DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MANUAL FOR ECE 227
ELECTRICAL MACHINES LABORATORY

(2/4 ECE, 2-Semester)

SIR C.R.REDDY COLLEGE OF ENGINEERING
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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ECE227 ELECTRICAL MACHINES LABORATORY
(2/4 ECE, II- SEMESTER)

Experiment Name

1. **Swinburnes Test on D.C Shunt Motor**
2. **Speed control of D.C Shunt Motor**
3. **Load Test on D.C Shunt Motor**
4. **D.C. Shunt Generator Characteristics**
5. **O.C.C. of D.C. Seperately excited Generator**
6. **Hopkinson's Test on D.C Machines**
7. **D.C. Series Generator Characteristics.**
8. **D.C. Compound Generator Characteristics.**
9. **V & Λ Curves of Synchronous Motor.**
10. **Regulation of alternator by EMF Methods**
11. **Load Test on a 3-ϕ Squirrel cage Induction Motor**
12. **Load Test on a 1-ϕ Induction Motor**
13. **O.C & S.C Test on a 1-ϕ Transformer**
14. **Equivalent circuit of a 3-ϕ Slip-ring Induction Motor**

Exp. No : 1

SWINBURNE'S TEST ON D.C. SHUNT MOTOR

Aim:-To conduct the no load test on the DC shunt machine and determine its efficiency at different loads when operating as a) Motor & b) Generator

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Ammeter	(M.C)	0 – 1.5 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0-9999 R.P.M	1
6	DC shunt motor		-	1
7	Connecting wires	PVC insulated	-	-

Theory:- Swinburne's test is a simple indirect method to calculate the efficiency of constant flux DC machines. In this method constant losses are calculated at no-load and from this efficiency at any desired load can be pre-determined in advance. In this method the machine is run as a motor at no-load, at its rated voltage & rated speed (adjusted by using shunt field Rh)

Limitations

- Applicable to constant flux machines i.e shunt & compound machines

Advantages:

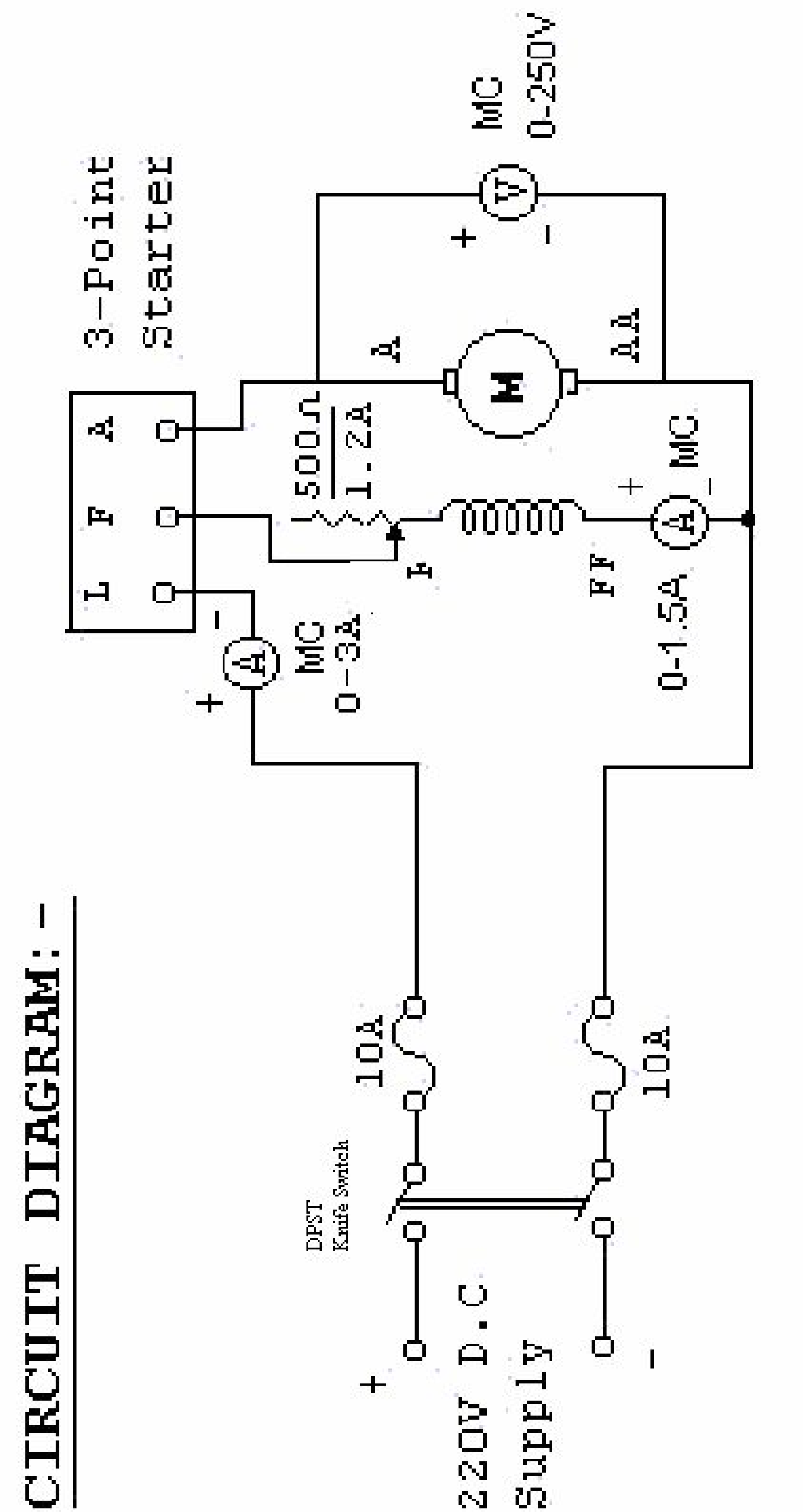
- It is economical because power required to test the machine is very small i.e no load input power.
- The efficiency can be pre-determined at any desired load.

Disadvantages:

- At full load due to armature reaction, flux is destroyed which increases the iron losses. No account is taken for this change in iron losses.
- As the test is on no-load, it is impossible to know whether commutation would be satisfactory at full load and whether the temp. rise would be within the specified limits.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOUT position, 3-point starter handle at its initial position, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. All the meter readings are noted into the tabular column.
6. The motor field rheostat is brought back to cut out position and the supply switch is opened.


CIRCUIT DIAGRAM:-
3-Point Starter
L F A
MC 0-250V
V
MC 0-3A
A
500Ω / 1.2A
F
FF
MC 0-1.5A
AA
M
10A
10A
DPST Knife Switch
220V D.C Supply
+
-

Tabular column:-

Sl.No	I_0 In Amps	I_{sh} In Amps	V In volts

Specimen calculations:-

1. No load armature current $= I_{ao} = I_o - I_{sh}$ amps
   where I_o - is the no-load input current of the D.C motor
   I_{sh} – is the shunt field current
2. Armature copper loss $= I_{ao}^2$ Ra watts
   where R_a – is the armature resistance of the D.C.Machine
   it can be determined by Volt-Amp method.
3. Total input power $= P_i = V I_o$ watts
4. Constant power loss $= P_c = V I_o - I_{ao}^2$ Ra watts
5. Calculation of Efficiency

when running as motor : If I_L = Full Load current in amps

	At full Load	At Half Full Load
a. Armature current	$= I_a = I_L - I_{sh}$ amps	$I_a = \frac{I_L}{2} - I_{sh}$ amps
b. Armature cu. Loss	$= w_c = I_a^2$ Ra watts	$w_c = I_a^2 R_a$ watts
c. Motor input	$= P_i = V I_L$ watts	$P_o = ½ VI_L$ watts
d. Constant losses	$= P_c$ watts	
e. Total losses	$= P_t = P_c + w_c$ watts	

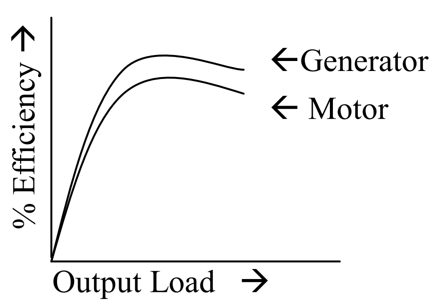
$$\therefore \text{ \% efficiency of motor} = \frac{p_i - p_t}{p_i} \times 100$$

when running as generator:

	At Full Load	At Half Full Load
a. Armature current	$= I_a = I_L + I_{sh}$ amps	$I_a = \frac{I_L}{2} + I_{sh}$ amps
b. Armature cu. Loss	$= w_c = I_a^2 R_a$ watts	$w_c = I_a^2 R_a$ watts
c. Generator output	$= P_o = V I_L$ watts	$P_o = ½ VI_L$ watts
d. Constant losses	$= P_c$ watts	
e. Total losses	$= P_t = P_c + w_c$ watts	

$$\therefore \text{\% efficiency of generator} = \frac{p_o}{p_o + p_t} \times 100$$

Nature of Graph :-



Viva – Voce Questions:

1. Do you require a startor for a dc motor under the running condition, why?
2. Can you use the dc motor as a dc generator? If so, what is to be done.
3. What are the losses taking place in a dc machine.?
4. What is the power o/p & efficievcy during swinburns test?
5. What is the fuse rating for conducting swinburns test on a dc machine of 18A?
6. What is the principle of operation of dc motor?
7. What happens to dc shunt motor if source polarity reversed?
8. A dc shunt motor refuses to start when switched on what could be the possible reasons and remedies?
9. What happens to motor if field circuit is suddenly opened?
10. What are the advantages and disadvantages of Swinburns test over the other tests?
11. When will you get the maximum efficiency for a dc machine?

Exp. No : 2

SPEED CONTROL OF D.C. SHUNT MOTOR

Aim:- To control the speed of a D.C. shunt motor by Armature control method and field control method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Voltmeter	(M.C)	0 – 250 V	1
3	Rheostat	Wire wound	500 Ω, 1.2 A	1
4	Rheostat	Wire Wound	38 Ω, 10 A	1
4	Tachometer	Digital	0 – 9999 rpm	1
6	D.C. shunt motor		3HP, 220 V, 12 A	1
7	Connecting wires	PVC insulated	-	-

Theory:-

The speed of a dc shunt motor can be controlled by varying

i) Flux/pole (Flux control method)
ii) Resistance of armature circuit (rheostat control method)
iii) Applied voltage (Voltage control method)

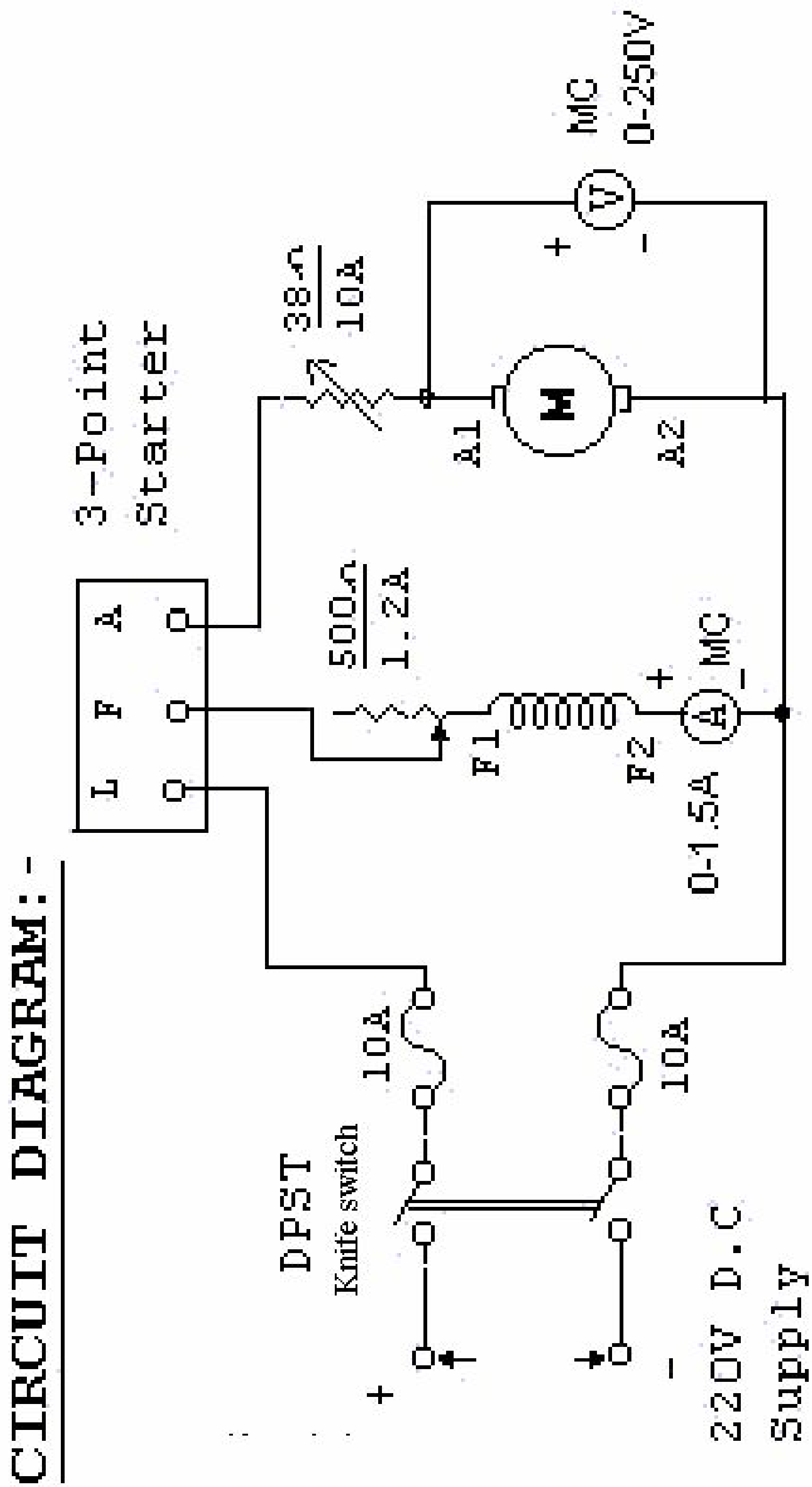
Speed of a motor is given by the relation:

$$N \propto \frac{E_b}{\phi} \quad \text{-- (1)}$$

i) Flux control method:-This method is used when speeds above normal speeds are required. In the above equation (1) by decreasing the flux, the speed can be increased and vice versa. The flux of a dc motor can be changed by changing I_{sh} with the help of a shunt field rheostat. The current in shunt field rheostat is less. I^2R loss is small, so that rheostat is small in size.

ii) Armature or rheostat control method:- This method is used when speeds below the no-load speeds are required. In this method the voltage across the armature is varied by increasing a variable rheostat in series with the armature circuit, as resistance is increased, potential difference across the armature is decreased, there by decreasing the armature speed. This method is expensive (Cu loss more) and unsuitable for rapidly changing loads because for a given value of R_t, the speed will change with load.

iii) Voltage control method:- This method is also used to control the speeds below the no-load speeds. In this method the shunt field of the motor is connected across the fixed supply and then by supplying different voltage to the armature different speeds are obtained. The control voltage is obtained from potential dividers, solid state rectifier and Ward-Leonard system.


