DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

MANUAL FOR EEE 417
ELECTRICAL MACHINES LABORATORY

(A.C.MACHINES)

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

EEE 417 ELECTRICAL MACHINES LABORATORY

(4/4 EEE, I Semester)

1. Sumpner's test
2. Scott connection
3. Equivalent circuit of a 1-ϕ Capacitor start Induction Motor
4. Load Test on a 3-ϕ Squirrelcage Induction Motor
5. Equivalent circuit & Circle diagram of a 3-ϕ Squirrelcage Induction Motor
6. Equivalent circuit of a 3-ϕ Slip-ring Induction Motor
7. Induction generator
8. V & Λ Curves of Synchronous Motor.
9. Regulation of alternator by a) EMF b) MMF c) ZPF Methods
10. Synchronization of Alternator.
11. Separation of no load losses of a transformer
12. Separation of no load losses in a 3Φ induction motor
13. Measurement of sequence reactances of alternator
14. Study of turbo 2000

Exp. No.1

SUMPNER'S TEST

Aim: - To predetermine the efficiency & regulation at any load and power factor for a pair of identical transformers by conducting Sumpner's test. (Back to Back Test) and also draw the equivalent circuit.

Apparatus: -

S. No	Apparatus	Type	Range	Qty
1	Ammeter	M.I		1
2	Ammeter	M.I		1
3	Voltmeter	M.I		3
4	Wattmeter (L.P.F)	Dynamometer type		1
5	Wattmeter (U.P.F)	Dynamometer type		1
6	Dimmerstat	Core type		1
7	Identical transformer pair			1
8	Booster transformer			-
9	Connecting wires	P.V.C insulated		-

Theory:-

The efficiency and regulation of a transformer can be determined by OC and SC tests. If the maximum temperature rise of the machine is to be determined, then it must be connected to its full load for a long time. In case of large transformers i.e power transformers it is difficult to have such large loads and also it is waste of electric power because of this sumpner's test is conducted on two identical transformers.

This test requires two identical transformers whose load voltage windings are connected in parallel and are energized at rated voltage and rated frequency.

With the secondaries open the wattmeter records of the transformers. Then the two secondaries are connected in with phase opposition, which is checked by the voltmeter V_2 which has a range double the rated voltage of either transformer. If this V_{ab}=0 then the secondaries are in opposite phase, if this is not case the terminals are interchanged.

If the temperature of the transformer is to be measured, then the two transformers is to be measured, then the two transformers are kept under rated loss condition, for several hours, still maximum stable temperature is reached. Since the two transformers do not work under identical conditions on may have slightly less temperature than the other.

Procedure:-

1. Make the connections as shown in the circuit diagram
2. Adjust the Dimmer stat at zero output position, and keep SPST switch in open position then close the supply main (DPST)
3. Adjust the Dimmer stat output gradually such that the voltmeter (V_1) reads rated voltage of the primary winding.
4. If voltmeter (V_2) reads double the secondary winding voltage interchange the secondary winding terminals of the transformer and once again observe the voltmeter (V_2) reading.
5. If V_2 reads zero close the SPST switch.
6. Switch on the booster transformer, and adjust it to circulate full load current in the secondaries.
7. The readings of the meters in the primary & secondary circuits are read at full load &tabulate the readings
8. Make all the meter readings zero & open the supply switch

Tabular column:-

Main Circuit:-

V_o (Volts)	I_o (Amps)	W_o (Watts)	$Cos\phi_o$	Loss per transformer$W_o/2$ (Watts)

Booster circuit:-

Booster Output Voltage(V_z) (Volts)	Isc (Amps)	Wsc (Watts)	$Cos\phi_{sc}$	Loss per transformer (Watts)

Model Calculations:-

Core loss per Transformer - $W_o/2$

Copper loss per transformer - $W_{sc}/2$

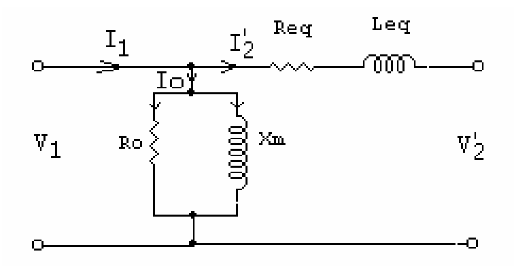
$$\text{Efficiency (\%)} = \frac{X \text{ x KVA x } Cos\phi}{X \text{ x KVA x } Cos\phi + W_i + X^2.W_{CU}}$$

$$\text{\% Regulation} = \frac{I.R.Cos\phi \pm I.X.Sin\phi}{V} X100$$

$$Z_{eq} = \frac{V_Z}{Isc} \qquad R_{eq} = \frac{Wsc}{2Isc^2} \qquad X_{eq} = \sqrt{Z_{eq}{}^2 - R_{eq}{}^2}$$

$$Cos\phi_o = \frac{W_o}{V_o I_o} \qquad I_W = I_o Cos\phi_o \qquad I\mu = I_o Sin\phi_o \qquad R_O = \frac{V_O}{Iw} \qquad X_o = \frac{V_O}{I_m}$$

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

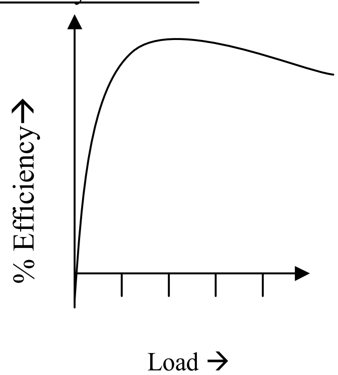
$$R_{eq} = a^2 R_{eq}^{1}$$

$$X_{eq} = a^2 X_{eq}^{1}$$

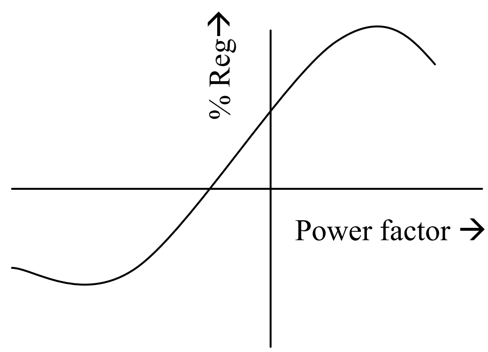
where a = $\frac{N_1}{N_2} = \frac{L.V}{H.V}$

Nature of graph:-

a) % Efficiency Vs Load



b) % Regulation Vs Power Factor



Viva-Questions:-

1. What is the advantage of this test?
2. What are the various methods for obtaining experimentally the performance of the transformer?
3. How the primaries of the two transformers are connected in this test?
4. How the secondaries are connected in this test?
5. What does the wattmeter's on the primary side of the transformers record?
6. What is the condition for maximum efficiency?
7. Why transformer rating is in KVA?
8. Define regulation?
9. Why do we conduct sumpners test?
10. Why sumpners test is known as back-to-back test?
11. What are limitations of sumpners test?
12. What is the purpose of booster transformer in sumpners test?
13. What is condition of power factor to obtain zero regulation in case of sumpners test?
14. How much power is drawn from the supply?
15. How much voltage is required to obtain rated current in the secondary circuit under SC conditions?
16. What is the range of no load current?

Exp. No.2

SCOTT CONNECTION

Aim:- To convert 3-ϕ supply to 2-ϕ supply

Apparatus:-

S. No	Apparatus	Type	Range	Qty
1	Voltmeter	M.I		4
2	Ammeter	M.I		1
3	3-ϕ Dimmerstat	Core type		1
4	Transformer			1
5	Connecting wires	P.V.C insulated		1

Theory:

Scott connection can be used to convert a 3-ϕ supply to 2-ϕ supply and vice versa. It can be also used to obtain 1-ϕ supply with all lines properly balanced for a 3-ϕ to 2-ϕ connection. Consider the scott connection. In this two single phase transformers one is called 'main' and other is 'teaser' having same number of secondary turns [N_2] are taken primary of main transformer is centre-tapped and has N_1 primary turns, primary of teaser transformer has $\frac{\sqrt{3}}{2}N_1$, turns, the two transformers are connected to each-other and 3-ϕ supply is given for the 2-ϕ system the voltage induced in the two secondary windings to have the same magnitude the above connection is adopted. This can be proved as followed

If 'V' is the supply voltage across R-Y, Y-B from the phasor diagram voltage between points R and Y(-Ve) can be calculated from to triangle R_{SB}

$$V_{RS} = \sqrt{V^2 - \left(\frac{V}{2}\right)^2} = \sqrt{\frac{3}{2}V}$$

At the same time the number of turns between R and S are also kept by choice at $\frac{\sqrt{3}}{2}N_1$ turns. Hence the volt per turn of the teaser transformer is V/N_1 same as that for main transformer hence voltage induced in the two secondaries will have same magnitude but will be in phase–quadrature.

The neutral point N divides teaser primary turns in the ratio of 1:2

Procedure:-

1 Make the connections as per the circuit diagram.
2 Place the auto-transformer in the minimum output position and switch on the supply.
3 Increase variac output voltage to rated voltage of single phase (main) transformer.
4 Note down the readings.
5 Take the readings for lower variac settings also.

Tabular column:-

S.No	I_1 in Amps	V_1 in Volts	V_{21} in Volts	V_{22} in Volts	V_{23} in Volts	$\sqrt{2}V_{21}$ or $\sqrt{2}V_{22}$ volts

