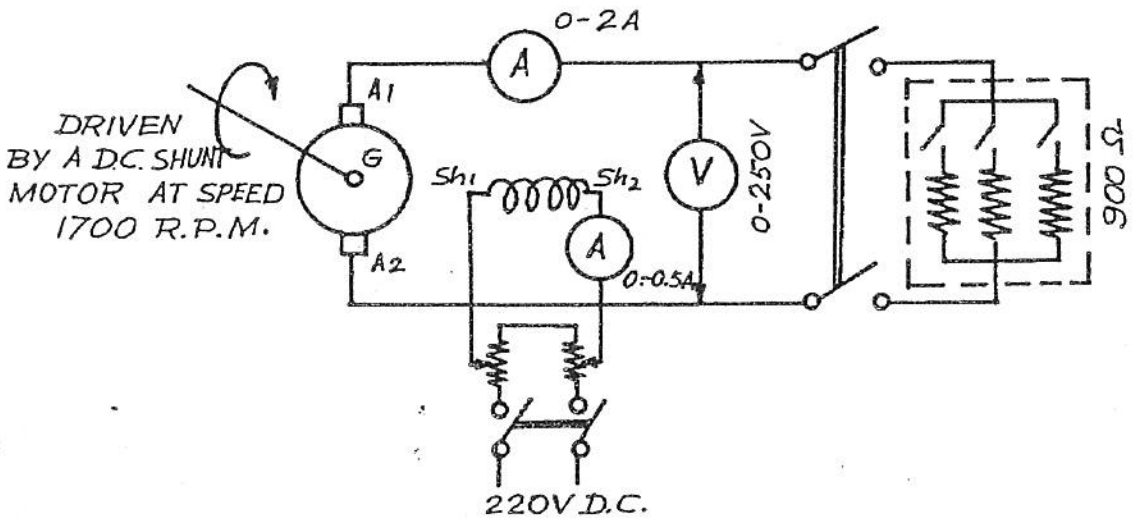


Fig. 1: Connection Diagram

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

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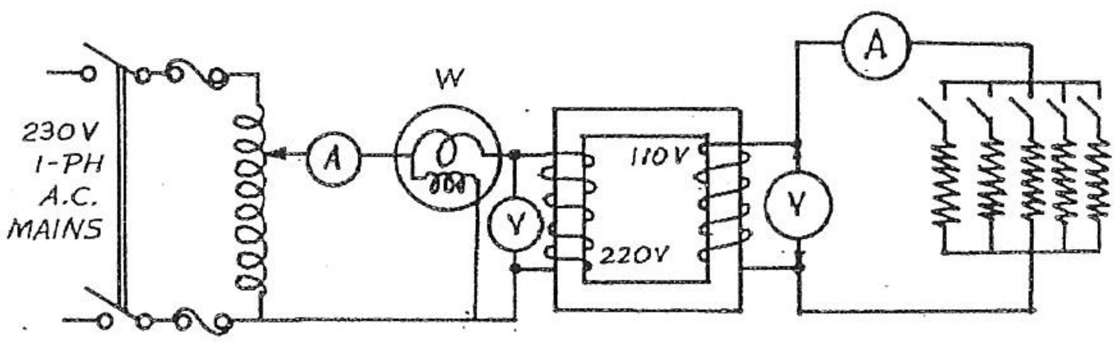
Expt.No: 6

LOAD TEST OF SINGLE PHASE TRANSFORMER

Object : To study the variation of (i) Secondary terminal voltage (ii) Regulation and (iii) Efficiency of a single phase Transformer when loaded at unity power – factor.

Procedure :

1. Make connections as shown in figure.
2. With load switches in the 'off' position, switch on the supply voltage.
3. Adjust the variacto apply rated voltage to the primary winding. Take readings of primary voltage, primary current, input-power and secondary voltage at no load.
4. Load the secondary winding by switching on the load switches in five steps and in each step take readings to fill up the data-sheet.



Connection Diagram

Report : 1. Plot the following characteristics :–

i) Secondary terminal voltage vs. Load current.

ii) Regulation vs. load current.

iii) Efficiency vs. load current.

2. Show one sample calculation :

Note : 1. Regulation %

$$= \frac{V_0 - V_2}{V_2} \times 100$$

where V_0 secondary terminal voltage at no-load

V_2 secondary terminal voltage at any load

2. Efficiency

$$(\eta) = \frac{P_O}{P_1} \times 100$$

where P1 = Input power given by the wattmeter reading connected to the primary.

$P_o = V_2 I_2 \text{Cos}\,\varphi = V_2 I_2$, (Since the load is resistive power factor Cos ϕ = 1) where V_2 = secondary terminal voltage and I_2 = Secondary load current.

DATA - SHEET

LOAD TEST ON TRANSFORMER

Name : ________________________________ Roll No. ____________

Date ______________

Machine under test ____________ Volts ____________ Amps ___________ H.P.

Lab. No. _____________________ r.p.m. ________________ _____________ Motor.

Apparatus used :

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

Transformer under test :

Primary Voltage : Secondary Voltage :

KVA : Phase : Frequency : 50 Hz.

Experimental Data

No. of Obvs.	Primary Side			Secondary Side			Sufficiency	Regulation
	Voltmeter Reading	Ammeter Reading	Wattmeter Reading	Voltmeter Reading	Ammeter Reading	Power Out put (P_o)		
	V	A	W	V	A	W	T	D
1.								
2.								
3.								
4.								
5.								
6.								

____

(Signature of the Teacher)