CIRCUIT DIAGRAM:-
3-Point Starter
L F A
38Ω / 10A
MC 0-250V
V
A1 M A2
500Ω / 1.2A
F1 F2
A
MC 0-1.5A
10A
10A
DPST Knife switch
220V D.C Supply

Procedure:-

a) **For Armature voltage control method:-**

1. The connections are made as shown in the circuit diagram.
2. With the armature rheostat is CUTIN position, the field rheostat in CUTOUT position and the 3-point starter handle at its initial position, the D.C. supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in armature circuit so that the motor starts and runs at some speed.
4. The armature rheostat is brought to cut out position so that rated voltage is applied across the armature.
5. The field current is adjusted to a certain value by varying the field rheostat such that the motor runs at nearly rated speed.
6. The armature rheostat is CUTIN gradually so that the armature voltage is varied in steps and the corresponding speeds are noted in the tabular column.
7. Step no. 5 is repeated until the armature rheostat is completely CUTIN.
8. The field rheostat is brought back to CUTOUT position, the armature rheostat to CUTIN position and the D.C. supply switch is opened.

b) For field control method:-

1. Step nos. 1, 2 & 3 of armature voltage control method are repeated.
2. The armature rheostat is varied such that the rated voltage is applied across the armature terminals.
3. The field rheostat is gradually cut in steps so that the field current is varied in steps of 0.05A and the corresponding value of speeds are noted.
4. Step no. 3 is repeated until the field rheostat is completely CUT IN.
5. Step no. 3 and 4 are repeated for an armature voltage of 200V.
6. The field rheostat is brought back to CUT OUT, the armature rheostat to CUT IN position and the supply switch is opened.

Tabular column:-

a) Armature voltage control

Field current =

Sl.No	Armature voltage In Volts	Speed In rpm

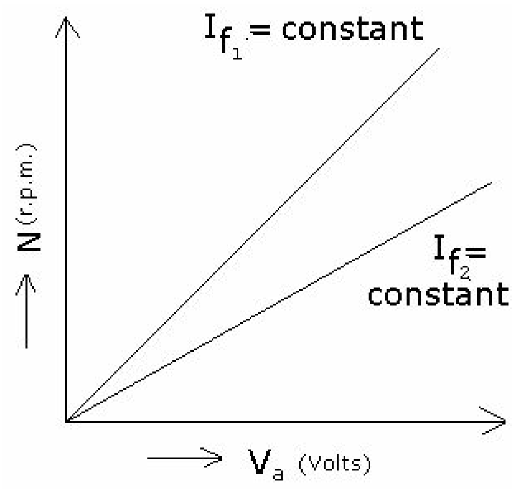
b) Field control method

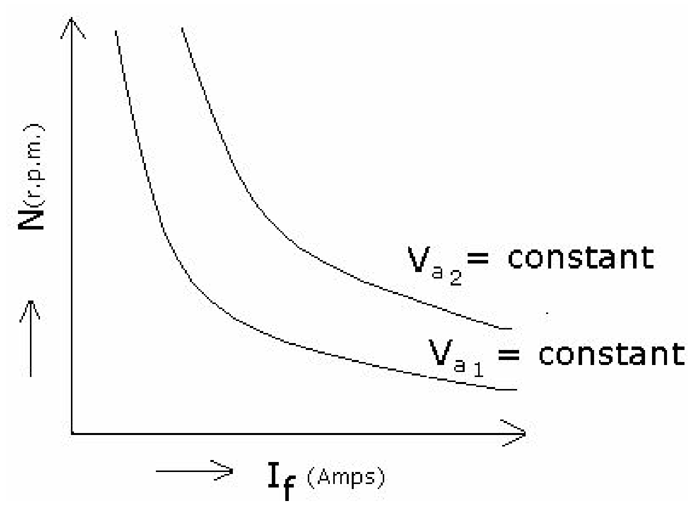
Armature voltage =

Sl.No	Field current In Volts	Speed In rpm

Nature of graph:

a) Armature Voltage Control **b) Field Control**





Viva – Voce Questions:-

1. Speed of a dc shunt motor is directly proportional to field current (true or false)?
2. A dc shunt motor rated speed as 1500 rpm. How do you get speed below and above 1500 rpm?
3. Give the equation of the back EMF induced in a dc motor. What is the other equation by which it can be calculated?
4. What is the difference between arm voltage control and arm series resistance control in case of dc shunt motor? Which one is preferable?
5. Define speed regulation of a dc motor? How much percent will it be usually for a shunt motor?

Exp. No : 3

LOAD TEST ON D.C. SHUNT MOTOR

Aim:- To conduct the brake load test on D.C. shunt motor and determine its performance characteristics.

Apparatus:-

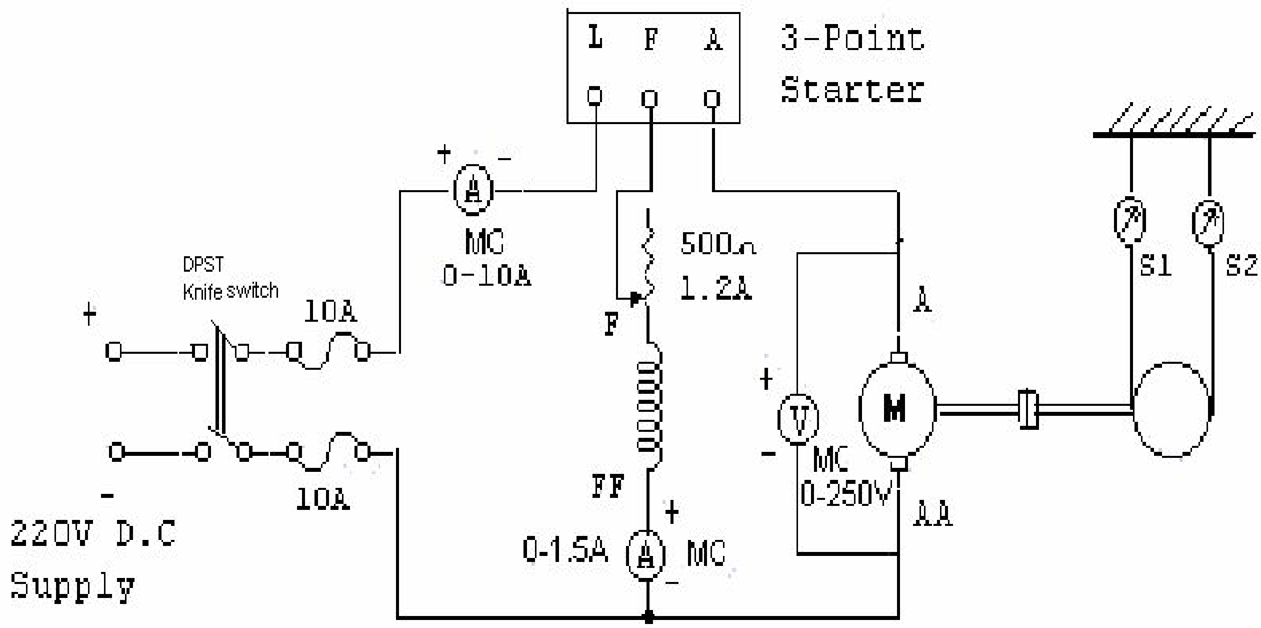
S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 10 A	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Voltmeter	(M.C)	0 – 250 V	1
4	Rheostat	Wire wound	500 Ω, 1.2 A	1
5	Tachometer	Digital	0-9999 rpm	1
6	D.C. shunt motor with loading arrangement		-	1
7	Connecting wires	PVC insulated	-	-

Theory:- This is a direct method of testing dc machine. This test is conducted on low Horse power machines the machine is run as a motor and a brake frictional load is applied to the moving shaft. The moment of the brake drum is restricted with a braking arrangement. The braking arrangement consists of
a) Water cooled brake drum b) belt c) Spring balances to measure the tension on the brake belt and d) tension adjusting mechanism. The friction between brake drum and belt acts as a mechanical load. By adjusting the tension of the belt the load on the motor can be adjusted. Due to brake friction terrible heat is produced. To keep the brake drum with in the working temperature or to remove the heat due to friction the brake drum is filled with water for cooling.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cutout position, the 3 point starter handle in initial position and ensuring that the belt over the brake drum is totally loosened, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat and all the meter readings as well as speed are noted.
5. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
6. Step no. 5 is repeated until the rated current of the motor is nearly reached.
7. The load is removed in steps, the motor field rheostat is brought back to cut out position and the supply switch is opened.

CIRCUIT DIAGRAM:-



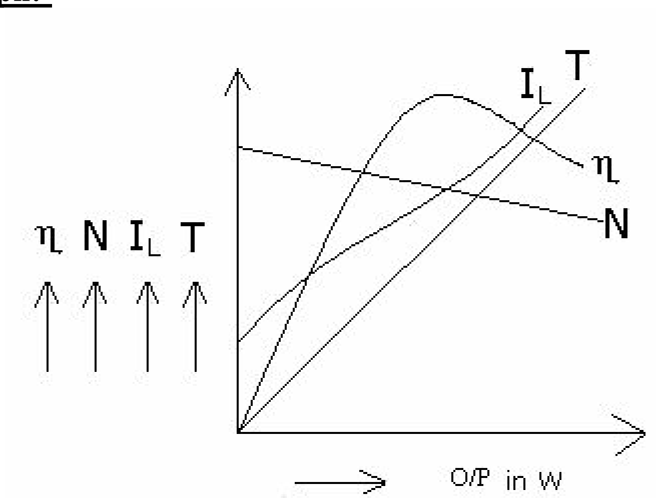
Tabular column:-

Sl. No	V In Volts	I_l In Amps	I_{sh} In Amps	S_1 In Kgs	S_2 In Kgs	T In N - m	N In rpm	I_a In Amps	Input In Watts	Output In watts	% Efficiency

Specimen calculations:-

1. Torque $T = (S_1 \sim S_2) \times r \times 9.81$ N – m
2. Armature current $I_a = I_L - I_{sh}$ amps
3. Motor input power $P_i = V \cdot I_L$ watts
4. Motor output power $P_o = \frac{2\pi NT}{60}$ watts
5. % efficiency $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

Nature of the graph:-



Viva – Voce Questions:-

1. What is the condition for maximum output in a dc motor?
2. What happens if the field circuit of a dc motor is opened under running condition?
3. Write down the torque equation of a dc motor?
4. Draw the characteristics & performance curves of a dc shunt motor?
5. The lost torque in a dc motor is proportional to which loss?
6. What is meant by critical speed?
7. What are the usual ranges of field winding resistance armature resistance in case of a dc shunt motor?
8. Can we use 3-point starter for the speed control of dc motor using field rheostat method? Why?
9. What are the different speed control methods used for dc series motor?

Exp. No : 4

DC SHUNT GENERATOR CHARACTERISTICS

Aim:- To conduct the no-load and load test on a D.C. shunt generator and draw its O.C.C, internal and external characteristics.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Ammeter	(M.C)	0 – 2 A	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0 – 9999 rpm	1
6	Load box	Resistive	230 V/ 10 A	1
7	D.C. shunt generator coupled D.C. motor		-	-
8	Connecting wires	PVC insulated	-	-

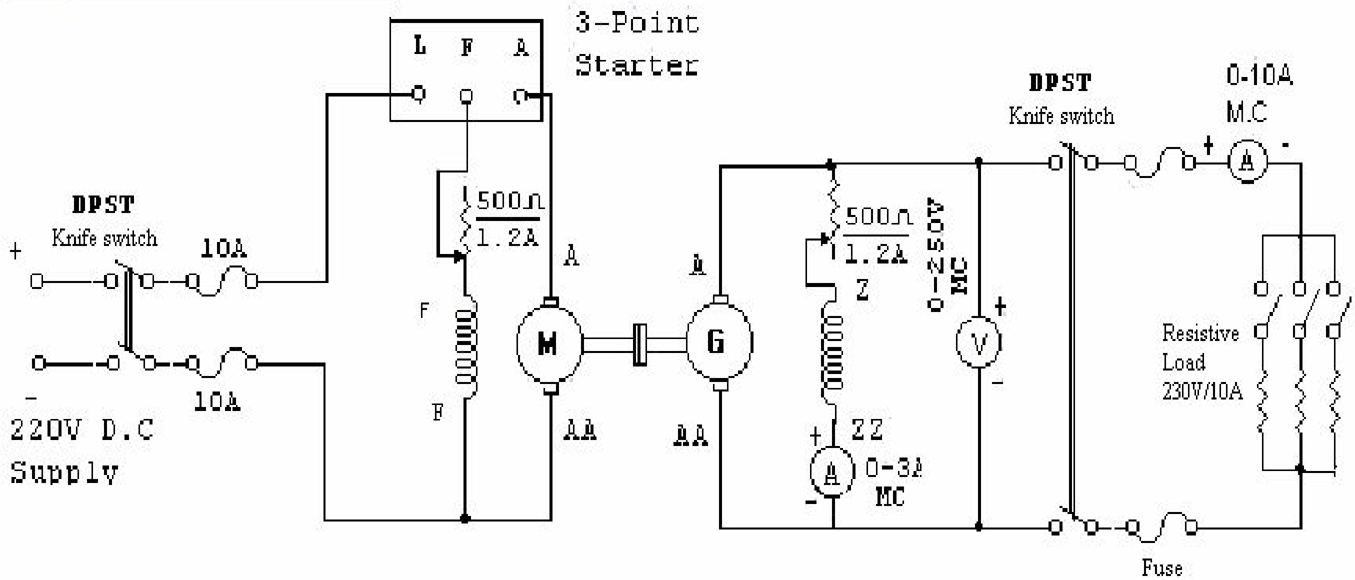
Theory:-

External characteristic curve (ECC):- This is drawn under load condition.
It is the curve drawn between load current or line current and load voltage or terminal voltage taking current on X axis induced emf on Y axis.
Internal characteristic curve (ICC). It is also called as total characteristic curve. It is drawn between armature current and generated voltage. Taking armature current on X axis, induced emf on Y axis
Relation between terminal voltage and induced emf:-The voltage measured at the terminals is known as terminal voltage and that induced in the generator is known as induced emf which is represented by E.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the motor field rheostat is in CUTOUT position, generator field rheostat is in CUTIN position, 3-point starter handle is in initial position and the load switch is in off position and the supply switch (DPST) is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied in steps and the readings of field current and terminal voltage are noted.
6. Step No 5 is repeated until the generator voltage reaches to its rated value.
7. The load switch (DPST) is closed to connect the load to the generator and all the meter readings are noted in the tabular column.
8. The load is varied in steps and all the meter readings are noted in the tabular column.
9. Step no.8 is repeated until the rated current of the generator is reached.
10. The load is reduced in steps, the load switch is opened, the generator field rheostat is brought back to CUTIN position, the motor field rheostat to CUTOUT position and the supply switch is opened.