Model Calculations:-

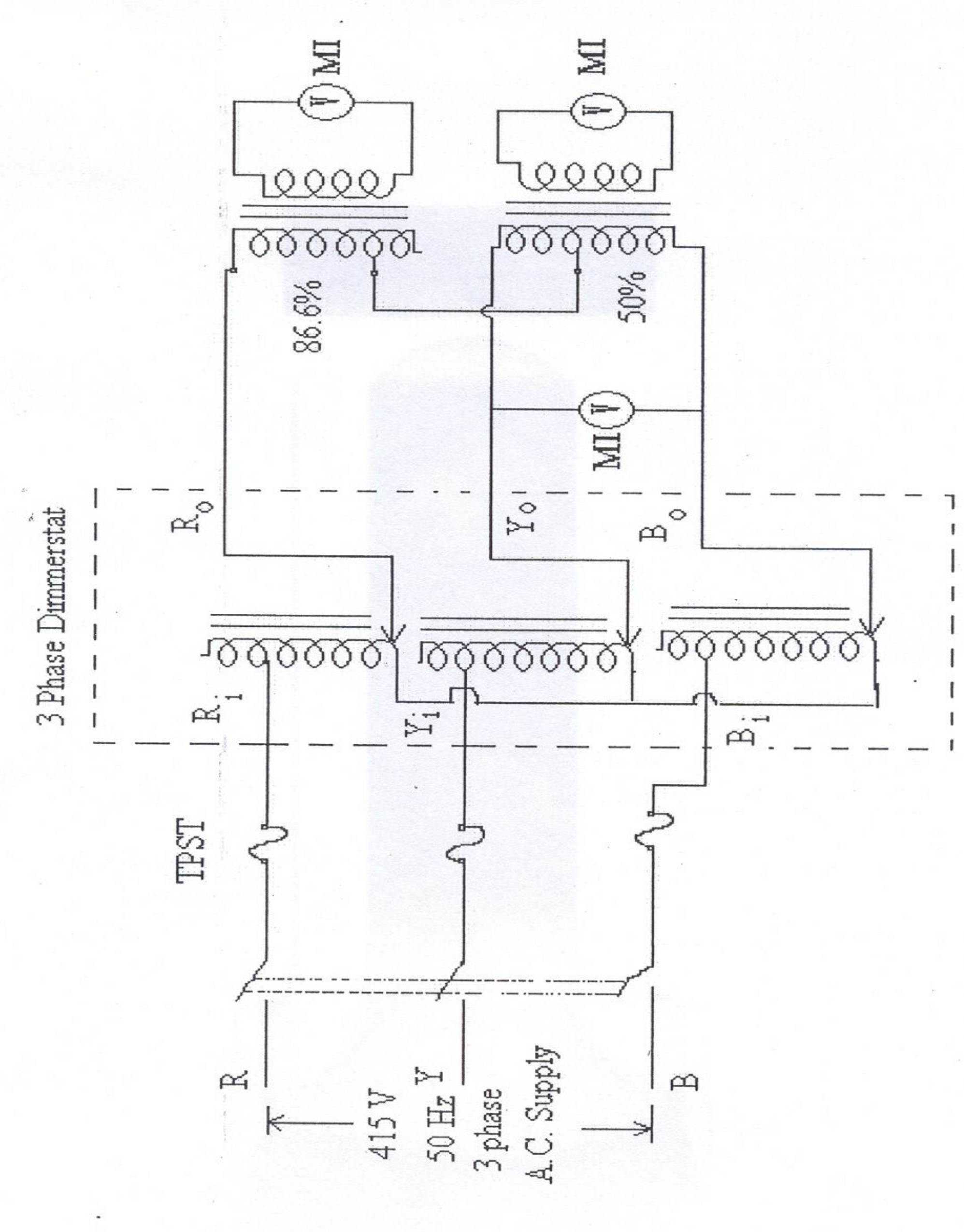
$\sqrt{2}V_{21}$ =
$\sqrt{2}V_{21}$ =
$\sqrt{2}V_{21}$ =
$\sqrt{2}V_{21}$ =

Result:-

Viva Questions:-

1. What is achieved by Scott-connection of transformer?
2. What is major field of application of a 2-phase ac system obtained from Scott-connection?
3. Where is the position of neutral point of 3-phase balanced acsystem in this connection?
4. What is the phasor difference between the output voltages of Scott-connection?
5. What is the advantage of Scott-connection?
6. What is the voltage rating of the teaser transformer?
7. What is the relation between current & voltage in teaser transformer and main transformer?
8. Under balanced condition what is the rating of main transformer?
9. Why T-T transformer cannot be parallel with λ-Δ transformer?
10. For a particular voltage constant, if the frequency increases what are the changes that take place in a transformer?

Circuit diagram for Scott Connection



Exp. No 3

EQUIVALENT CIRCUIT OF 1-ϕ CAPACITOR START INDUCTION MOTOR.

Aim:- To conduct the no-load and blocked motor test on a 1-ϕ capacitor start induction motor to draw its equivalent circuit.

Apparatus:-

S. No	Apparatus	Type	Range	Qty
1	Voltmeter	M.I		1
2	Voltmeter	M.I		1
3	Ammeter	M.I		1
4	Ammeter	M.I		1
5	Wattmeter (L.P.F.)	Dynamometer type		1
6	Wattmeter (U.P.F)	Dynamometer type		1
7	Dimmer stat	Core type		1
8	l- ϕCapacitor start Induction motor			-
9	Connecting wires	P.V.C insulated		-

Theory:

A single-phase motor may be looked upon as consisting of two motors having a common stator winding but with their respective rotors revolving in opposite directions. The equivalent circuit of such a motor based on double field revolving theory is shown in fig. Here the single-phase motor has been imagined to be made up of (i) one stator winding and (ii) two imaginary rotors. The stator impedance is $Z=R_1+JX_1$. the impedance of each rotor is (r_2+jx_2) where r_2 and x_2 represent half the actual rotor values in stator terms (i.e. x_2 stands for half the standstill reactance of the rotor as referred to stator). Since iron loss has been neglected, the exciting branch is shown consisting of exciting reactance only. Each rotor has been assigned half the magnetizing reactance (i.e x_m represents half the actual reactance). The impedance of forward running rotor is

$$Z_f = \frac{jx_m\left(\frac{r_2}{s} + jx_2\right)}{\frac{r_2}{s} + j(x_m + x_2)}$$

And it runs with a slip of s. the impedance of 'backward' running rotor is

$$Z_b = \frac{jx_m\left(\frac{r_2}{2-s} + jx_2\right)}{\frac{r_2}{2-s} + j(x_m + x_2)}$$

And it runs with a slip of (2-s). under standstill conditions, $V_f = V_b$ but under running conditions, V_f is almost 90 to 95% of the applied voltage.
The forward torque in synchronous watts is $T_f = I_3^2 r_2/s$. similarly, backward torque is $T_b = I_5^2\ r_2/(2-s)$
The total torque is $T = T_f - T_b$.

Equivalent circuit – with core loss:
The core loss can be represented by an equivalent resistance which may be connected either in parallel or in series with the magnetizing reactance as shown in fig
Since under running conditions V_f is very high (and V_b is correspondingly, low) most of the iron loss takes place in the forward motor consisting of the common starter and forward running rotor. Core-loss current I_w = core loss/V_f. Hence half value of core-loss equivalent resistance if $r_c = V_f/I_w$. As shown in fig. 31-15 (a) r_c has connected in parallel with r_m in each rotor.

Procedure:-

No load test:-

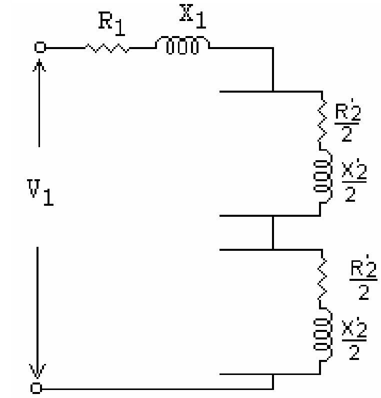
1. The connections are made as shown in the circuit diagram.
2. With the dimmer stat at zero out put the supply switch is closed.
3. The dimmer stat is varied such that the rated voltage is applied to the motor and all the meter readings are noted in the tabular column.
4. The dimmer stat is brought back to zero out put and the supply switch is opened.

Blocked rotor test:-

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 motor draws its rated current with the rotor being blocked and all the meter readings are noted in the tabular column.
4. The dimmer stat is brought back to zero out put position and the supply switch is opened.

Tabular column:-

	No Load test			Blocked Rotor 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



Specimen calculations:-

From blocked rotor test data :

Slip at balance rotor test s = 1

Equivalent impedance $Z_{01} = \frac{V_{SC}}{I_{SC}}$

Equivalent resistance $R_{01} = \frac{W_{SC}}{I_{SC}^{2}}$

Equivalent reactance = rotor reactance referred to start =

$$X_1 = X_2' = \frac{X_{01}}{2}$$

Stator resistance $R_1 = 1.5\ R_{DC}$

Where R_{DC} = stator resistance form voltage ampere method

Rotor circuit resistance referred to stator R_2 - $R_{01} - R_1$

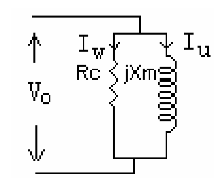
$$\therefore R_2' = \frac{R_2}{2}$$

From no-load test data:

Slip at no-load s = 0

Under no-load test assume that stator and rotor copper losses are negligible

$\therefore$ The equivalent circuit consists



$I_m = I_0 \sin\theta_0$

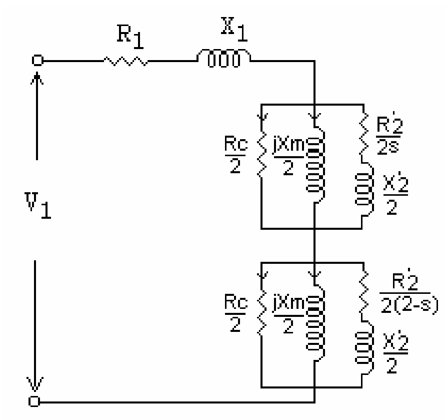
$I_w = I_0 \cos\theta_0$

Where $\cos\theta_0 = \frac{W_0}{V_0 I_0}$

$$\therefore I_C = \frac{V_0}{I_W}$$

$$X_M = \frac{V_0}{I_M}$$

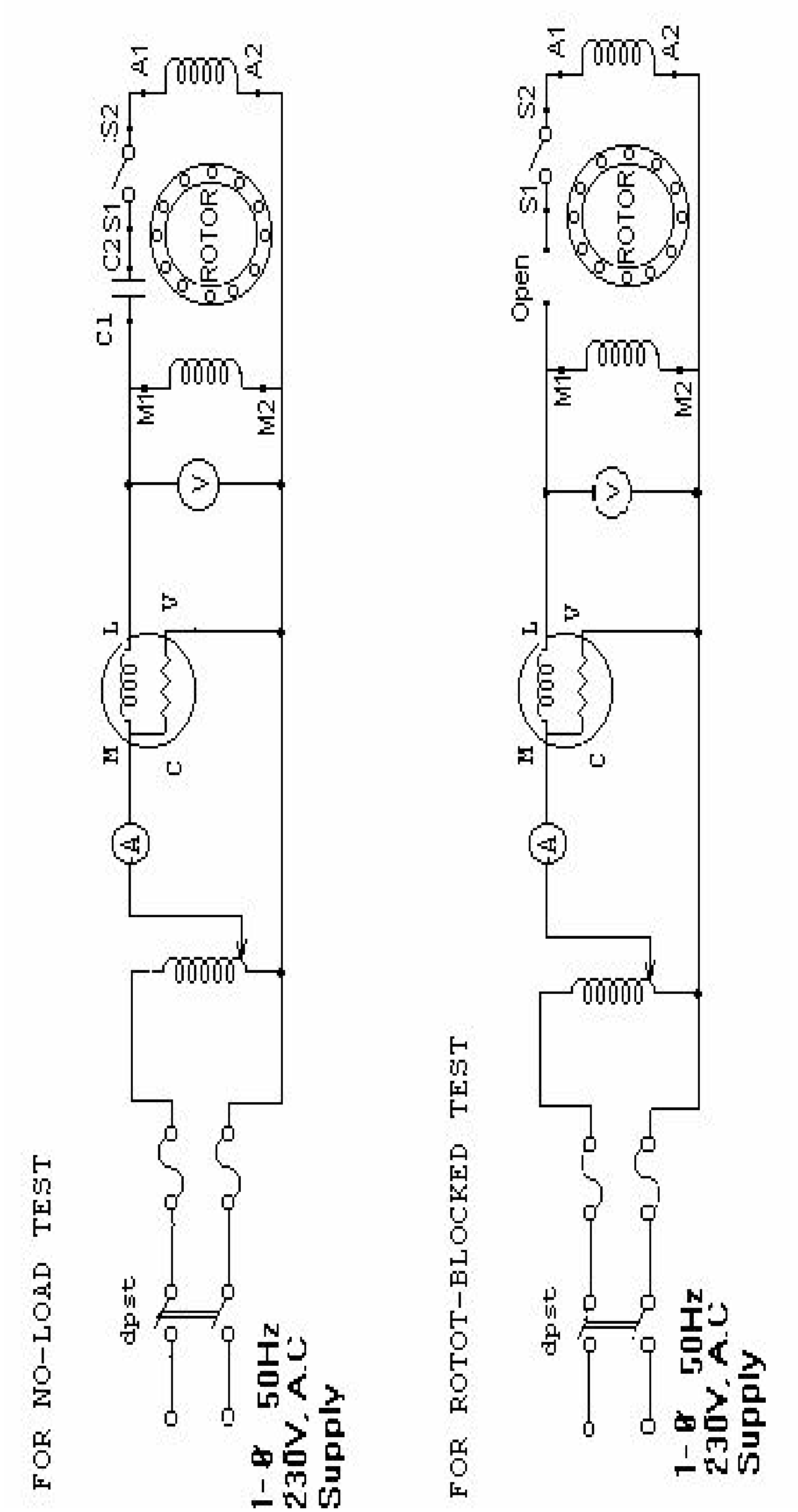
Equivalent Circuit :



Viva Questions:-

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?

Circuit Diagram:-



Exp. No 4

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.No	Apparatus	Type	Range	Qty
1	Ammeter	M.I		1
2	Voltmeter	M.I		1
3	Wattmeter (U.P.F)	Dynamometer type		1
4	Tachometer	Digital		1
5	3-ϕ Dimmer stat	Core type		1
6	3-ϕ Squirrel cage induction motor with loading arrangements	Belt driven type load		1
7	Fuse	Wire		
8	Connecting wires	P.V.C 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 a 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: Of 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. Ensure that the belt over the drum is loosened and then the supply switch is closed,
3. Switch on the DOL starter then the motor runs at no load speed. 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.5 is repeated until the rated current of the motor is reached
6. The load is removed in steps, switch off the DOL starter 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**	**Slip in %**

Specimen calculations: -

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

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

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

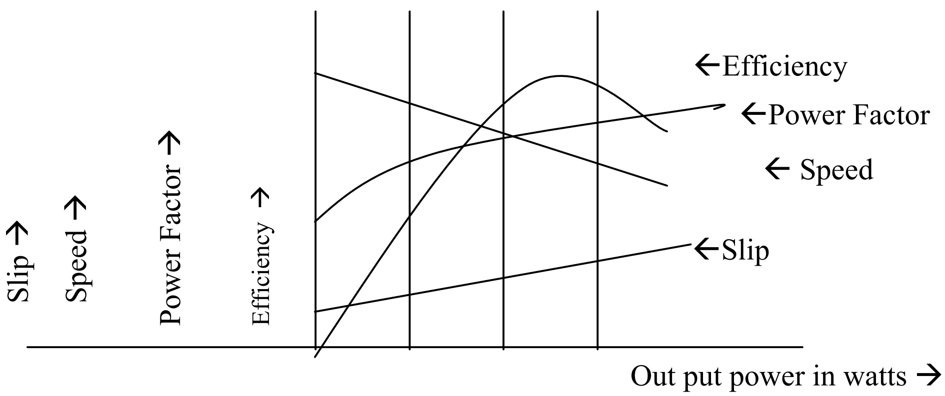
3. Out put Power $= \dfrac{2\prod NT}{60}$ watts

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

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

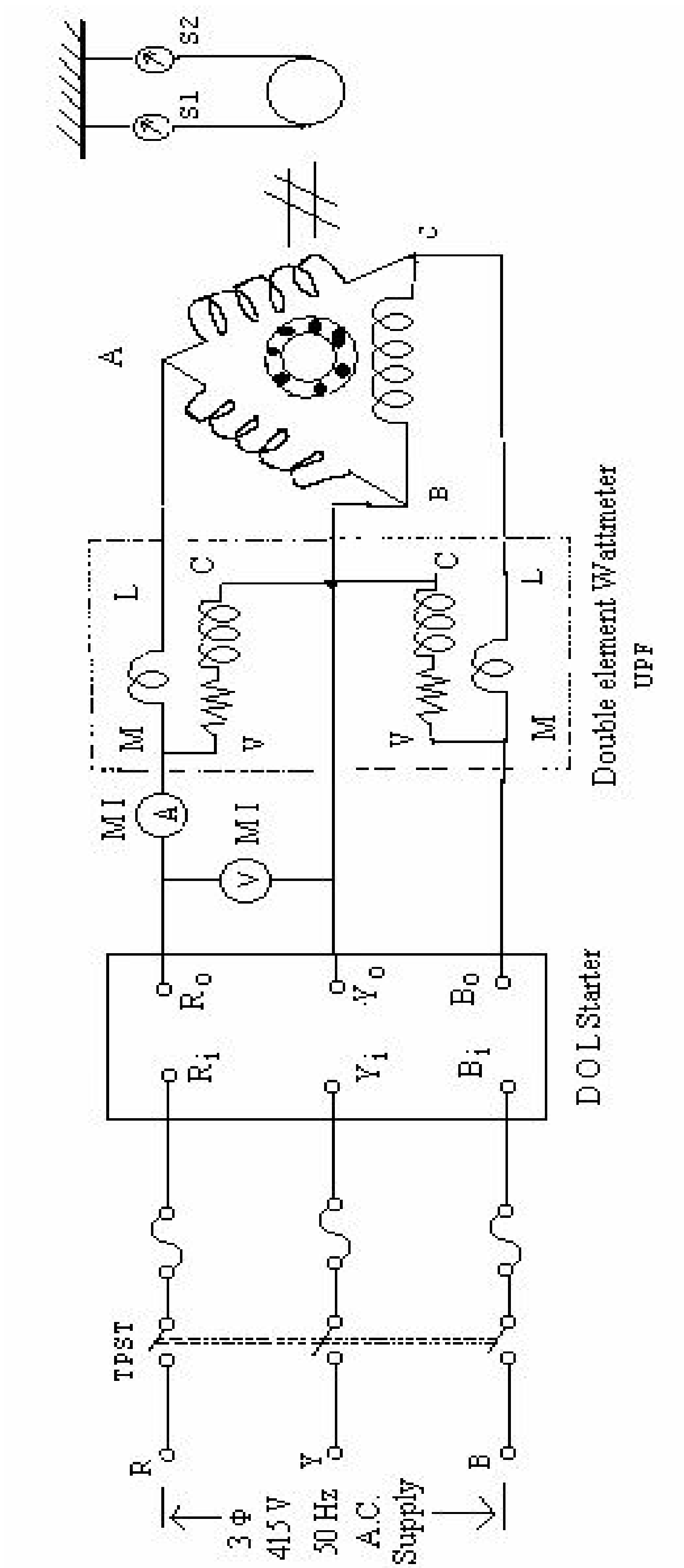
6. % Slip $= \frac{Ns - N}{Ns} \times 100$ where $Ns = \frac{120f}{P}$ r.p.m

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?
10. In a three phase wound rotor induction motor ,three phase supply is given to the rotor and stator is short circuited, what will happen to the rotor?
11. if the rotor of a three phase induction motor is assumed purely resistive, then what will be electromagnetic torque?
12. If the auto-transformer tapping k is less than 1, then what is the starting torque of cage induction motor with this auto transformer starter?
13. Motor A has deeper and narrow slots ,where as motor B has shallow and wide slots what happens to induction motor A ,as compared to motor B
14. Why the rotor is skewed?
15. Write the condition for maximum torque?


S1
S2
A
B
C
M I
M I
M
L
C
V
V
C
L
M
Double element Wattmeter
UPF
R0
Y0
B0
R1
Y1
B1
D O L Starter
TPST
R
Y
B
3 Φ
415 V
50 Hz
A.C.
Supply

Exp. No.5

EQUIVALENT CIRCUIT AND CIRCLE DIAGRAM OF 3-ϕ SQUIRREL CAGE INDUCTION MOTOR

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

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Voltmeter	M.I		1
2	Voltmeter	M.I		1
3	Ammeter	M.I		1
4	Ammeter	M.I		1
5	Wattmeter (U.P.F)	Dynamometer type		2
6	Wattmeter (L.P.F)	Dynamometer type		2
7	Dimmerstat 3-ϕ	Core type		1
8	3-ϕ induction motor			1
9	Connecting wires	P.V.C insulated		

Theory:

The performance characteristics of a induction motor are derived from its circle diagram. The circle diagram is a vector locus diagram starter and motor currents is very useful and invaluable for estimating certain working conditions. The circle diagram can be drawn by using the data obtained from no-load test, blocked rotor test and stator resistance test.

No-load test:-From no-load test we can calculate the no-load current I_0, no load power factor cos ϕ_0, windage and friction losses, no-load core losses no load resistance R_0 and reactance X_0.

This test is similar to the open circuit no-load test on a transformer. The motor is run on no-load at rated voltage and frequency. The applied voltage, current and power input to motor are measured.

Blocked rotor test:-This is analogous to the short circuit test of a transformer. The rotor is held stationary and the rotor windings one short circuited (in case of slip ring induction motor). A reduced voltage (upto 15 to 20% of the rated voltage) is applied to the stator terminals and is so adjusted that full load current flows in the stator. The voltage V_{BR} current I_{BR} and power W_{BR} are measured.

Since the motor is blocked, the voltage required to calculate the rated current is far less than the rated value. Hence the magnetizing current is negligible.