CIRCUIT DIAGRAM:-



Tabular Column:-

Open circuit characteristic

Sl.no	I_f In Amps	E In Volts

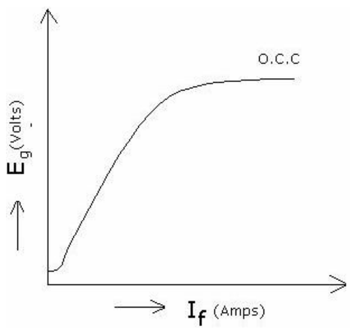
Internal and external characteristic

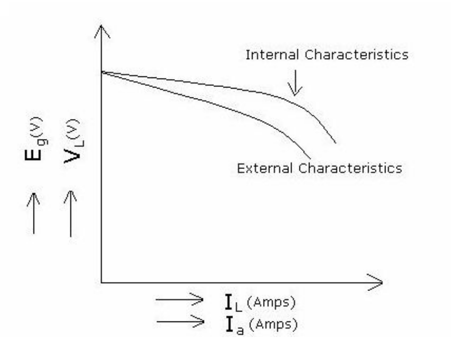
Sl.no	I_f In Amps	I_L In Amps	V In volts	I_a In Amps	$I_a R_a$ In Volts	E In volts

Specimen calculations:-

Induced voltage under load = $E = V + I_a R_a$

Nature of graph:-





Fig(a) : Open Circuit Characteristic *Fig (b)* : Internal (E_g Vs I_a) and External (V_L Vs I_L)Characteristics

Viva – Voce Questions:-

1. What are the conditions to be fulfilled for the shunt generator to build up voltage?
2. What is meant by the term "critical field resistance" related to the dc shunt generator?
3. What is meant by the term "critical load resistance" in case of a dc shunt generator?
4. What is the type of voltage induced in the armature of a dc generator.
5. Can you measure the "Induced voltage" under load condition for a dc generator? Why?
6. Represent the armature reaction drop in the load characteristics of a dc shunt generator?
7. What is the purpose of the commutator in a dc machine?
8. What is meant by "critical speed N_0" in case of a dc shunt generator?
9. What is the principle of operation of dc generator?
10. List out the factors affecting the voltage fall in a dc shunt generator?
11. What will happen if you given ac supply to the field of a dc generator
12. A properly connected generator is showing a zero terminal voltage when it is run by a prime mover. What is the reason?

Exp. No : 5

OPEN CIRCUIT CHARACTERISTICS OF A D.C. GENERATOR

Aim:- To plot the open circuit characteristics of a separately exited D.C. generator.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 1 A	1
3	Rheostat	Wire Wound	500 Ω, 1.2 A	2
4	Tachometer	Digital	0-9999 R.P.M	1
5	DC Motor coupled to D.C Generator		-	-
6	Connecting wires	PVC insulated	-	-

Theory:- The field current I_f is obtained from an external independent DC source. It can be varied from zero upwards by a potentiometer and its value is read by Ammeter connected in the field circuit.

Voltage equation of a DC generator is $E_g = \phi ZNP/60A$

Hence if speed is constant, the above relation becomes $E = K\phi$

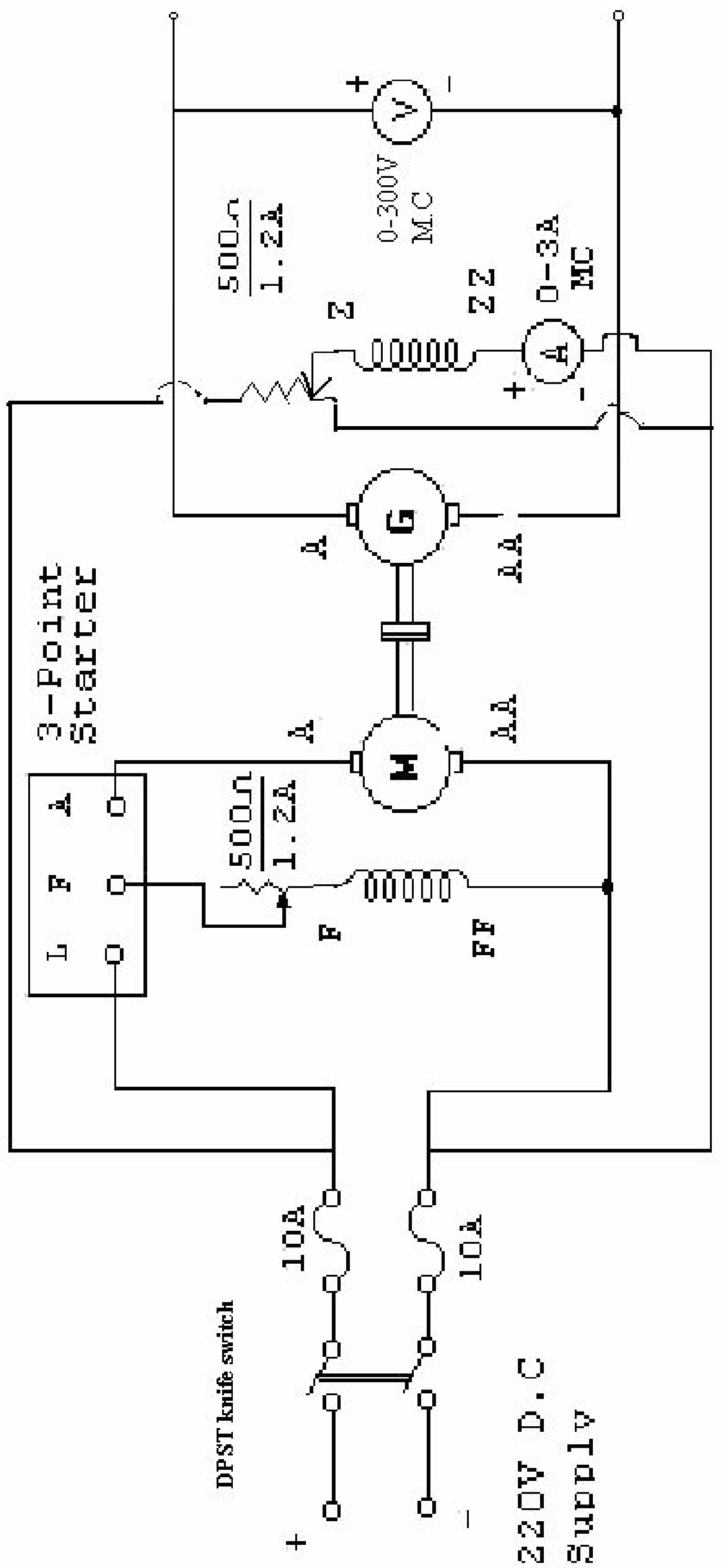
It is obvious that when I_f is increased from its initial small value, the flux ϕ and hence generated emf increases as current while the poles are unsaturated. But as the flux density increases, the poles become saturated so a generator in I_f is requires to produce a given increase in voltage than as the lower part of the curve.

The curve showing relation between the terminal voltage 'V' and field current I_f when the generator is on no-load

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in CUTOUT position, the generator field rheostat in CUTIN position and the motor 3-point starter handle at its initial position, the DC supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field is excited by gradually varying the resistance of the generator field rheostat in steps and for each step the corresponding field current and the no load voltage are noted.
6. Step no. 5 is repeated until the rated voltage of the generator is reached and all the meter readings are noted for each step.
7. The generator field rheostat is brought back to CUTIN position, the motor field rheostat to CUTOUT position and the supply switch is opened.

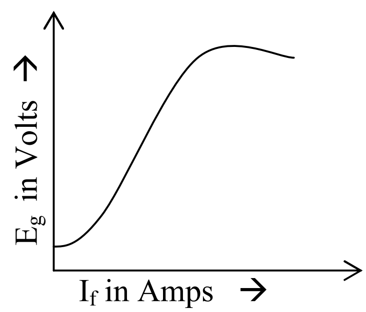
CIRCUIT DIAGRAM: -



Tabular column:-

Sl.No	I_f In Amps	E_g In volts

Nature of graph:-



Viva – Voce Questions:-

1. Identify the locations of field and armature windings for different machines.
2. What do you mean by rated values of a machine
3. What is to be done if the residual flux is not present in a dc generator?
4. Write down the EMF equation of a dc genertor?
5. To found OCC of a self excited shunt generator it has to be connected as a separately excited generator when it is (true or false).
6. Expand OCC what is the other name for it? Where does OCC of dc generator lies at speed N_1 with respect to that of OCC at N_2 if $N_1 < N_2$.
7. Commutator works as a ______________ in dc generator and as a ___________ in a dc motor.
8. Large dc generators will have __________ winding and high voltage, small generator will have _____________ windings.
9. Interpoles will be placed between ____________ in a dc generator.
10. A dc shunt motor can be started using 4 point starter (True or False) ?

Exp. No : 6

HOPKINSON'S TEST ON D.C. MACHINES

Aim:- To conduct Hopkinson's test on two identical DC shunt machine and determine the efficiency of each M/C at various loads.

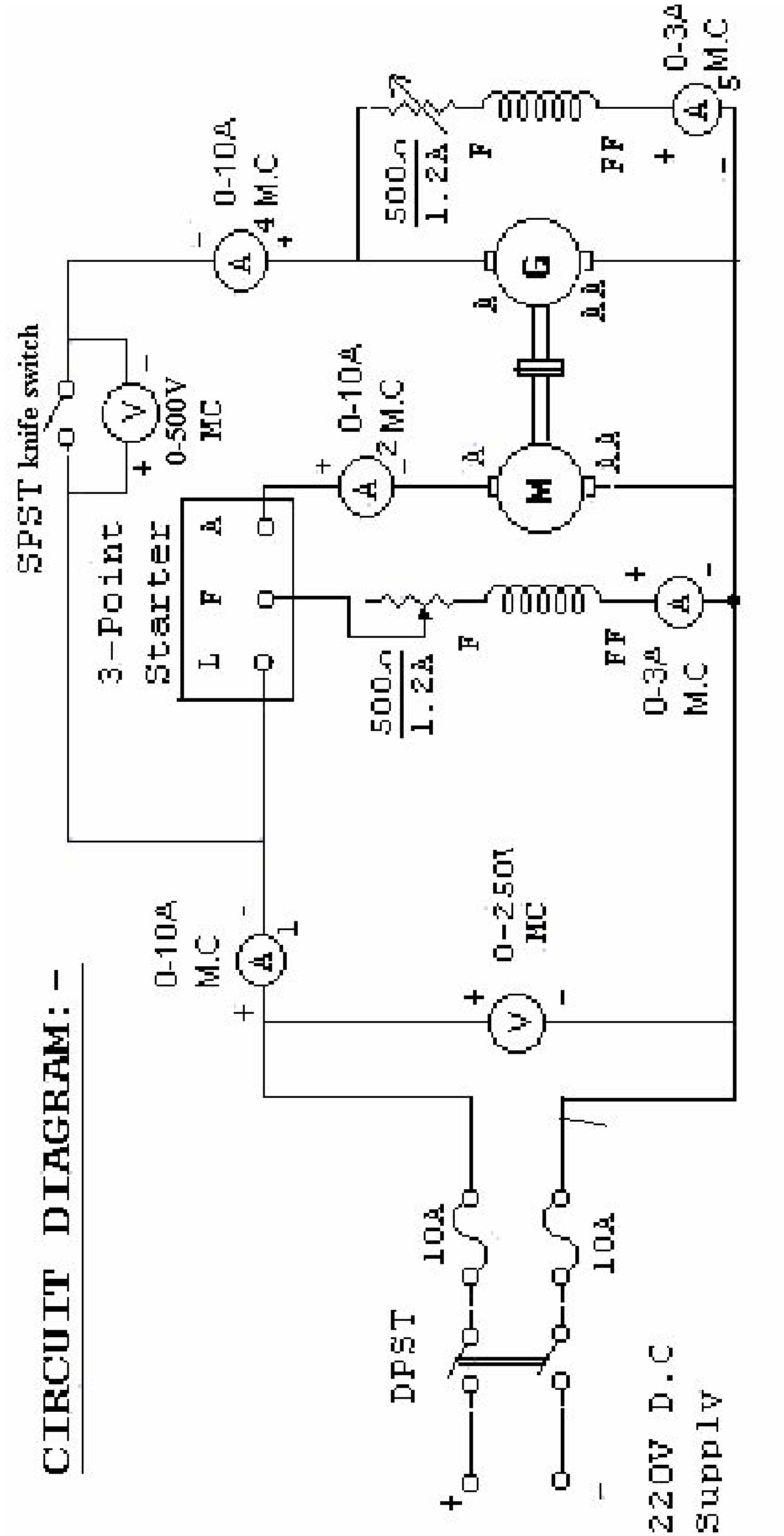
Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	2
2	Ammeter	(M.C)	0 – 10 A	3
3	Ammeter	(M.C)	0 – 2 A	2
4	Tachometer	Digital	0 – 9999 rpm	1
5	Rheostat	Wire wound	500 Ω, 1.2 A	2
6	D.C. shunt motor coupled generator			
7	Connecting wires	PVC insulated		

Theory:- By this method full load test can be carried out on two shunt machines, preferably identical ares, without wasting their outputs. The two m/c are mechanically coupled and are adjusted electrically that are of them runs as a motor and the other as a generator. The mechanical o/p of the motor drives the generator and the electrical o/p of generator is used in supplying the greater part of input to motor. If there were no losses in the m/ces they would have run without any external supply. But due to these losses gen o/p is not sufficient to drive the motor and vice versa. The losses are supplied either by an extra motor which is belt connected to the MG set or by suggested by kapp electrically born the supply mains