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_1 Watts	W_2 Watts	$W_o=W_1+W_2$ Watts	$Cos\phi_o$

Blocked rotor test:

S.No	V_{BR} Volt	I_{BR} Amps	W_1 Watts	W_2 Watts	$W_{BR}= W_1+W_2$ Watts	$Cos\phi_{BR}$

Specimen calculations:-

No-load power factor $\text{Cos}\,\phi_0 = \dfrac{\omega_0}{\sqrt{3}V_0 I_0}$

Where V_0 = no load voltage (line to line)

I_0 = no load current

ω_0 = no load input power

Magnetizing current $I_u = I_0 \text{ Sin } \phi_0$

Working component of no load current = $I_w = I_0 \text{ Cos } \phi_0$

No-load resistance $R_0 = \frac{V_0}{I_w/\sqrt{3}}$

Magnetizing reactance $X_m = \frac{V_0}{I_u/\sqrt{3}}$

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

Equivalent resistance/ph referred to stator $R_{01} = \frac{W_{BR}}{3 \times I_{BR}^2}$

Equivalent reactance/ph referred to stator $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

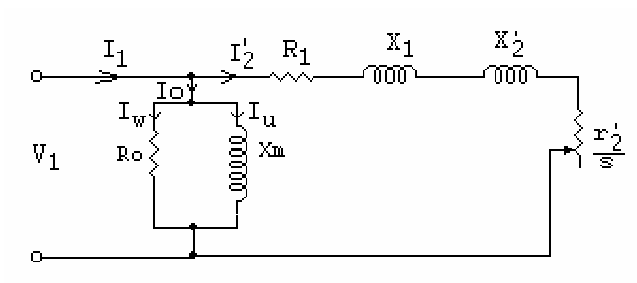
Assume that stator reactance = Rotor reactance

i.e $X_1 = X_2' = \frac{x_{01}}{2}$

Stator resistance/ph = R_1 (using volt-amp method)

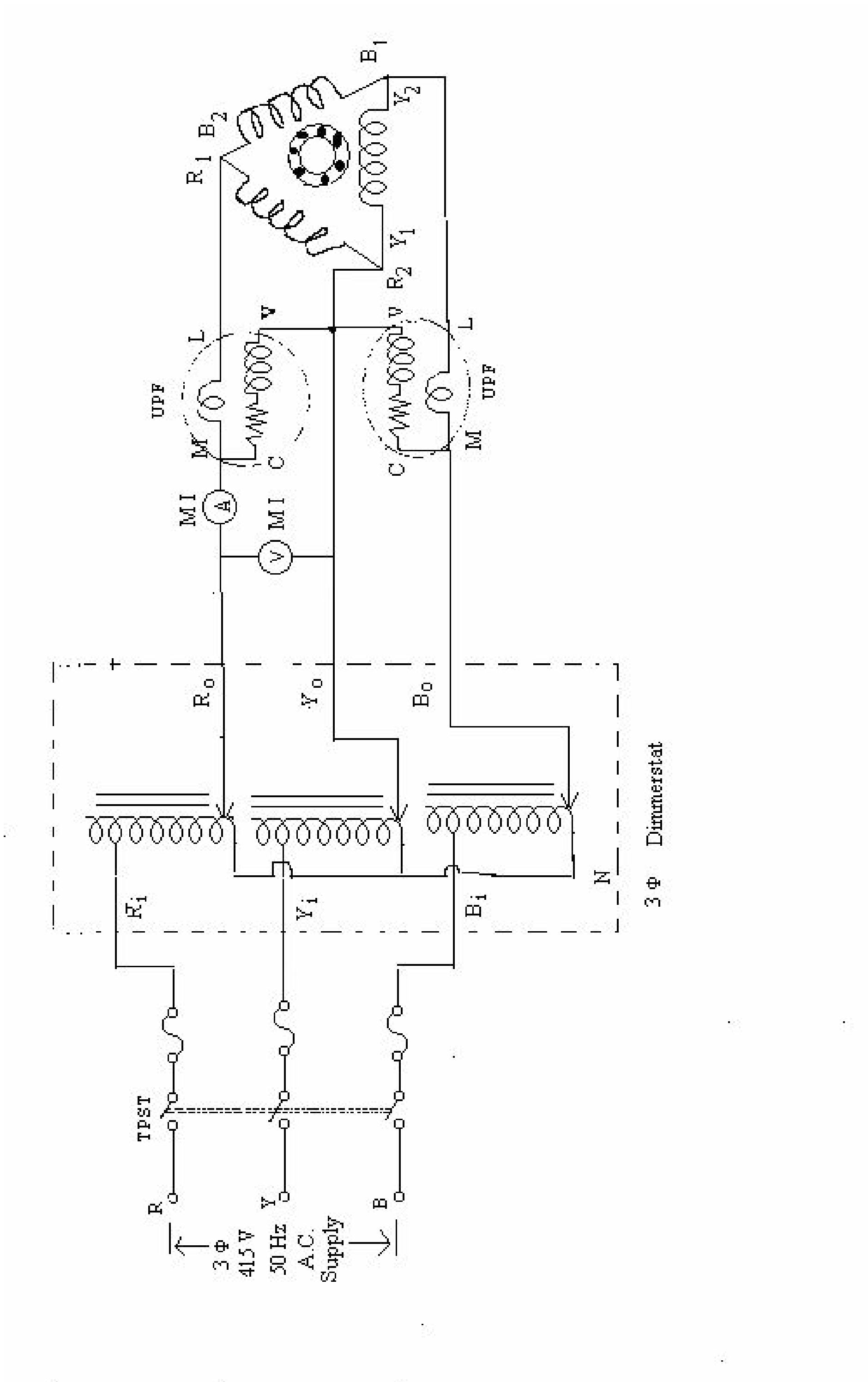
Rotor resistance/ph referred to stator $R_2' = R_{01} - R_1$

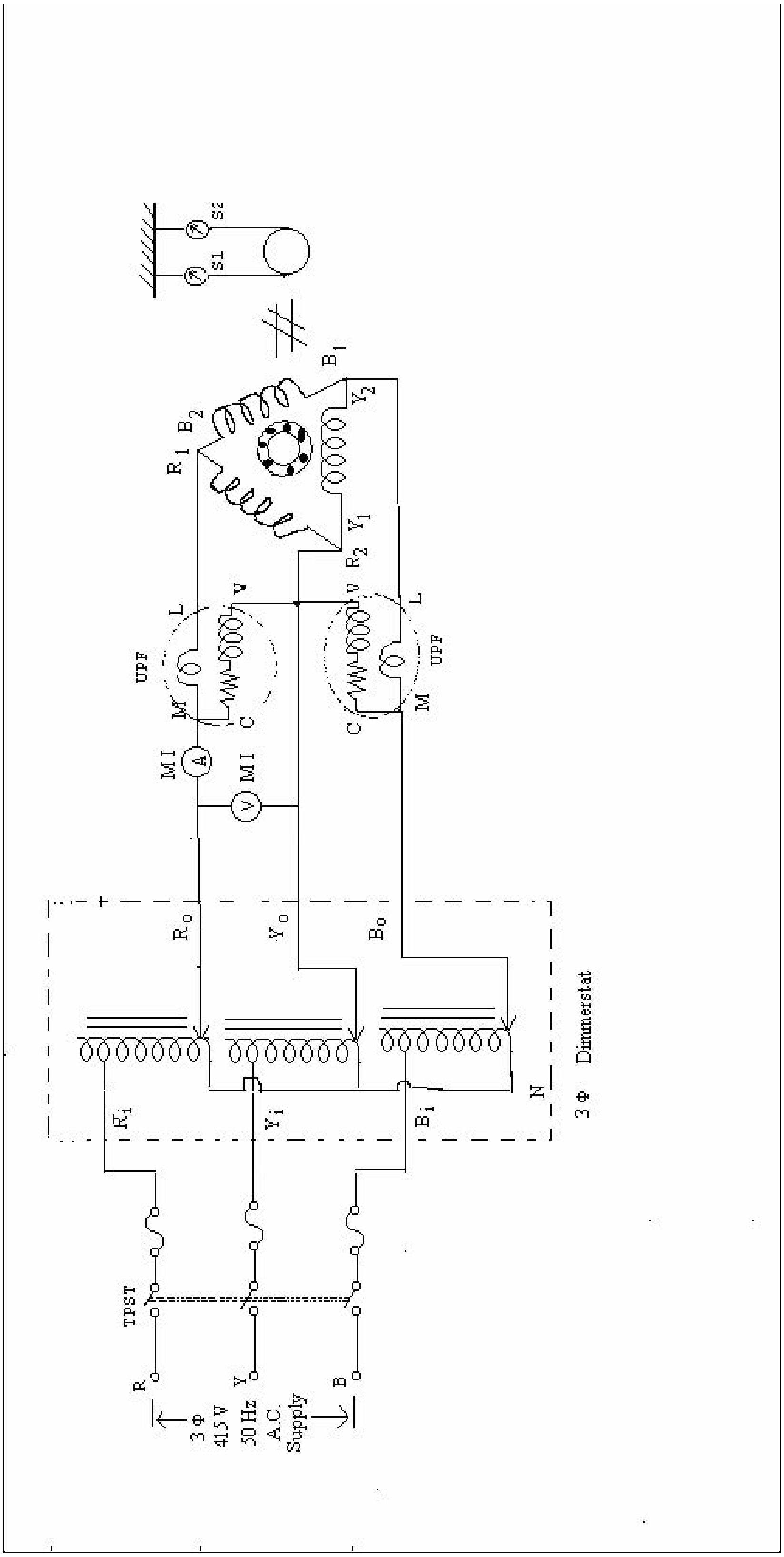
Equivalent Circuit:-



Viva Questions:-

1. What is relationship between slip, rotor copper losses and rotor input?
2. Express the mechanical power developed by the rotor, in terms of slip and power input to the rotor?
3. Why the no load power factor of the motor is quite low?
4. Out of the input power factor at no load and under blocked rotor condition, which one is higher?
5. What is the slip of the motor under blocked rotor conditions
6. comment about the readings of two wattmeter's connected in the stator circuit to measure input power under no load and blocked rotor test.
7. How much is the output of the motor under blocked rotor test?
8. Where will you use the squirrel cage induction motor?
9. Why we do not supply the full voltage at the short circuit test?
10. How can an induction motor be started?
11. Which induction motor at stand still is similar to a transformer at no load?
12. What are the different losses in induction motor?
13. Different types of starters used for starting squirrel cage motors
14. Applications of induction motors


UPF
UPF
M I
M I
3 Φ Dimmerstat
TPST
3 Φ
415 V
50 Hz
A.C.
Supply


3 Φ
415 V
50 Hz
A.C.
Supply
R
Y
B
TPST
3 Φ Dimmerstat
N
UPF
M I
M
L
C
V

Exp. No. 6

EQUIVALENT CIRCUIT OF A 3-ϕ SLIPRING INDUCTION MOTOR

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

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Voltmeter	M.I		1
2	Voltmeter	M.I		1
3	Ammeter	M.I		1
4	Ammeter	M.I		1
5	Wattmeter (U.P.F)	Dynamometer type		2
6	Wattmeter (L.P.F)	Dynamometer type		2
7	Dimmerstat 3-ϕ	Core type		1
8	3-ϕ induction motor			1
9	Connecting wires	P.V.C insulated		

Theory:-

The performance aspects of induction motor under steady state are variations current speed and losses as the load-torque measurements change, as well as the starting torque and the maximum torque. All these characteristics can be determined from the equivalent circuit.