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With motor field rheostat in cutout position, generator field rheostat in cut in position, ensuring that 3-point starter handle at its initial position and with the S.P.S.T. switch open, the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the resistance in the motor armature circuit, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied such that the generator terminal voltage is same as supply voltage so that the voltmeter across the SPST switch reads zero value and the SPST switch is closed.
6. The meter readings are noted in the tabular column.
7. The field rheostat of generator is varied in steps such that the field current is also varied in steps of 0.1 A and all the meter readings are noted in the tabular column for each step upto I_4 reads generator rated current.
8. The field rheostat of generator is brought back to cutin position, so that the generator current is zero, the motor field rheostat is brought back to cut out position and the supply switch is opened


CIRCUIT DIAGRAM: -
SPST knife switch
0-500V
MC
3-Point
Starter
L F A
0-10A
M.C
0-10A
4 M.C
500Ω
1.2A
F
FF
0-3A
5 M.C
G
M
A
AA
0-10A
M.C
1
0-250V
MC
10A
10A
DPST
220V D.C
Supply

Tabular column:-

Sl.No	Voltage In Volts	I_1 In Amps	I_2 In Amps	I_3 In Amps	I_4 In Amps	I_5 In Amps	Generator O/P in watts	Motor O/P in watts	Efficiency of Generator in %	Efficiency of Motor in %

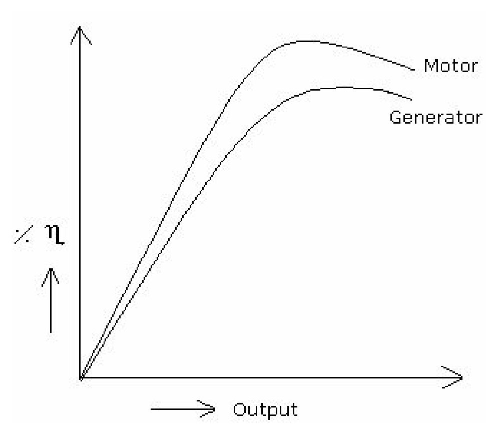
Specimen calculations:-

Armature cu losses of generator = $(I_4 + I_5)^2 R_a$
Armature cu losses of motor = $I_2^2 R_a$
Shunt field cu losses in generator = $V I_5$
Shunt field cu losses in motor = $V I_3$
Total stray losses $\rho_s = VI_1 - \left[(I_4 + I_5)^2 R_a + I_2^2 R_a + VI_5 + VI_3\right]$

$\therefore$ Efficiency of Generator $$\eta_g = \frac{VI_4}{VI_4 + \frac{\rho_S}{2} + (I_4 + I_5)^2 R_a + VI_5} \times 100$$

$\therefore$ Efficiency of Motor $$\eta_m = \frac{V(I_1 + I_4) - I_2^2 R_a - VI_3 - \frac{\rho_S}{2}}{V(I_1 + I_4)} \times 100$$

Nature of graph :-



Viva – Voce Questions:-

1. Stray loss in a dc machine depends on what quantities?
2. Draw the circuit diagram to measure the armature resistance of a dc machine?
3. What is the difference between the Swinburns test and Hopkinsons test?
4. Which loss is obtained from the Hopkinsons test?
5. Is the stray loss obtained from the Hopkinsons test really same for both the machines? Why?
6. Which part of the stray loss is not equal both the machines during Hopkinsons test? Why?
7. Which loss comes under rotational losses in case of a dc shunt machine?
8. For a dc shunt machine the efficiency obtained from the Swinburns test is more than the one obtained from the Hopkinsons test justify?

Exp. No : 7

D.C SERIES GENERATOR CHARACTERISTICS

Aim:- To draw the internal and external characteristics of DC series generator by conducting load test.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Rheostat	Wire Wound	500 Ω, 1.2 A	1
4	Tachometer	Digital	0 – 9999 rpm	1
5	Load box	Resistive	230 V/ 10 A	1
6	D.C. series generator coupled to DC motor		-	-
7	Connecting wires	PVC insulated	-	-

Theory:- In series generator the field winding is connected in series with the armature winding.

ECC: External characteristic curve . it is the curve drawn between the load current and terminal voltage. Taking load current (I_L) on X axis and terminal voltage on Y-axis

ICC: Internal characteristic curve. It is the curve drawn between armature current and generated voltage. Taking armature current I_a on X axis and generated voltage on Y axis

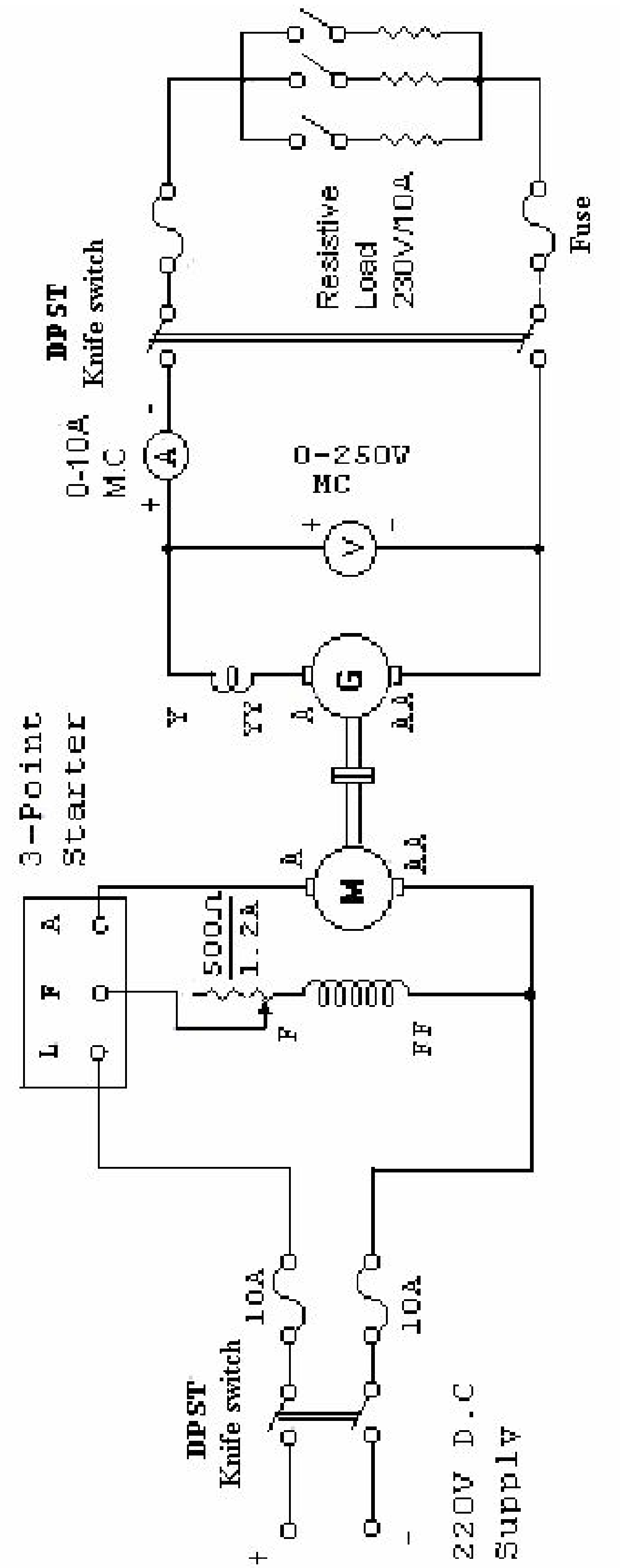
In series generator

Armature current = field current = load current

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the motor field rheostat is in CUTOUT position, the 3-point starter handle is in initial position, the generator load switch in open position the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually to cut out the motor armature circuit resistance, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat. And the voltmeter reading is noted (indicates residual voltage)
5. The load switch of the generator is closed.
6. The load is varied in steps and all the meter readings are noted in the tabular column.
7. Step No 6 is repeated until the rated current of the generator is reached.
8. The load is removed in steps, the load switch of the generator is opened the motor field rheostat is brought back to CUTOUT position and the supply switch is opened.

CIRCUIT DIAGRAM: -



Tabular Column :-

Sl. no	I_L In Amps	V_L In volts	$I_a R_a$ Drop In Volts	Induced E.M.F In volts

Specimen calculations :-

Induced E.M.F = E = $V + I_a (R_a+R_{sc})$

Nature of graph :-

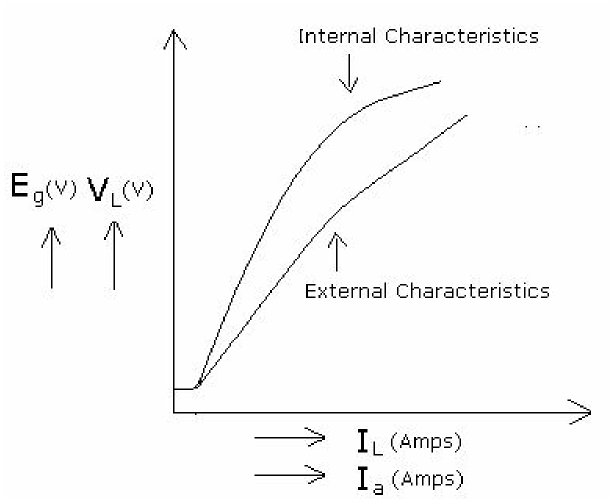


Fig: Internal (E_g Vs I_a) and External (V_L Vs I_L) Characteristics

Viva – Voce Questions:-

1. Draw the load characteristics of a dc series generator.
2. Can a dc series generator. Excite on no load, why? What is meant by critical load resistance of the above machine.
3. What is the usual range of field winding resistance in case of a dc series machine.
4. Series generator has _________ characteristics of series generator.

Exp. No : 8

D.C COMPOUND GENERATOR CHARACTERISTICS

Aim:- To draw the internal and external characteristics of DC short shunt compound generator by conducting load test (Both cumulative & differential)

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.C)	0 – 250 V	1
2	Ammeter	(M.C)	0 – 10 A	1
3	Ammeter	(M.C)	0 – 2 A	1
4	Rheostat	Wire Wound	500 Ω, 1.2 A	2
5	Tachometer	Digital	0 – 9999 rpm	1
6	Load box	Resistive	230 V/ 10 A	1
7	D.C. compound generator coupled to DC shunt motor		-	-
8	Connecting wires	PVC insulated	-	-

Theory:-The method of adding the series field flux with the shunt field flux is known as compounding. According to method of compounding the compound generators are classified into two categories.

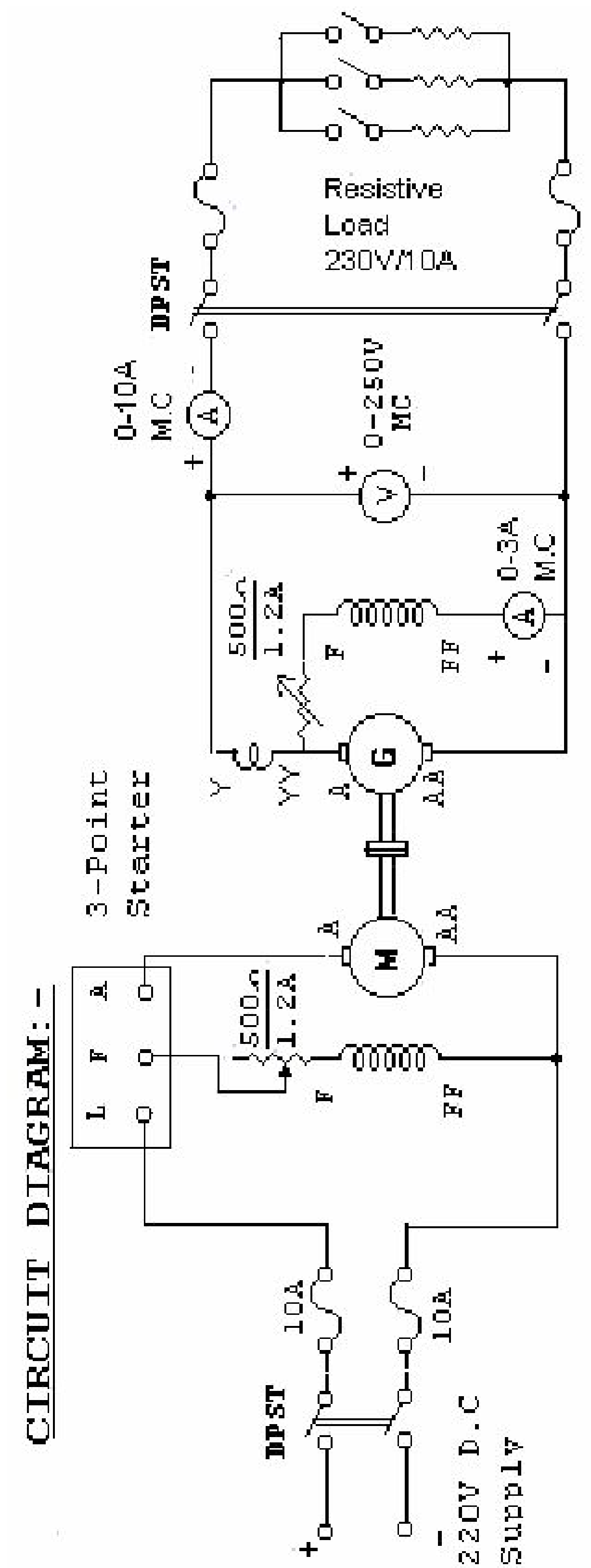
i) Cumulatively compounding generator.
ii) Differential compounding generator.

In cumulative compounding generator the flux produced by the series field winding must be right direction with the shunt field flux. ie the series field flux inphase with the shunt field flux. but in the case of differential compounding generator the flux produced by the series field winding is in such a direction that it should opposes the shunt field flux. there by the resultant flux decreases.

Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With motor field rheostat is in CUTOUT position, generator field rheostat in CUTIN position, ensuring that the 3-point starter handle is in initial position, and load switch in off position the supply switch is closed.
3. The 3-point starter handle is moved clock wise gradually, so that the motor starts.
4. The motor is brought to its rated speed by varying the motor field rheostat.
5. The generator field rheostat is varied gradually so that the generator voltage is built up to its rated value.
6. The load switch of the generator is closed
7. The load is applied in steps and for each step all the meter readings are noted.
8. Step No.(7) is repeated until the rated current of the generator is reached
9. The load is removed in steps, the load switch of the generator is opened the generator field rheostat is brought back to CUTIN position the motor field rheostat to CUTOUT position and the supply switch is opened.
10. The series field winding terminals of the generator are interchanged and the above procedure is repeated to get another type of compounding.

Note: If the first one is cumulative compound, second one will be differential compounding.


CIRCUIT DIAGRAM: -
3-Point Starter
L F A
500Ω / 1.2A
F FF
A M AA
A G AA
Y YY
500Ω / 1.2A
F FF
0-3A M.C
0-250V MC
0-10A M.C
DPST
Resistive Load 230V/10A
10A
10A
DPST
220V D.C Supply

Tabular Column:-

a) Cumulative Compounding:

Sl.no	I_L In Amps	V_L In volts	I_f In Amps	I_a In Amps	E_g In volts

b) Differential Compounding:

Sl.no	I_L In Amps	V_L In volts	I_f In Amps	I_a In Amps	E_g In volts

Specimen calculations:-

The Induced E.M.F $E_g = V_L + I_a R_a + I_L R_{sc}$

Nature of graph:-

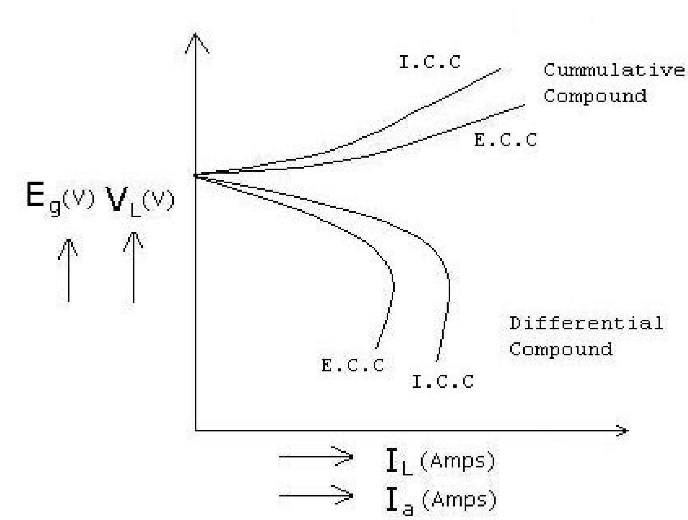


Fig: Internal (E_g Vs I_a) and External (V_L Vs I_L) Characteristics

Viva – Voce Questions:-

1. Mention the difference between cumulative and differential compound dc generator.
2. Sketch load characteristics of compound generators
3. How can you identify the machine whether it is cumulative, differential compounded machine?
4. When do you load the generator?
5. A generator will be loaded by a mechanical load (true or false).

Exp. No. 9

‘V’ AND ‘Λ’ CURVES OF A SYNCHRONOUS MOTOR

Aim:- To draw ‘V’ and ‘Λ’ curves of an auto induction start synchronous motor at no load and at different loads.

Apparatus:-

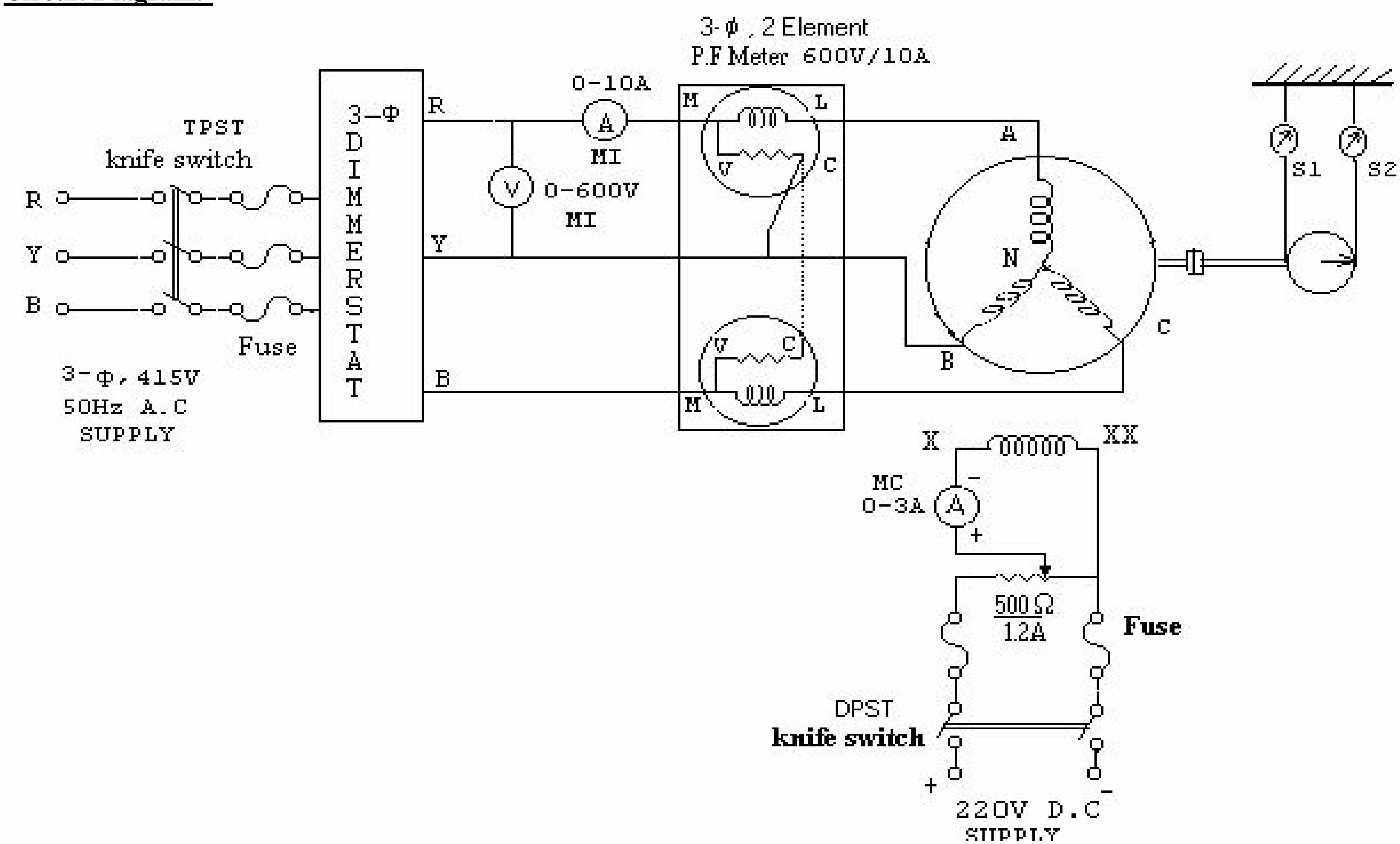
S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 3 A	1
2	Ammeter	(M.I)	0 – 10 A	1
3	Voltmeter	(M.I)	0 – 600 V	1
4	3-ϕ , 2 –element Power factor meter	Dynamometer	500 V / 10 A	1
5	Rheostat	Wire Wound	500Ω / 1.2A	1
5	3-ϕ Dimmer stat	Core type	415/0-470V, 10 A	1
6	Synchronous motor		3 HP, 415V, 3.5A	1
7	Connecting wires	PVC insulated		

Theory:-

When the field current of a synchronous motor is reduced, a lagging armature current is produced and that exceeds the minimum current at unity power factor at normal excitation. Similarly, when the motor is over excited the armature current also rises and exceeds the current required at normal excitation to develop to necessary torque at any given load. By applying a given constant load to the shaft of a synchronous motor and varying the field current from under excitation to over excitation and recording the armature current at each step, we can obtain the ‘V’ curves. The armature phase current is plotted against the DC field current both for no-load and load.

The power factor is plotted against the DC field current for no-load and load also note that both sets of curves show that a slightly increased field current is required to produce normal excitation as the load is increased, at no-load, the armature current at unity power factor is zero. But some small value of armature current is necessary to produce the torque to counter balance notational losses. As load is applied not only does the armature current lose, but also it is also necessary to increase the excitation to bring the armature current back in phase with the bus phase voltage.

Circuit Diagram:-



Procedure:-

1. The connections are made as shown in the circuit diagram.
2. Ensuring that the dimmer stat is at zero out put, the belt over the brake drum is loose , the 3-ϕ ac supply switch is closed.
3. The dimmer stat is gradually varied so that rated voltage is applied and the motor runs as an induction motor closed to the synchronous speed.
4. With the alternator field rheostat in cut in position the DC supply switch is closed. Due to the excitation of the field, the machine starts operating as a synchronous motor.
5. The field current is varied in steps from min value to max value using the rheostat all the meter readings are noted for each step.
6. The load is applied in steps to the motor by tightening the belt on the brake drum and step no 5 is repeated for each step of load.
7. The load is removed in steps by loosing the belt on the brake drum, the field rheostat is brought back to cutin position, the dc supply switch is opened and the ac supply switch is also opened.

Tabular column:-

No-load

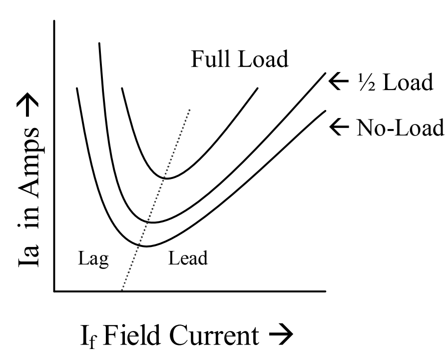
S.No	I_f In Amps	I_a In Amps	p.f

With Load:

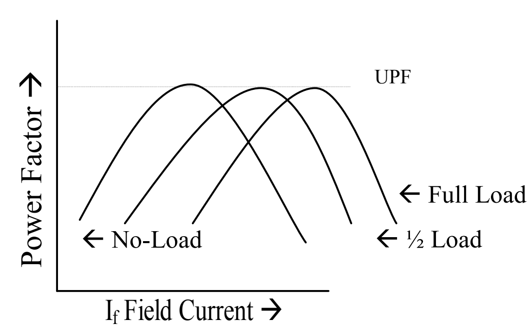
S.No	I_f In Amps	I_a In Amps	p.f

Nature Of Graph:-

'V'- Curves



Inverted 'V' - Curves



Viva Questions:-

1 What is meant by V curve of synchronous motor?
2. What is meant by inverted V of synchronous motor?
3. How the synchronous motor does behave, when it is under excited?
4. How the synchronous motor does behave, when it is over excited?
5. What is the nature of the power factor, when the motor is operated at over excited?
6. What is the nature of the power factor, when the motor is operated at no-load and under excited?
7. How does the synchronous motor behaves, when it is normal excited?
8. Where we use over excited synchronous motor?
9. At which power factor the motor will draw minimum armature current?
5. In which applications the synchronous motor can be used when it operated at over excited?
11. Application of synchronous motor
12. Whether the synchronous motor is self excited or not why?
13. What is under excitation?
14. What is over excitation?
15. What is normal excitation?

Exp. No. 10

REGULATION OF AN ALTERNATOR BY EMF METHOD

Aim:- To conduct open circuit and short circuit test on a 3-ϕ alternator and determine the full load regulation curve with E.M.F method.

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	(M.C)	0 – 1.5 A	1
2	Ammeter	(M.I)	0 – 10 A	1
3	Voltmeter	(M.I)	0 – 300 V	1
5	Rheostat	Wire Wound	500 Ω / 1.2 A	2
8	Tachometer	(digital)	0.99999 rpm	1
9	Motor alternator set		-	1
10	Connecting wires	PVC insulated	-	-

Theory:-

The voltage regulation of an alternator is defined as the increase in the terminal voltage when the load is through off, produced that the field excitation and the speed are constant.

$$\% \text{ regulation} = \frac{E - V}{V} \times 100$$

Where E – is the no-load voltage
V – is the load voltage

The variation is terminal voltage 'V' is due to the following reasons.

1. Voltage drop due to armature resistance Ra.
2. Voltage drop due to armature leakage reactance.
3. Voltage drop due to armature reaction.

Regulation of an alternator can be determined by measuring the voltage of the alternator, i.e. 'V' when loaded and 'E' when the load is taken off. In actual practice it will be difficult to load a big alternator in the testing laboratory as the laboratory may not have such heavy loads. More ever, during the testing period a considerable amount of electrical energy will be wasted as losses in the machine and in the load. This is why regulation of large alternators are not generally determined by direct loading method.

Regulation of an alternator can be determined from the results of the following two tests.

a. Open circuit test.
b. Short circuit test.

Open circuit test:-This test is carried out with the alternator running no-load and at rated speed. The field current and corresponding terminal voltage is recorded up to about 120% of rated terminal voltage. The characteristic shows the relationship between field current and terminal voltage on no-load is called the open circuit characteristic.

Short circuit test:-This test is performed when the alternator is running at rated speed. The armature terminals are short circuited with a very low excitation current and the field current corresponding to rated armature current is rated and a plot of field current versus armature current is called short circuited characteristic.

From these curves synchronous impedance can be calculated and then synchronous reaction can be separated as $X_S = \sqrt{Zs^2 - Ra^2}$

Procedure:-

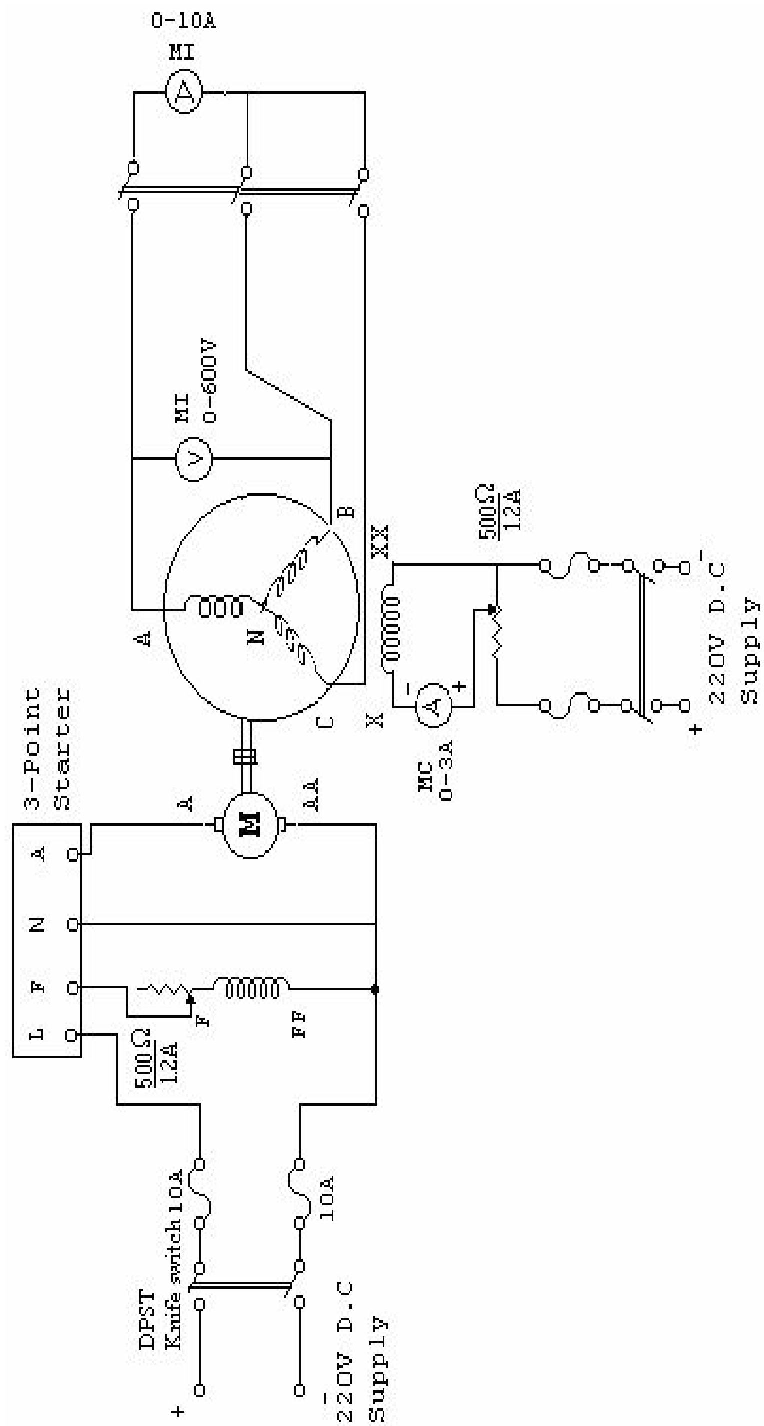
Open circuit characteristic Test

1. The connections are made as shown in the circuit diagram.
2. With the motor field rheostat in cut out position, the alternator field rheostat is cut in position, the 4-point starter handle is initial position and the TPST opened, the supply switch is closed.
3. The 4-point starter handle is moved slowly in the clockwise direction to cut out the resistance in the motor armature circuit so the motor starts.
4. The motor is brought to its rated speed, which is the rated speed of the alternator also by adjusting the motor field rheostat.
5. The dc supply switch of the alternator field is closed, the field current of the alternator is varied in steps and for each step the alternator voltage along with the field current are noted.
6. Stepno5 is repeated until the alternator voltage reaches about 120% of it rated value.
7. The alternator field rheostat is brought back to cutin position, the alternator field dc supply switch is opened, dc motor field rheostat is brought back to cutout position and the supply switch is opened.