The equivalent circuit shows that the total power Pg, transferred across the our gap from the stator is

$$Pg = \frac{3I_2^{\,2}R_L}{s}$$

The total rotor I^2R loss (copper loss) is given by = 3 I_2^2 R_L

The internal mechanical power ‘ρ’ developed by the motor is there fore

$$P = Pg - \text{motor } I^2R \text{ loss } = \frac{3I_2^{\,2}R_L}{s} - 3I_2^{\,2}R_L$$

$$= 3I_2^{\,2}R_2\left(\frac{1-s}{s}\right)$$

or $P = (1 - s)\, Pg$

These parameters can be determined by conducting no-load, blocked rotor and stator resistance

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_1 Watts	W_2 Watts	$W_o=W_1+W_2$ Watts	$Cos\phi_o$

Blocked rotor test:

S.No	V_{BR} Volt	I_{BR} Amps	W_1 Watts	W_2 Watts	$W_{BR}= W_1+W_2$ Watts	$Cos\phi_{BR}$

Specimen Calculations:

Stator resistance (from volt ampere method) R_1 = _______ Ω

No-load power factor $$\text{Cos}\,\phi_0 = \frac{\omega_0}{\sqrt{3}V_0 I_0}$$

Where V_0 = no load voltage (line to line)
I_0 = no load current
ω_0 = no load input power

Magnetizing current $I_u = I_0 \text{ Sin } \phi_0$

Core loss current componen $I_w = I_0 \text{ Cos } \phi_0$

No-load resistance $$R_0 = \frac{V_0/\sqrt{3}}{I_w}$$

Magnetizing reactance $X_m = \frac{V_0/\sqrt{3}}{I_u}$

Form brake rotor rest :

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

Equivalent resistance $R_{01} = \frac{W_{BR}}{3 \times I_{BR}^2}$

Equivalent reactance $X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$

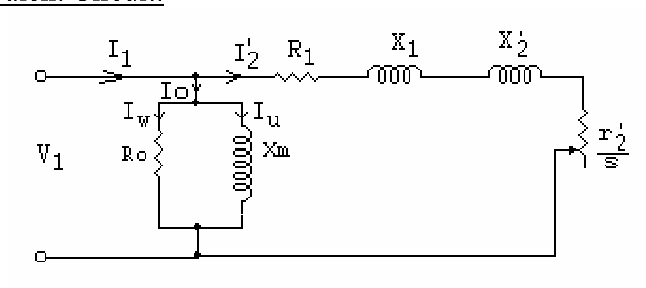
Stator resistance/ph **R_1** = _____ **Ω** (using volt-amp method)

Rotor resistance/ph $R_2' = R_{01} - R_1$ (referred to stator)

Assume that stator reactance = Rotor reactance referred to stator

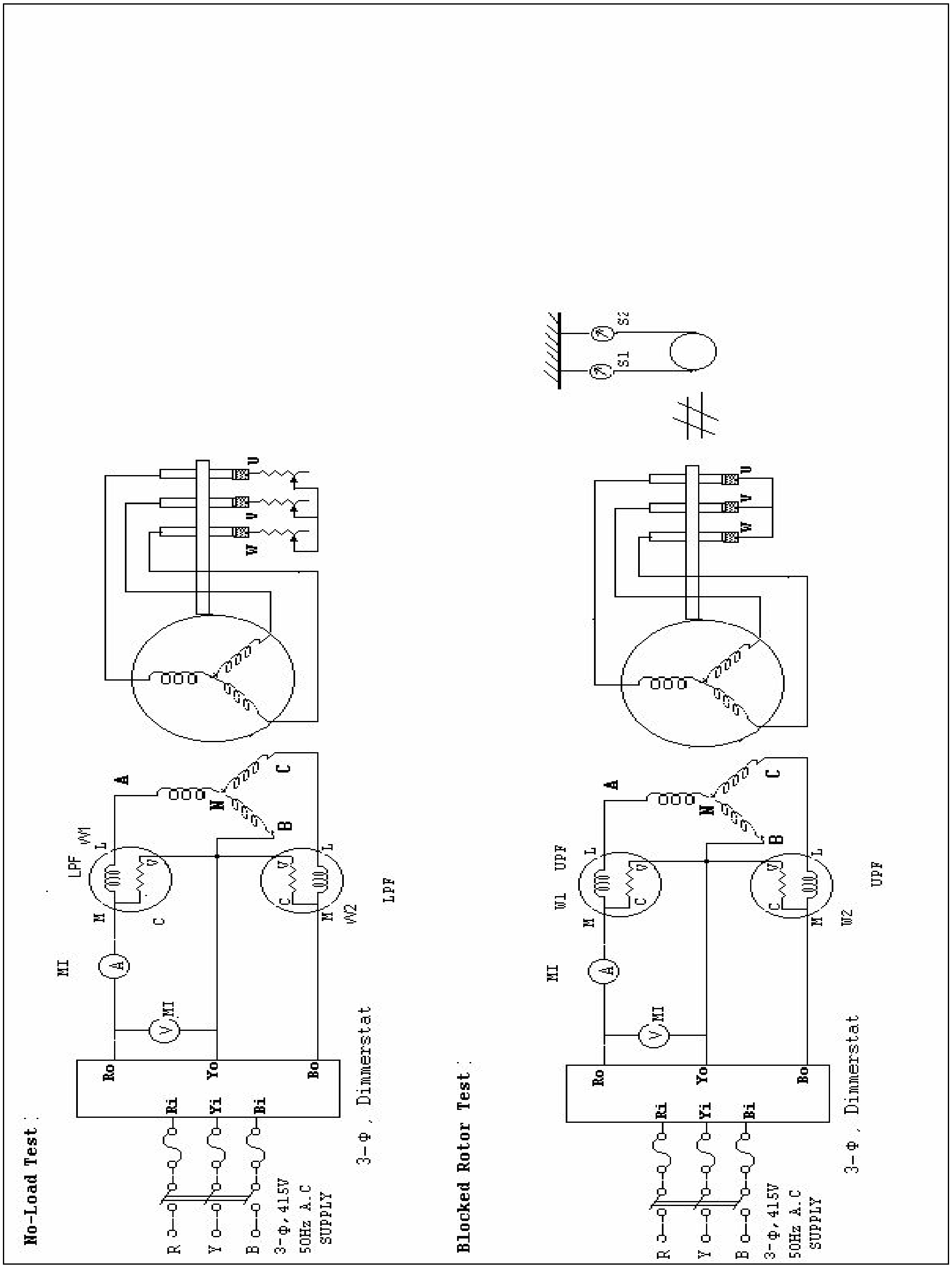
i.e $X_L = X_2' = \frac{X_{01}}{2}$

Equivalent Circuit:



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?


No-Load Test :
3-Φ, 415V
50Hz A.C
SUPPLY
3-Φ , Dimmerstat
Ri
Yi
Bi
Ro
Yo
Bo
MI
LPF
W1
W2
A
B
C
N
U
V
W
Blocked Rotor Test :
UPF
S1
S2

Exp. No.7

INDUCTION GENERATOR

Aim:- To run given induction machine coupled to DC machine as induction generator and study it's performance i.e slip, power factor power flow etc.

Apparatus:-

S. No	Apparatus	Type	Range	Qty
1	Ammeter	M.C		41
2	Voltmeter	M.C		1
3	Voltmeter	M.C		1
4	Ammeter	M.I		1
5	Voltmeter	M.I		1
6	Wattmeter U.P.F	Dynamometer type		2
7	Rheostat	Wire wound		1
8	Tachometer	Digital		1
9	SPST switch			1
10	Connecting wires	P.V.C insulated		

Theory:-

When a 3-ϕ induction motor runs above synchronous speed it acts as induction generator. As speed during induction generator operation is not synchronous it is called a synchronous generator. Induction generator not self starting machine and must therefore continue to get it's magnetizing current and reactive power from supply mains to which it was connected to run as poly phase induction motor thus 3-ϕ induction generator can't work in isolation it must work in parallel with busbar or other synchronous generator which can supply magnetizing current and reactive power needed by 3-ϕ induction generator

Procedure:-

1. The connections are made as shown in circuit diagram
2. Ensuring rotor resistance is in cut in position, rotor switch on control panel is at position 1 close the TPST switch
3. By pressing on push button on control panel cutout rotor resistance in steps i.e rotor switch on control panel rotated clockwise from position 1 to 4 via 2 & 3 then release on push button.
4. Switch on DC circuit by closing DPST Switch and make voltmeter across SPST switch to read zero by varying field rheostat and close SPST switch.
5. Run DC motor at 1500 RPM by varying field circuit rheostat and record all meter readings
6. Run induction motor as induction generator by increasing speed of prime mover above 1500 RPM.
7. Tabulate readings of all meters by varying in steps.
8. Make armature line current by using field rheostat and then open SPST switch and DPST switch.
9. Press OFF button and then open TPST switch to stop set.

Tabular Column:

S.No	V_{DC} in Volts	I_{DC} in Amps	W_1 in Watts	W_2 in Watts	W_T in Watts	Speed in RPM	P.F	I in Amps	Slip	V_{gn} in Volts

Model calculations:-

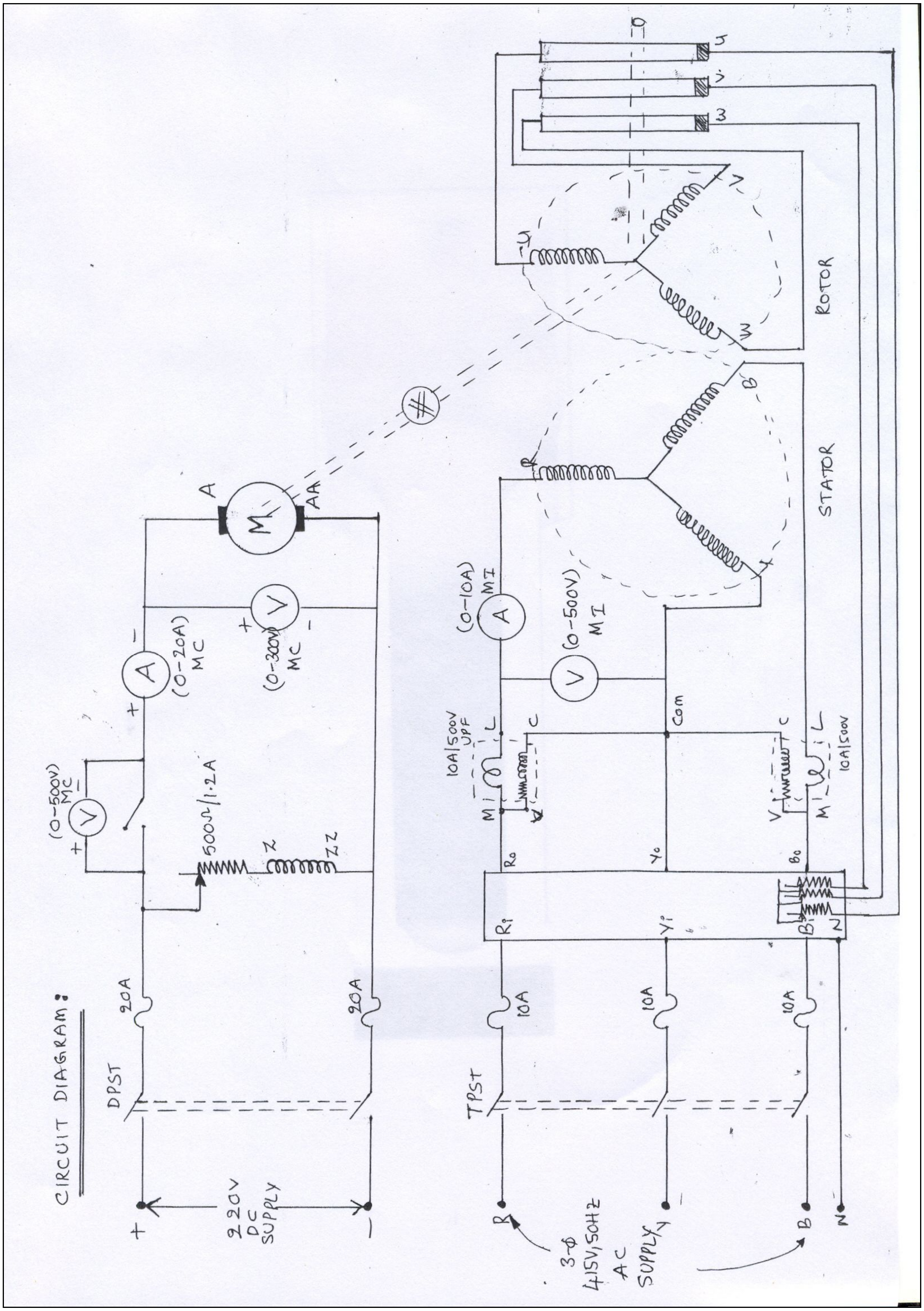
$$Cos\phi = \frac{[W_1 + W_2]}{\sqrt{3} x V_L x I_L}$$