Short circuit test:

1. Step no's 1, 2, 3 and 4 of o.c.c. test are repeated.
2. The TPST switch is closed, so that the alternator terminals are short circuited.
3. The dc supply switch of the alternator field is closed and the alternator field rheostat is varied such that the ammeter reads the rated current of the alternator and the corresponding field current is noted.
4. The TPST switch is opened, the alternator field rheostat is brought back to cut in position, the alternator field dc supply switch is opened, the motor field rheostat is brought back cut out position and the dc supply switch is opened.

Circuit diagram:-



Tabular column:-

O.C test:

Sl.No	I_f In Amps	E_0 In volts

S.C test:

Sl.No	I_f In amps	I_a In amps

Specimen calculations:-

D.C armature resistance per phase = R_{DC}

AC cumulative resistance per phase = 1.2 to 1.6 × R_{DC}

E.M.F. method (or) synchronous impedance method:

The synchronous impedance per phase $Z_s = \frac{E_0}{I_a}$ / at constant field current

$\therefore Z_S = \frac{\text{AC in volts}}{\text{AB in amps}}$ & Synchronous reactance $X_S = \sqrt{Zs^2 - Ra^2}$

% Regulation $= \frac{E_0 - V}{V} \times 100$

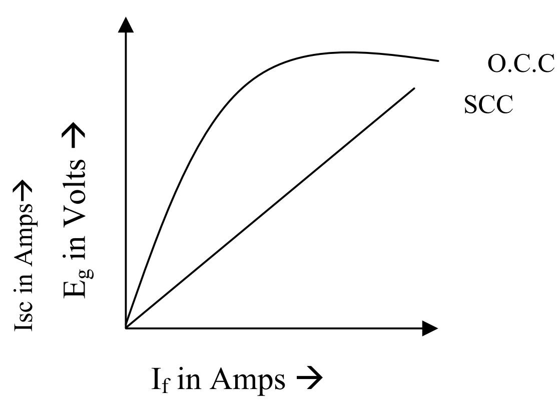
Where V – is the rated terminal voltage/phase

$$E_0 = \sqrt{(V\,\mathrm{Cos}\phi + I_a R_a)^2 + (V\,\mathrm{Sin}\phi \pm I_a X_s)^2}$$

(+) → for lagging power factor (-) → for leading power factor

for different power factors the regulation is calculated and tabulated

Nature of graph:-



Viva Questions:-

1. Why is it important to pre-determine the value of regulation of alternator?
2. What are the basic parameters on which regulation of alternator depends
3. What are the various indirect methods for finding out the regulation of alternator?
4. Which method gives fairly reliable value for regulation of alternator?
5. Why ZPF method is most reliable and accurate to find out the regulation of alternator?
6. Which of the method of finding out regulation is optimistic method?
7. Which of the method of finding out regulation is pessimistic method?
8. What is short circuit ratio (SCR)?
9. Can a dc generator be converted into alternator?
10. What is skin effect?
11. Why regulation up is considered in case of alternator?
12. What are the different excitation systems for synchronous machines?
11. How the alternators are classified
14. What is meant by hunting?
15. What is the difference between salient rotor and smooth cylindrical rotor?

Exp. No.11

LOAD TEST ON THREE PHASE INDUCTION MOTOR

Aim:- To conduct load test on three phase squirrel cage Induction motor and obtain the performance Characteristics.

Apparatus:-

Sl.	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 – 10A	1
2.	Voltmeter	(M.I)	0 – 600V	1
3.	Wattmeter U.P.F.	Dynamometer	10A/600V	1
4.	Tachometer	Digital	0-10,000 rpm	1
5.	3-ϕ Dimmer stat	Core type	415V/0-470V, 10A	
6.	3-ϕ Squirrel cage Induction motor with loading arrangements		Belt driven type Load	1
7.	Connecting wires	PVC insulated	-	-

Theory:-

The load test on induction motor is performed to compute its complete performance i.e. torque, slip, efficiency, power factor etc. during this test, the motor is operated at rated voltage and frequency and normally loaded mechanically by brake and pulley arrangement from the observed data, the performance can be calculated, following the steps given below.

Slip: The speed of the rotor, N_n droops slightly as load on the motor is increased.

Synchronous speed, $N_S = \frac{120f}{P}$ r.p.m. f → frequency

P → No. of poles

Then, slip $S = \frac{N_S - N_r}{N_S} \times 100\%$

Normally, the range of slip at full load is from 2 to 5 percent.

Torque: A brake drum is coupled to the shaft of the motor and the load is applied by tightening the belt, provided on the brake drum.

Net force exerted, $\omega = (S_1 - S_2)$ kg

Then, load torque, $T = \omega \times \frac{d}{2} \text{kg} - \text{m}$

$$= \omega \times \frac{d}{2} \times 9.81\, \text{N}\omega - \text{m}$$

Where, d is-effective diameter of the brake drum in meters.

Output power: The output power in watts developed by the motor is given by

Output power, $P_0 = \frac{2\pi NT}{60}$ watt

Where N is the speed of the motor in r.p.m

Power factor: If ϕ is the power factor angle, then $\cos\phi = \frac{\omega}{\sqrt{3}VI}$

Where ω is the input power.

Efficiency: Percentage efficiency of the motor, $\eta = \frac{\text{output power}}{\text{input power}}$ X 100

Full load efficiency of 3-phase induction motor lies in the range of 82% (For small motor) to 92% (For very large motors)

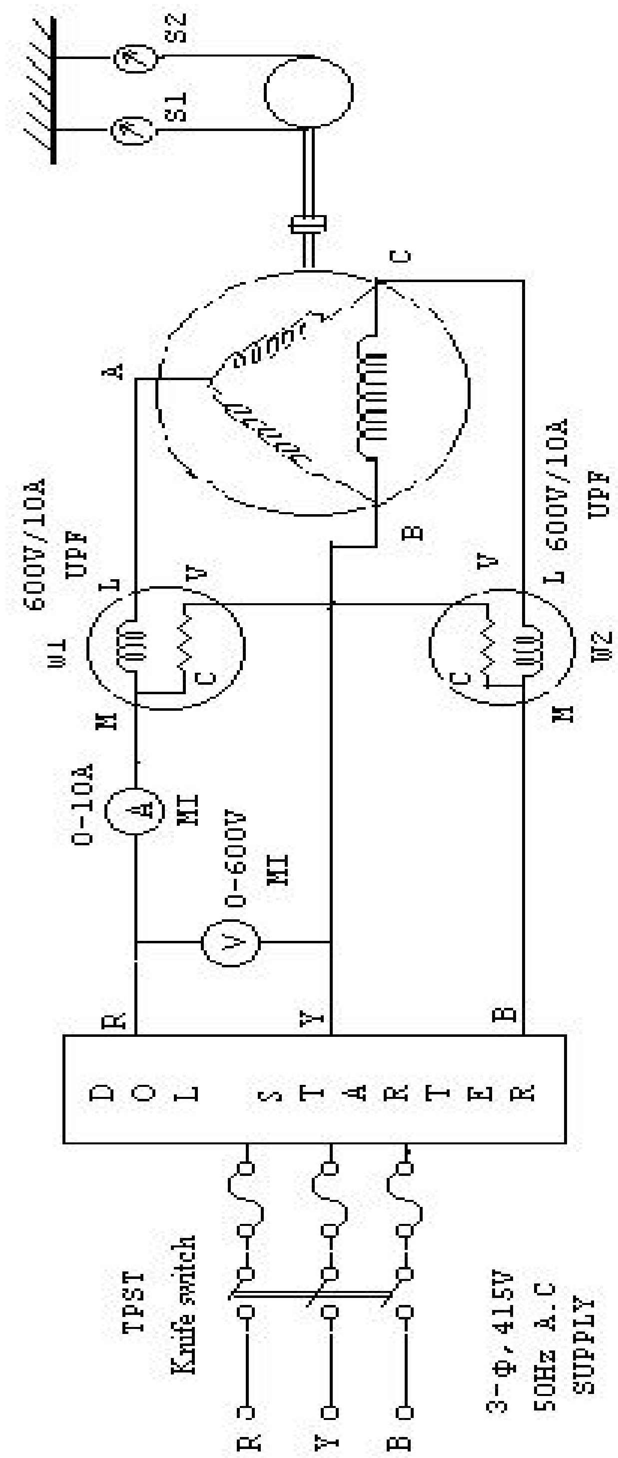
Procedure:-

1) The connections are made as shown in the circuit diagram.
2) Ensuring that the dimmerstat is at zero output and the belt over the brake drum is totally loosened, the supply switch (TPST) is closed
3) The dimmerstat is gradually varied so that the motor is brought to its rated speed and all the meter readings as well as speed are noted.
4) The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
5) Step no.4 is repeated until the rated current of the motor is reached.
6) The load is removed in steps, the Dimmerstat is brought back to zero output and the supply switch is opened.

Tabular column:-

S.l No	V_L in volts	I_L in Amps	W_1 in Watts	W_2 in Watts	S_1 In kgs	S_2 In kgs	W_T in Watts	Speed in rpm	Torque in N-m	Output In Watts	η in %	Power Factor $\cos\phi$	Slip in %

Circuit diagram:-



Specimen calculations: -

Wattmeter constant $= \dfrac{\text{voltage range of } W \times \text{current range of } W}{\text{Maximumum Wattmeter scale reading}}$

1. Input Power = ($W_1 \pm W_2$) watts

2. Torque $= (S1 \sim S2) * R * 9.81$ N-m

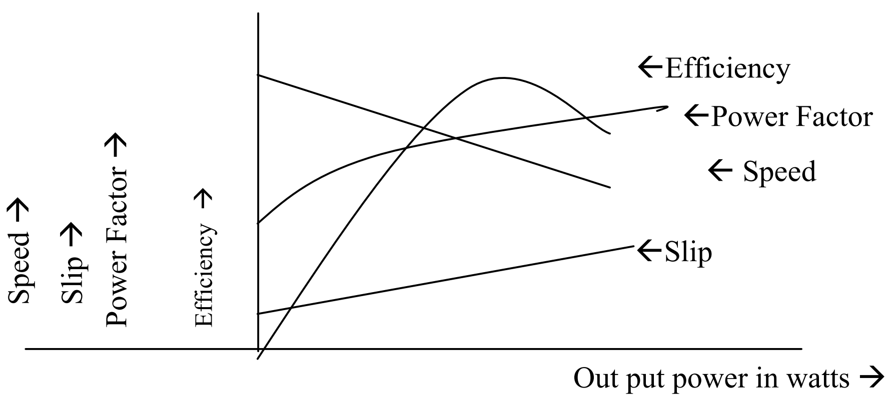
3. Out put Power $= \dfrac{2\prod NT}{60}$ watts

4. % Efficiency $= \dfrac{Output\ power}{Input\ power} \times 100$

5. Power Factor $= \text{COS}\ \phi = \text{COS}\left\{Tan^{-1}\sqrt{3}\,\dfrac{(w_1 - w_2)}{(w_1 + w_2)}\right\}$

6. % Slip $= \dfrac{Ns - N}{Ns} \times 100$ where $Ns = \dfrac{120f}{P}$ r.p.m

Nature of graph:-



Viva Questions:-

1. What are various types of three phase induction motor as per rotor construction?
2. What is the basic operation of a three phase induction motor?
3. How the starting torque can be increased in squirrel cage motors?
4. How does the slip vary with load?
5. What is the percentage slip at full load (appox)?
6. What is meant by cogging (magnetic locking)?
7. What is meant by crawling?
8. How much is appox the starting current drawn by three phase induction motor, when started at rated voltage in terms of full load current?
9. What happens to the induction motor when it rotates at synchronous speed?

Exp. No.12

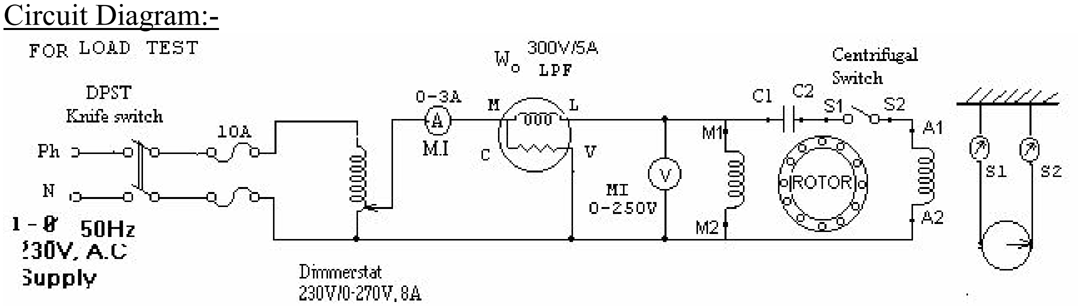
LOAD TEST ON 1-ϕ CAPACITOR START INDUCTION MOTOR.

Aim:- To conduct the load test on 1-ϕ induction motor and determine its performance characteristics.

Apparatus:-

S. No	Apparatus	Type	Range	Qty
1	Voltmeter	(M.I)	0 – 250 V	1
4	Ammeter	(M.I)	0 – 10 A	1
6	Wattmeter (U.P.F.)	Dynamometer	300V/10A	1
7	Dimmer stat	Core type	230 V / 0-270 V	1
8	1-ϕ Capacitor start Induction motor		230V, 5A	-
9	Connecting wires	PVC insulated	-	-

Circuit Diagram:-



Procedure:-

1. The connections are made as shown in the circuit diagram.
2. With the dimmer stat at zero out put the supply switch is closed.
3. The dimmer stat is varied such that the rated voltage is applied to the motor and all the meter readings are noted in the tabular column.
4. The load is applied in steps and for each step all the meter readings, spring balance readings as well as speed are noted.
5. Step no.4 is repeated until the rated current of the motor is reached.
6. The load is removed in steps, the dimmer stat is brought back to zero out put and the supply switch is opened.

Tabular column:-

Sl. No	V_L in Volts	I_L in Amps	W_T in watts	S_1 in Kgs	S_2 in Kgs	W_T in watts	Speed in RPM
	.						

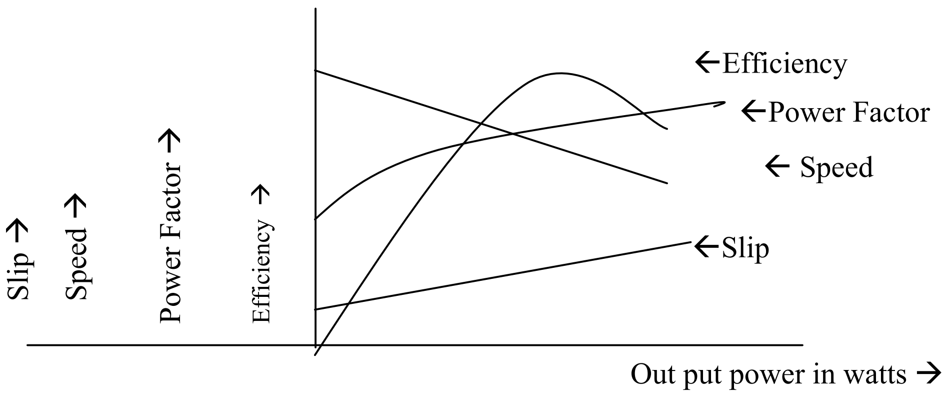
Torque n N-M	Output in Watts	η in %	Power factor Cosϕ	

Specimen calculations: -

Wattmeter constant $= \frac{voltage\ range\ of\ W \times current\ range\ of\ W}{Maximumum\ Wattmeter\ scale\ reading}$

1. Input Power = (W_1) watts
2. Torque = $(S1 \sim S2) * R * 9.81$ N-m
3. Out put Power = $\frac{2 \prod NT}{60}$ watts
4. % Efficiency = $\frac{Output\ power}{Input\ power} \times 100$
5. Power Factor = COS ϕ = P/VI

Nature of graph:-



<u>Viva Questions:-</u>

1. Which theory is commonly used for the analysis of 1-Φ induction motor?
2. What is the slip of forward and backward rotor?
3. How many winding are provided on the stator of split-phase induction motor?
4. What is the phase displacement in space between the two winding?
5. How these two windings connected at the time of starting the motor?
6. How much is the phase splitting between these two windings?
7. How the phase splitting between two windings can be increased?
8. At what speed of the motor ,starting winding is disconnected from the circuit of main winding?
9. How the auxiliary winding is disconnected from the circuit of the main winding?
10. What will happen, if the starting winding is not disconnected during the normal running conditions of the motor?
11. Why 1-Φ induction motor is not self starting?
12. What is the necessity of connecting capacitor in series with the starting winding?
13. What are the advantages of connecting a capacitor?
14. How do you reverse the direction of rotation of the capacitor start induction motor?
15. What is the difference between capacitor start and capacitor run induction motor?

Exp. No.13

OPEN CIRCUIT AND SHORT CIRCUIT TESTS ON 1-ϕ TRANSFORMER

Aim: -Conduct the open circuit and short circuit test on 1-ϕ transformer and determine the efficiency and regulation at different loads.

Apparatus: -

Sl.No	Apparatus	Type	Range	Qty
1.	Ammeter	(M.I)	0 - 3A	1
2.	Ammeter	(M.I)	0 – 10A	1
3.	Voltmeter	(M.I)	0 – 30V	1
4.	Voltmeter	(M.I)	0 – 115V	1
5.	Wattmeter L.P.F	Dynamometer	2.5A/150V	1
6.	Wattmeter U.P.F.	Dynamometer	10A/75V	1
7.	Variac	Core type	230V/0-270V, 8A	1
8.	1-ϕ Transformer	Core type	230V/115V 2kVA	1
9.	Connecting wires	P.V.C Insulated	-	-

Theory:-

By conducting O.C. and S.C. tests on a given transformers we can predict the efficiency, regulation and equivalent circuit without actually loading it. The purpose of this test is to determine no-load loss (or) core loss and no-load current, which is helpful in finding x_0 and R_0.

In O.C test one winding of the transformer usually high voltage winding is left open and the other is connected to its supply of normal voltage and frequency. A wattmeter w, voltmeter V, and an ammeter A are connected in L.V. winding, with the normal voltage is applied to the primary, normal flux will be setup in the core hence normal iron losses will occur which are recorded by the wattmeter. The no-load current is small so copper loss is negligibly small. Hence the wattmeter reading represents practically the core loss.

In S.C. test one winding, normally L.V. winding is short-circuited and meters are connected in H.V. side. Very low voltage is applied on H.V. side and it is increased slowly until full load current is flowing in the winding. Under these conditions wattmeter reading represents the full load copper loss. There is also a small amount of core loss, which is negligible compared to the copper loss.

Procedure:-

For O.C Test:-

7) The connections are made as shown in the circuit diagram .
8) With the dimmer stat at zero output, the supply switch (DPST) is closed.
9) The output of the dimmer stat is adjusted such that the voltmeter reads the rated voltage at the L.V winding of the transformer and all the meter readings are noted in the tabular column.
10) The dimmer stat is brought back to zero output and the supply switch (DPST) is opened

For S.C Test:-

1) The connections are made as shown in the circuit diagram .
2) With the dimmer stat at zero output, the supply switch is closed.
3) The output of the dimmer stat is adjusted such that the ammeter reads the rated current at the H.V winding of the transformer and all the meter readings are noted in the tabular column.
4) The dimmer stat is brought back to zero output and the supply switch is opened

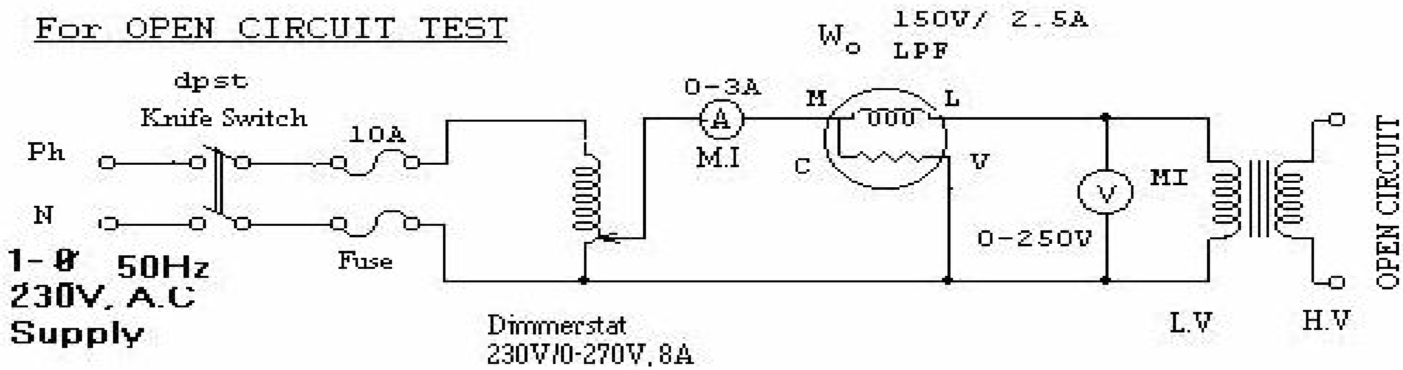
Tabular Column:-

	Open circuit test			Short circuit Test		
S.l No	V_o in volts	I_o in Amps	W_o in Watts	V_{SC} in volts	I_{SC} in Amps	W_{SC} In Watts

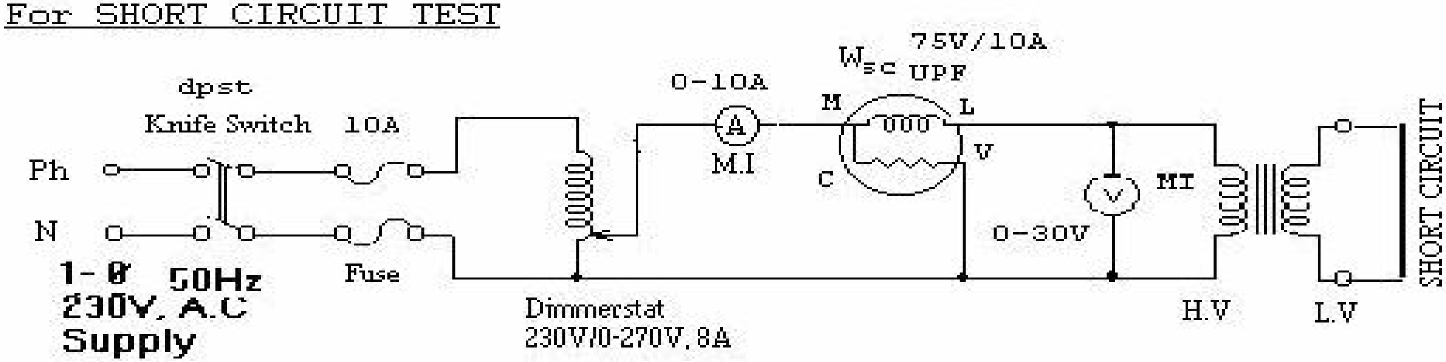
S.l No	COS ϕ_o	I_w in Amps	I_m in Amps	R_o in Ω	X_m in Ω	Cos ϕ_{sc}	R_{eq} in Ω	X_{eq} in Ω	W_{SC} In Watts

Circuit Diagram:-

For OPEN CIRCUIT TEST



For SHORT CIRCUIT TEST



Specimen calculations:-

Rated current of transformer $= \dfrac{\text{KVA rating of transformer}}{\text{Supply voltage}}$

Wattmeter Multiplication factor $= \dfrac{\text{Voltage Range X Current Range}}{\text{Maximum wattmeter scale reading}} \times \text{Power factor}$

Input Power = Wattmeter reading X Wattmeter Multiplication factor

1. $Cos\phi_0 = \dfrac{w_0}{v_0 i_0}$ 2. $I_W = I_0 \text{Cos}\phi_o$ 3. $I_m = I_0 \text{Sin}\phi_o$ 4. $R_o = \dfrac{V_o}{I_w}$

5. $X_m = \dfrac{V_o}{I_m}$ 6. $R_{eq} = \dfrac{W_{sc}}{I_{sc}^2}$ 7. $Z_{eq} = \dfrac{V_{sc}}{I_{sc}}$ 8.

$X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$

% Efficiency at full load = $\dfrac{FullloadVA \times Cos\phi}{FullloadVA \times Cos\phi + W_o + W_{sc}} \times 100$

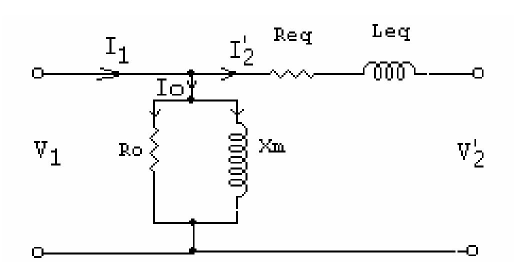
Efficiency at any load X*F.L, where X = ¼ or X= ½ or X = ¾

% Efficiency at X.* F.L = $\dfrac{X \cdot FullloadVA \times Cos\phi}{X \cdot FullloadVA \times Cos\phi + W_o + X^2 W_{sc}} \times 100$

% Regulation = $\dfrac{R_{eq} COS\phi \pm X_{eq} SIN\phi}{V_{rated}}$ X 100

where + is for Lagging P.F
- is for Leading P.F

Equivalent Circuit:-



R_o, X_m – are refered to L.V Side

R_{eq}^1. X_{eq}^1 – Refered to H.V Side

These values refered L.V Side are

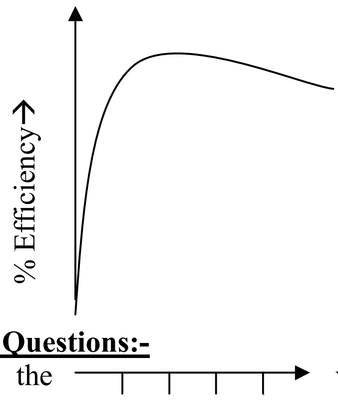
$$R_{eq} = \frac{R_{eq}^1}{k^2}$$

$$X_{eq} = \frac{X_{eq}^1}{k^2}$$

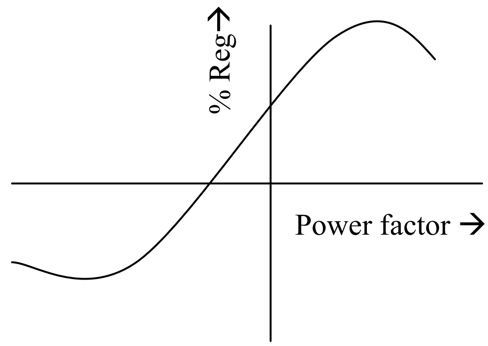
where k = $\dfrac{N_{21}}{N_1} = \dfrac{E_2}{E_1}$

Nature of graph:-

a) % Efficiency Vs Load



b) % Regulation Vs Power Factor



Viva – Voce Questions:-

1 What is the working principle of a transformer?
2. Name the different types of transformers?
3. Write the EMF equation of the transformer.
4. What is an ideal transformer?
5. What are the losses takes place in a transformer?
6. Define step-up and step-down transformers?
7. Why the transformer rating in KVA?
8. From Open Circuit Test which losses are determined?
9. From Short Circuit Test which losses are determined?
10. A single phase, 2 KVA, 230/115V transformer is connected to OC test. Calculate the rated primary current and why the ammeter rating is fixed as (0-3)A?
11. A single phase, 2 KVA, 230/115V transformer is connected to SC test. Calculate the rated primary current and why the voltmeter rating is fixed as (0-30) volts?
12. What is the condition for maximum efficiency in a transformer?
13. Define the Efficiency of a transformer?
14. For a particular voltage constant, if the frequency is increases, what are the changes takes place in a transformer?
15. Define regulation?
16. Define All-Day efficiency?
17. In this experiment we got the Maximum efficiency at ½ full loads, why?