$$\% \text{ Slip} = \frac{N_S - N}{N_S} x100$$

Result:-

Viva Questions:-

1. What is the nature of slip in induction generation?
2 How induction motor is operating as induction generation?
3 What is other name of induction generator and why it is so called?
4 What happen if prime mover torque exceeds the maximum torque?
5. What are the directions of active and reactive power?
6. What are the applications of induction generators?
7. What is the main disadvantage of induction generator and how is it overcome?
8. What is the starting method of induction generator?
9. classify the induction generator based on excitation
10. At what power factors the induction generators operates?


CIRCUIT DIAGRAM:
DPST
20A
20A
220V DC SUPPLY
+
−
(0−500V) MC
500Ω/1.2A
Z
ZZ
(0−20A) MC
(0−300V) MC
A
M
AA
TPST
10A
10A
10A
3-Φ 415V, 50Hz AC SUPPLY
R
B
N
R1
Y1
B1
R0
Y0
B0
10A/500V UPF
M
L
C
V
Com
(0−10A) MI
(0−500V) MI
STATOR
ROTOR

Exp. No.8

‘V’ and ‘Λ’ curves of a synchronous motor

Aim: To draw ‘V’ and ‘Λ’ curves of a synchronous motor at no load and at different loads

Apparatus:

S.No	Apparatus	Type	Range	Qty
1	Ammeter	M.C		1
2	Ammeter	M.I		1
3	Voltmeter	M.I		1
4	3-ϕ , 2 -element Power factor meter	Dynamometer		1
5	Rheostat	Wire wound		1
5	3-ϕ Dimmer stat	Core type		1
6	Synchronous motor			1
7	Connecting wires	P.V.C 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.

Procedure:

1 The connections are made as in the circuit diagram
2 Ensuring that the dimmerstat is at zero output position, the belt over the brake drum is totally loosened, field rheostat is in cut in position, DPST switch is in open position, TPST supply switch is closed
3 The dimmerstat 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 synchronous motor field rheostat in cut in position, the DC supply switch (DPST 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 minimum value to maximum value using the rheostat and all the meter readings are noted for each step.
6 The field rheostat is brought back to initial position and the load is applied in steps to the motor by tightening the belt over 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 over the brake drum, the field rheostat is brought back to cut in position, the DC supply switch is opened and the dimmerstat to zero output position and the TPST supply switch is opened.

Tabular column:

No-Load:

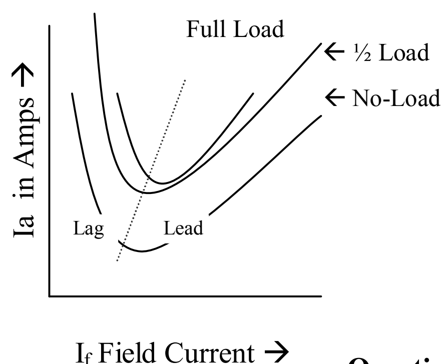
S.No	If in Amps	I_a in Amps	Power factor

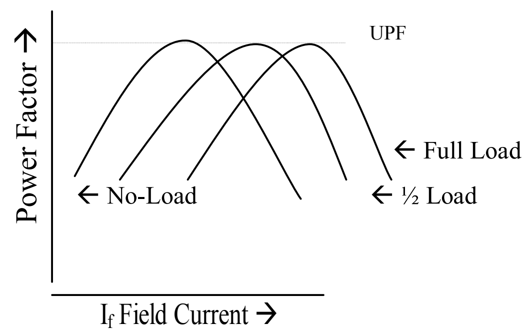
With Load:

S.No	If in Amps	I_a in Amps	Power factor

Nature Of Graph:-

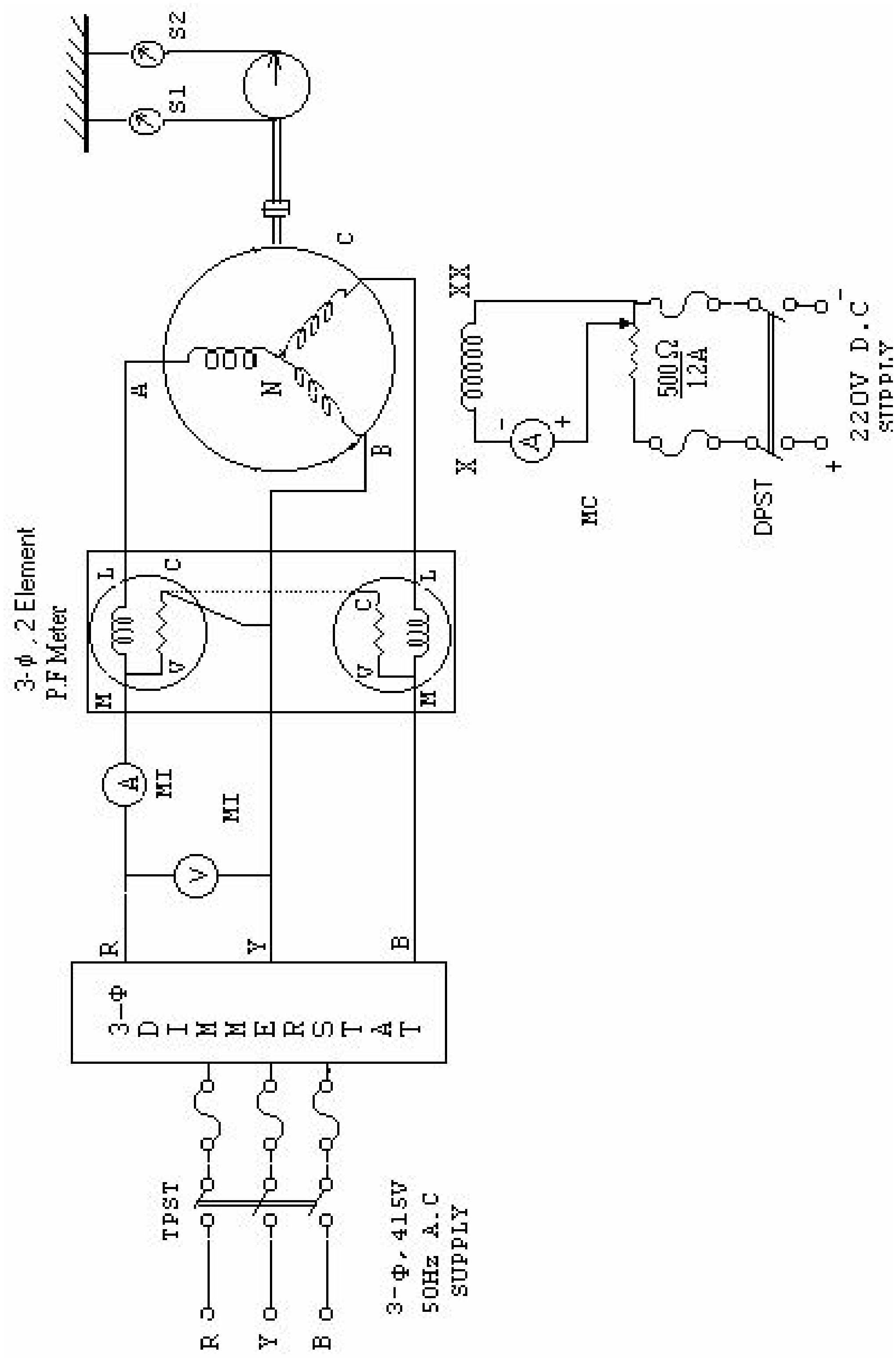
'V'- Curves





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?
10. 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?


S1
S2
A
B
C
N
X
XX
3-Φ , 2 Element
P.F Meter
M
L
C
V
MI
R
Y
B
3-Φ DIMMERSTAT
TPST
3-Φ, 415V
50Hz A.C
SUPPLY
MC
500 Ω
1.2A
DPST
220V D.C
SUPPLY

Exp. No.9

REGULATION OF AN ALTERNATOR BY E.M.F/M.M.F METHOD

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

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Ammeter	M.C		1
2	Ammeter	M.I		1
3	Voltmeter	M.I		1
5	Rheostats	Wire wound		2
8	Tachometer	Digital		1
9	Motor alternator set		-	1
10	Connecting wires		-	-

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:

Oven 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 cut in position, and then close the TPST switch, so that the alternator terminals are short circuited.

.8. Alternator field rheostat is varied such that the ammeter reads the rated current of the alternator and the corresponding field current is noted.

9. 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.