Exp. No.14

PARAMETERS AND EQUIVALENT CIRCUIT OF 3-ϕ SLIP RING INDUCTION MOTOR

Aim: To conduct no-load and blocked rotor tests on 3-ϕ slip ring induction motor and determine the equivalent circuit parameters

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I	0-5A 0-10A	1 1
2	Voltmeter	M.I	0-600V 0-300V	1 1
3	Wattmeter LPF	Dynamometer	500V/5A	1
4	Wattmeter UPF	Dynamometer	250V/10A	1

Procedure:

No-load test:

1. The connections are made as in the circuit diagram
2. Ensuring that the dimmerstat is at zero output, the belt over the brake drum is totally loosened and the rotor resistance is at maximum value, the TPST switch is closed
3. The dimmerstat is gradually varied so that the motor is brought to its rated speed by applying rated voltage and the rotor resistance is cutout gradually and all the meter readings are noted in the tabular column
4. The rotor resistance is brought back to maximum value, the dimmerstat to zero output position and the TPST supply switch is opened.

Blocked rotor test:

1. The connections are made as in the circuit diagram
2. Ensuring that the dimmerstat is at zero output, the belt over the brake drum is tightened so that the rotor is blocked and the TPST switch is closed
3. The dimmerstat is gradually varied so that the rated current of the motor is passed and all the meter readings are noted in the tabular column
4. The dimmerstat is brought back to zero output position and the TPST supply switch is opened and the belt over the brake drum is totally loosened.

Tabular column:

No-load test:

S.No	V_o Volt	Io Amps	W_o Watts	$\cos\phi_o$

Blocked rotor test:

S.No	V_{BR} Volt	I_{BR} Amps	W_{BR} Watts	$Cos\phi_{BR}$

Specimen Calculations:
From No-load test:

Stator resistance/Ph R_1=__________________ohms

No-load power factor $\cos\phi = \frac{W_o}{\sqrt{3}V_o I_o}$

Where V_o= no load voltage (line to line)
I_o = no load current
W_o= no load input power

Magnetizing current $I_\mu = I_o \sin\phi_o$

Core loas current component $I_w = I_o \cos\phi_o$

No load resistance $Ro = \frac{V_o/\sqrt{3}}{I_W}$

Magnetizing reactance $X_m = \frac{V_o/\sqrt{3}}{I_\mu}$

From Blocked rotor test:

Equivalent impedance per phase $Z_{01} = \frac{V_{BR}/\sqrt{3}}{I_{BR}}$

Equivalent resistance $R_{01} = \frac{W_{BR}}{3xI^2{}_{BR}}$

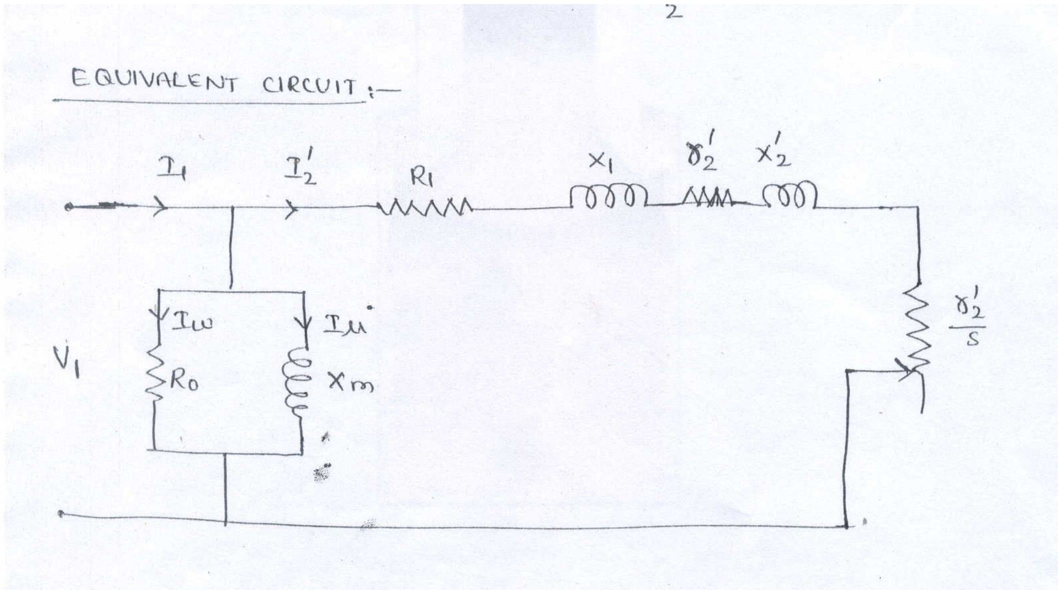
Equivalent reactance $X_{01} = \sqrt{Z^2{}_{01} - R^2{}_{01}}$

Stator resistance per phase R_1=________________ohms

Rotor resistance per phase referred to stator, $R^1{}_2 = R_{01} - R_1$

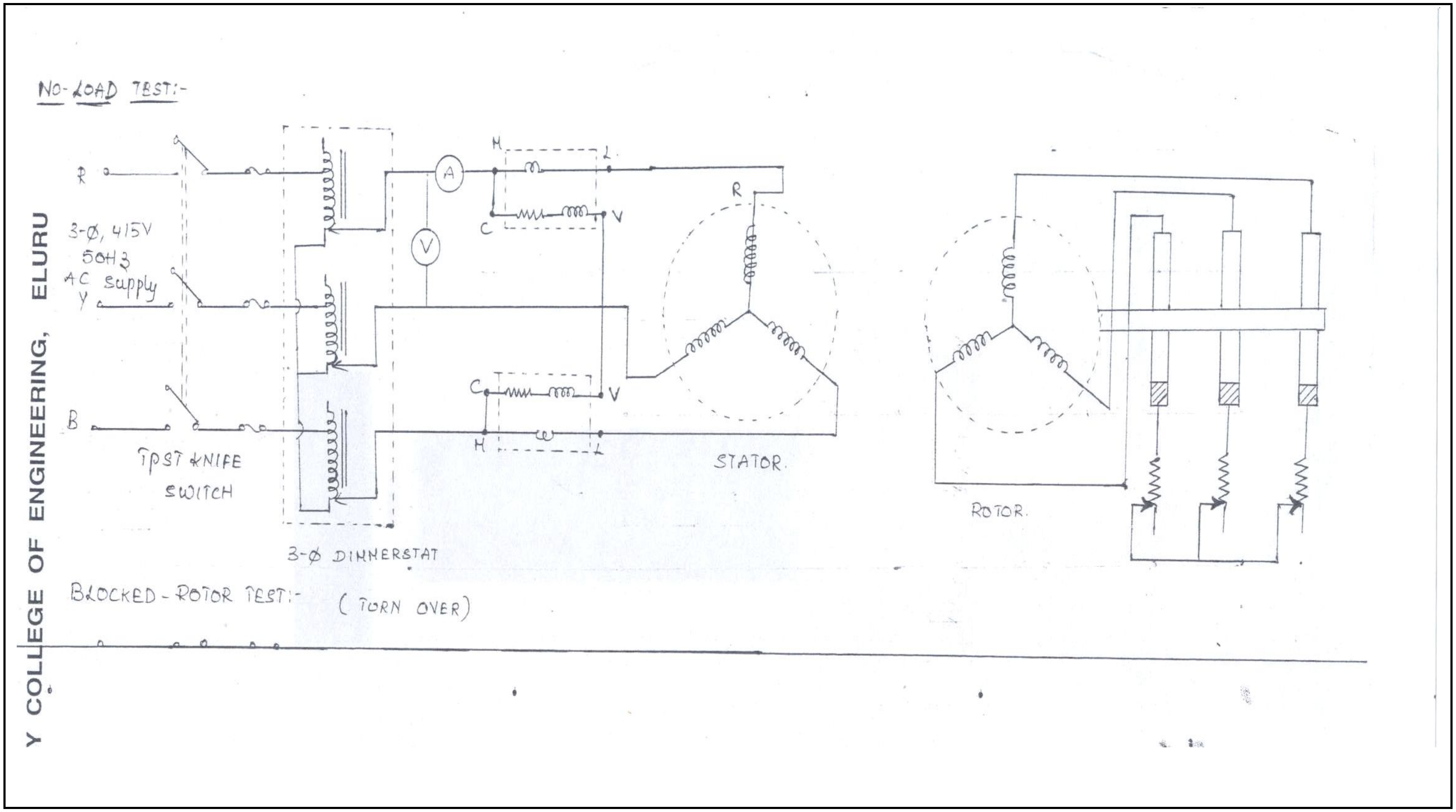
Assume that ; Stator reactance = rotor reactance referred to stator

i;e $X_1 = X^1{}_2 = \frac{X01}{2}$

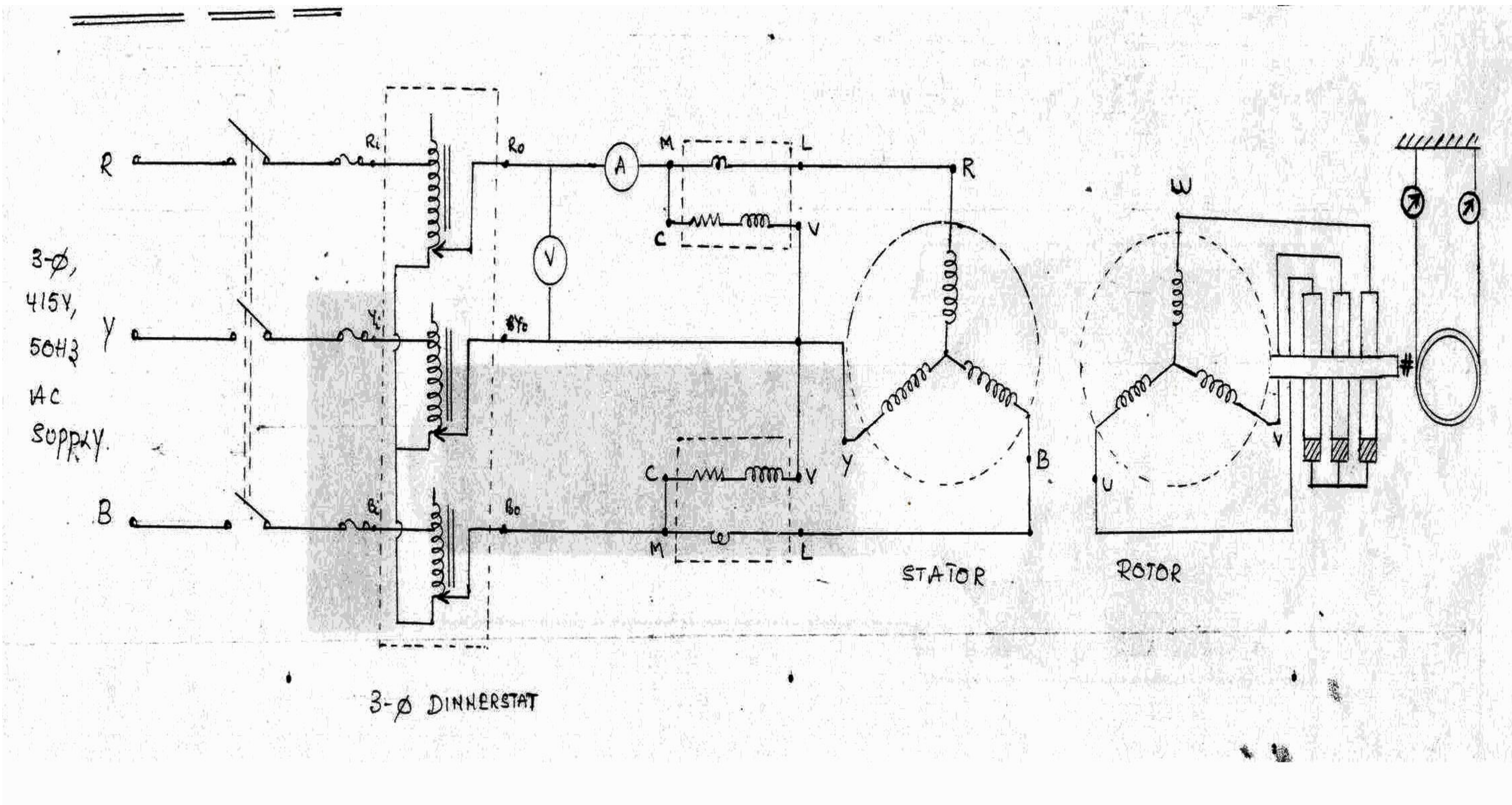


Result:

No-Load Test:


NO-LOAD TEST:-
R
3-Ø, 415V
50Hz
AC supply
Y
B
TPST KNIFE
SWITCH
3-Ø DIMMERSTAT
A
V
M
L
C
V
R
STATOR.
ROTOR.
BLOCKED-ROTOR TEST:-
(TURN OVER)

Blocked Rotor Test:



Viva Questions:-

1. In which type of induction motor, considerably high starting torque can be achieved?
2. How high starting torques are obtained in slip ring induction motors?
3. Why the rotor of an induction motor cannot run at synchronous speed, if it did so then what happens?
4. Why 3-phase induction motor is running at half full load. If the fuse in one of the phases burn, what happens to the motor?
5. In a 3-phase induction motor the electrical representation of the variable mechanical load is
6. Why core losses are neglected in blocked rotor test and copper losses are neglected in no load test?
7. Why we multiply DC resistance to AC with a value of 1.2 to 1.6?
8. Why we are using LPF wattmeters incase of no load test?
9. what precautions we have to take before switching on the supply in case of no-load test and blocked rotor test.
10. If two induction motors are identical in all aspects. if motor A has lesser air gap then motor B.Explain which of the motor will have a) poor no load power factor b) better full load power factor
11. Enumerate the possible reasons if 3-phase induction motor fails to start?
12. What is meant by single phasing?
13. Can a 3-phase induction motor run at 1-phase supply?
14. Can slip ring induction motor be reversed by transposing any two leads from sling rings?
15. What is the material used to make slip rings?