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 $Z_s = \dfrac{E_0}{I_a}$ / 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 $= \dfrac{E_0 - V}{V} \times 100$

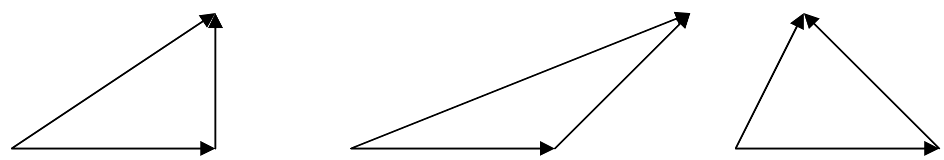
Where V – is the rated terminal voltage/phase

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

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

for different power factors the regulation is calculated and tabulated

MMF method:



U.P.F Lagging Leading

Let V – be the rated terminal voltage/phase
R_a – cumulative resistance/phase
I_{f2} – field current corresponding to short circuit current

For U.P.F:

$\therefore E_1 = V + Ia\,Ra$

I_{f1} → field current corresponding to E_1

I_{f2} field current corresponding to short circuit current)

$$\overline{I_{fr}} = \overline{I_{f1}} + \overline{I_{f2}} = \sqrt{{I_{f1}}^2 + {I_{f2}}^2}$$

E_0 → open circuit voltage corresponding to field current $\overline{I_{fr}}$

Lagging power factor:

$E_1 = V + Ia\,Ra\,Cos\,\theta$

I_{f1} → field current corresponding to E_1

$$\overline{I_{fr}} = \overline{I_{f1}} + \overline{I_{f2}} = \sqrt{{I_{f1}}^2 + {I_{f2}}^2 - 2I_{f1}I_{f2}}$$

E_0 → open circuit voltage corresponding to field current I_{fr}

Leading power factor:

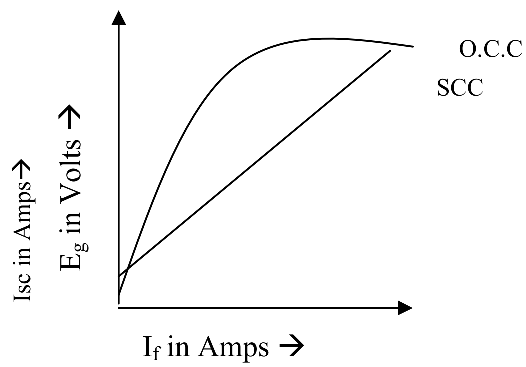
$E_1 = V + I\,R\,Cos\,\theta$

I_{f1} → field current corresponding to E_1

$$\overline{I_{fr}} = \overline{I_{f1}} + \overline{I_{f2}} = \sqrt{{I_{f1}}^2 + {I_{f2}}^2 - 2I_{f1}I_2}$$

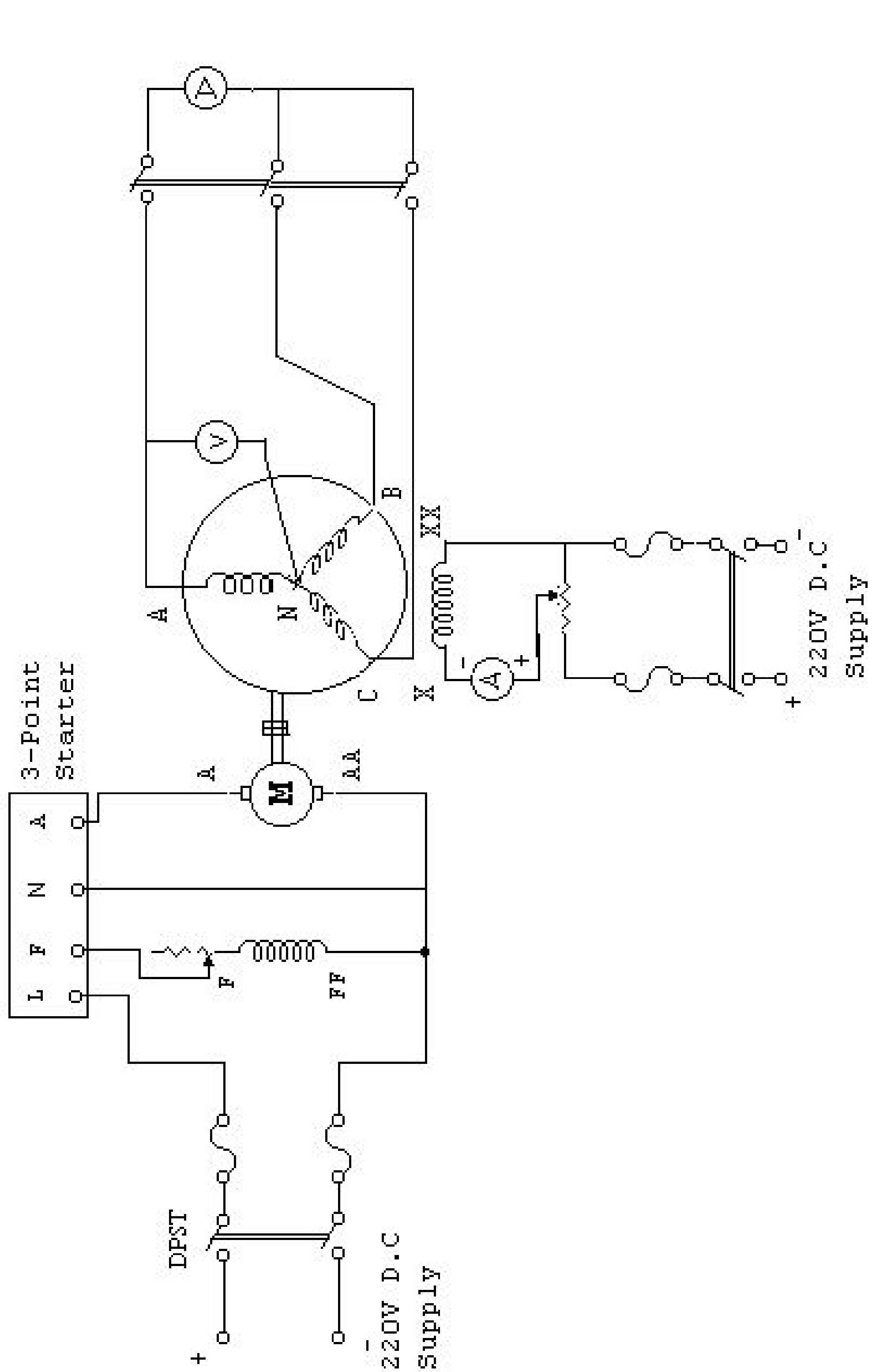
E_0 → open circuit voltage corresponding to field current I_{fr} from o.c.c

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?
13. How the alternators are classified
14. What is meant by hunting?
15. What is the difference between salient rotor and smooth cylindrical rotor?


3-Point Starter
L F N A
DPST
220V D.C Supply
220V D.C Supply
XX
X
A
B
C
N
AA
F
FF

Exp. No.10

SYNCHRONIZATION OF AN ALTERNATOR

Aim:- To synchronize the given alternator with infinite bus bar by using 3-lamp dark method

Apparatus:-

S.No	Apparatus	Type	Range	Qty
1	Voltmeter	MI		
2	Ammeter	MI		2
3	Ammeter	MC		1
4	Wattmeter (U.PF)	Dynamometer type		1
5	Phase sequence meter			1
6	Tachometer	Digital		1
7	Rheostats	Wire wound		2
8	Rheostat	Wire Wound		1
9	Synchronizing Switch With lamps			1
10	Connecting wires	P.V.C insulated		-

Theory-

The process of connecting an alternator to the infinite bus bar is called synchronization. The necessary conditions required to be satisfied for the parallel operation of the alternator are as follows.

1. The effective (A.C) values of voltage are the same i.e. all machines have the same effective rated voltage.
2. The phase sequence of poly phase voltages of connected alternator must be same as that of bus bar.
3. The voltage must exactly opposite the phase w.r.t. (two alternator (or) alternator and bus bar) their local circuits.
4. The frequencies of all alternators to be paralleled must be same.

To satisfy the above conditions, the following methods for synchronization are used.

1. Dark lamp method
2. Bright lamp method
3. Using synhroscope

In dark lamp method, all the lamps which are connected across the synchronizing switch must be in maximum dark position while closing the synchronizing switch.

In bright lamp method, the lamps are connected asymmetrically of the phase sequence is correct brighten and glow dim is sequence. The sets of star vectors will rotate at un equal speeds if the frequency of the two machines are different.

Synchronization in done at the moment the uncrossed lamp L1 is in the middle of the dark period and the other two crossed lamps L2 and L3 are equally bright.

Procedure:-

a) 3-Lamp Dark method

1. The connections are made as shown in the circuit diagram.
2. The 3-ϕ ac supply switch is closed and the phase sequence of the supply is checked with phase sequence meter.
3. The 3-ϕ ac supply switch is opened and the phase sequence meter is connected in the alternator circuit.
4. The motor field rheostat in cut out position the motor armature rheostat in cut in position, the 4-point starter handle in initial position, the synchronizing switch is open position, the DC supply switch is closed.
5. The 4-point starter handle is moved clock wise gradually to cut out the resistance in the armature circuit so that the motor starts.
6. The motor is brought to its rated speed so that the alternator also runs at its rated speed by varying armature rheostat and then vary the field rheostat.
7. With the alternator field rheostat in cut in position the DC supply switch of the alternator field is closed. The alternator field is exited such that the rated voltage of the alternator is built up.
8. The phase sequence of the alternator voltage is checked with the PSM and verify if it is same as that of bus bar voltage sequence. If not interchange any two line terminals of the 3-ϕ ac supply after reducing the excitation of the alternator to zero.
9. The 3-ϕ ac supply switch is closed and the voltage is measured. The voltage of the alternator is adjusted to the same value by varying in the excitation of alternator.
10. After ascertaining that the alternator voltage is same as bus bar voltage observed the frequency of flickering of the bulbs. The speed of the alternator is adjusted such that the flickering of the bulbs is slow the synchronizing switch is closed at the instant when all the bulbs are maximum dark condition.
11. The excitation of the alternator is changed to observe as to how the reactive power will change and similarly speed of the alternator is changed to observe how the active power will change.
12. The synchronizing switch is opened, the 3-ϕ ac supply switch is opened, the alternator field rheostat is brought back to cut in position the motor armature rheostat is brought back to cut in position and the motor dc supply switch is opened.

b) 1-Lamp dark 2- lamp equal bright method:

1. Step nos.1 to 9 of the above procedure are repeated
2. After ascertaining that the alternator voltage is same as bus bar voltage observed the frequency of flickering of the bulbs. The speed of the alternator is adjusted such that the flickering of the bulbs is slow the synchronizing switch is closed at the instant when the lamp in R-Phase is dark and other two lamps are at equal bright condition.
3. The excitation of the alternator is changed to observe as to how the reactive power will change and similarly speed alternates is changed to observe how the active power will change.

4. The synchronizing switch is opened, the 3-ϕ ac supply switch is opened, the alternator field rheostat is brought back to cut in position the motor armature rheostat is brought back to cut in position and the motor dc supply switch is opened

Tabular column:-

Constant excitation, variable speed:-

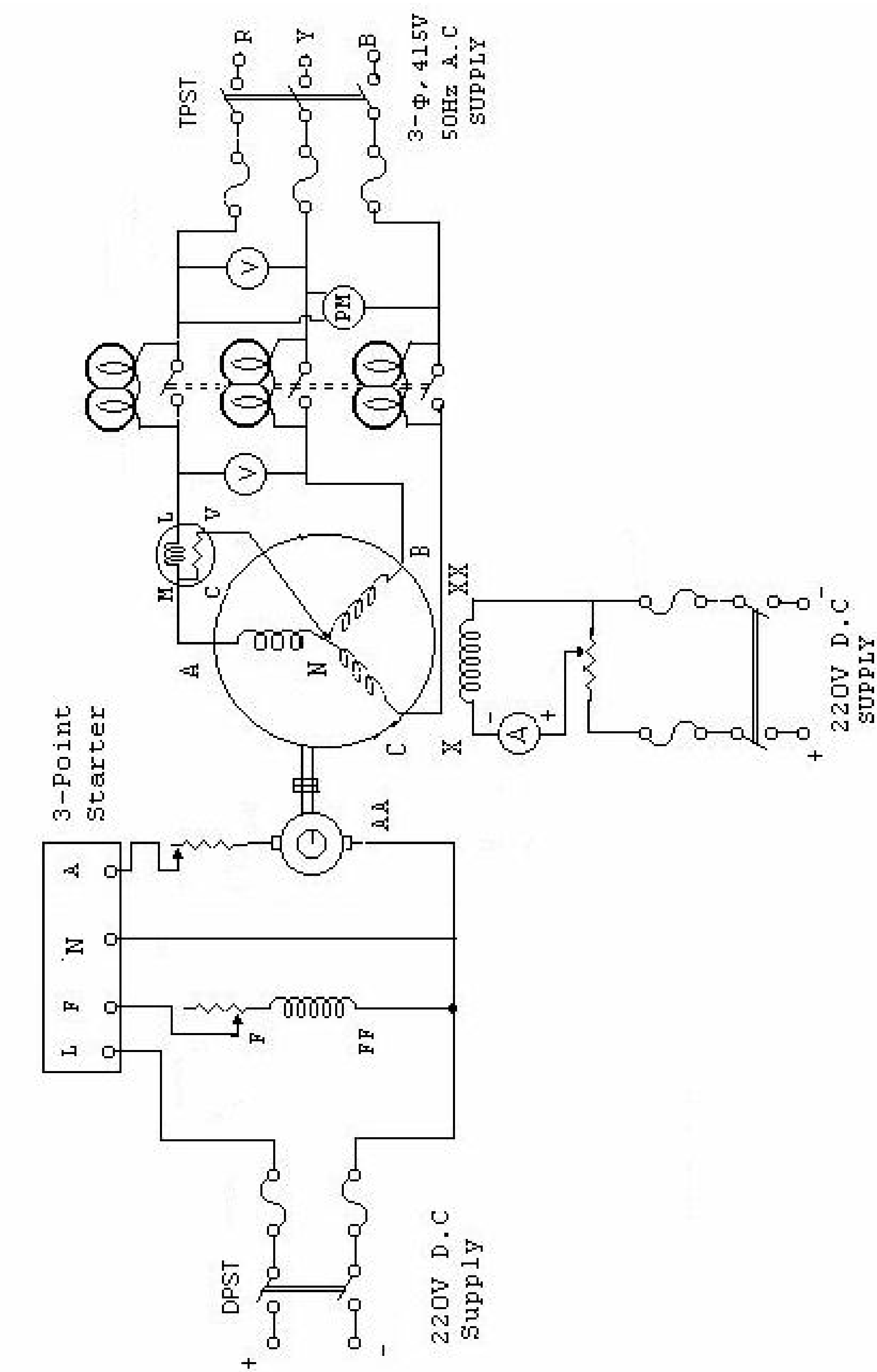
S.No	V in Volts	I_a in Amps	W in Watts	Cosϕ

Constant speed variable excitation:-

S.No	I_f in Amps	I_a in Amps	W in Watts	V in Volts

Viva Questions:-

1. What is meant by synchronization of an alternator?
2. what is the operating condition of the incoming alternator, when it just synchronized with the bus bar?
3. What are various conditions for synchronizing an incoming alternator to the bus bar?
4. what is the most commonly used method for checking the frequency equality and same phase sequence?
5. what is the voltage across each set of lamps that are cross connected, at the instant of synchronization?
6. What is the need of synchronization?
7. What happens if a stationary alternator is connected to live bus bar?
8. What happens if the excitation of a synchronized alternator changes?
9. What is effect of time period of oscillation on synchronization?
10. What is meant by synchronous machine stability?
11. Define synchronous impedance?
12. How many types of load is possible in case of Alternator?
13. In which unit the alternator rated?
14. How the field winding is excited in case of an alternat
15. What is the working principle of an alternator?


TPST
R
Y
B
3-Φ, 415V
50Hz A.C
SUPPLY
PM
V
M
L
C
A
B
N
XX
X
220V D.C
SUPPLY
3-Point
Starter
L
F
N
A
AA
FF
DPST
220V D.C
Supply

Exp. No.11

SEPARATION OF NO LOAD LOSSES OF A TRANSFORMER

Aim: To determine no-load losses and hence separate the hysteresis and eddy current losses of the given single phase transformer by conducting a suitable test on it.

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I		1
2	Voltmeter	M.I		1
3	Wattmeter U.P.F	Dynamometer type		1
4	Ammeter	M.C		1
5	Rheostat	Wire wound		2
6	Transformer			1
7	DPST switch			1
8	Connecting wires	P.V.C insulated		1

Theory:

Procedure:

1 The connections are made as in the circuit diagram ensuring that the dc motor field rheostat is in the cut-out position, alternator field rheostat is in cut in position and all the switches are open.

2 4-point starter handle is moved in clock-wise direction to start the dc shunt motor after the supply switch is closed.

3 By adjusting motor field rheostat the motor speed is brought to the rated speed of alternator which also corresponds to the frequency of 50HZ

4 DC supply to alternator field is closed and field current is adjusted to obtain rated voltage of primary of transformer. Calculate ratio of rated voltage to rated frequency value v/f. Note down all the meter readings.

5 By varying speed of DC motor and hence that of alternator so as to get a new frequency and voltage less than rated values ensuring that v/f remains constant. Note down the meter readings.

6 Repeat step 6 for different values of voltage and frequency and tabulate all the readings.

7 Bringing all the rheostats to their original positions, open both the supply switches.

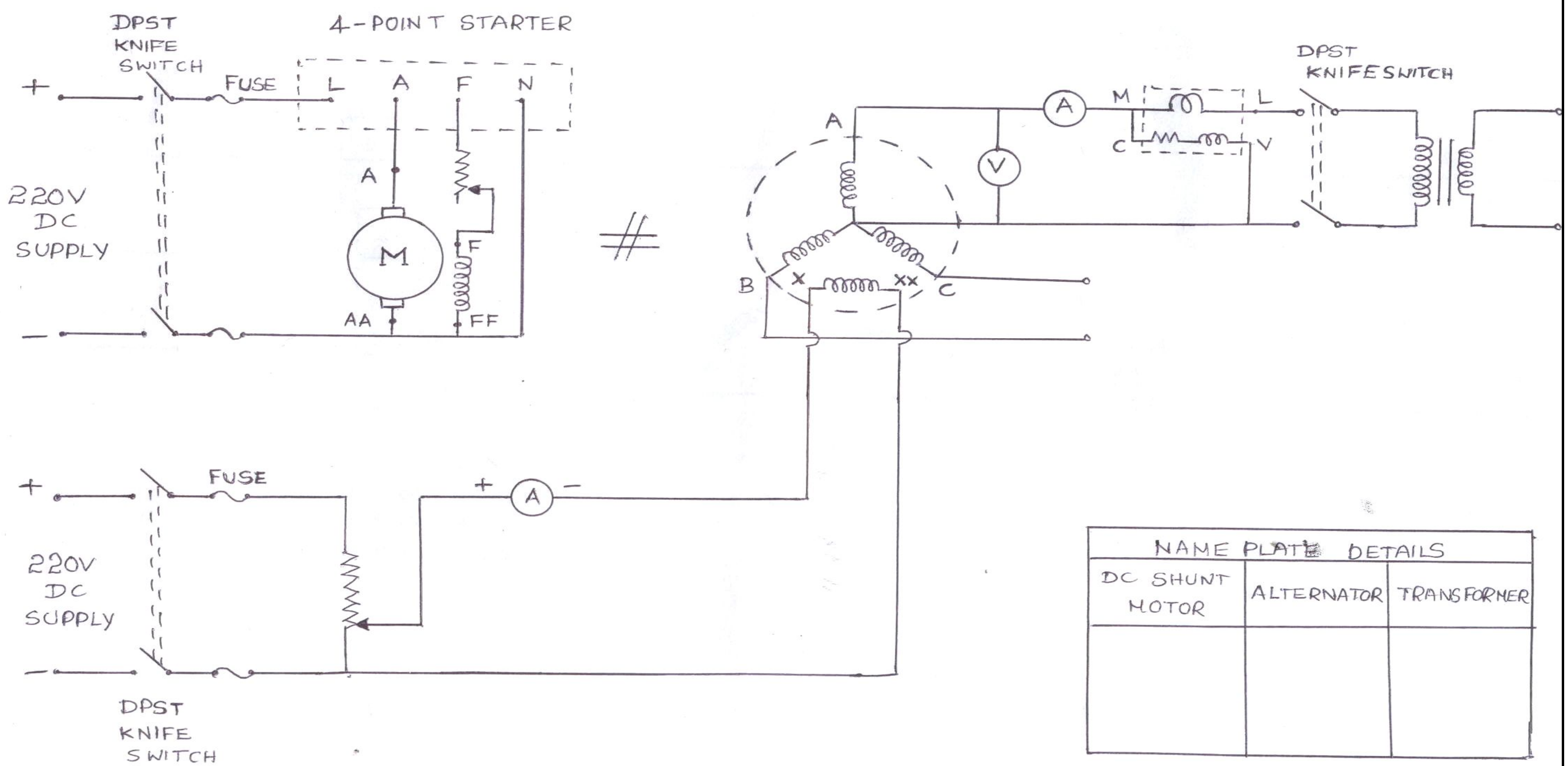
Observations & Calculations:

S.No	**V** **Volt**	**I** **Amps**	**W_i** **Watts**	**N(f)** RPM (HZ)	**v/f**	**w_i/f**

Result: A graph W_i/f and f has been plotted and hysteresis and eddy current losses have been separated from the no-load losses and are found to be

Hysteresis loss =
Eddy current loss =
No-load loss =

CIRCUIT DIAGRAM :



NAME PLATE DETAILS		
DC SHUNT MOTOR	ALTERNATOR	TRANSFORMER

Exp. No.12

SEPARATION OF NO LOAD LOSSES IN A 3Φ INDUCTION MOTOR

Aim: To separate no-load losses in the three phase squirrel cage induction motor as core loss and mechanical loss.

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I		1
2	Voltmeter	M.I		1
3	Wattmeter U.P.F	Dynamometer type		1
4	3-ϕ Dimmerstat	Core type		1
5	Induction motor			1

Procedure:

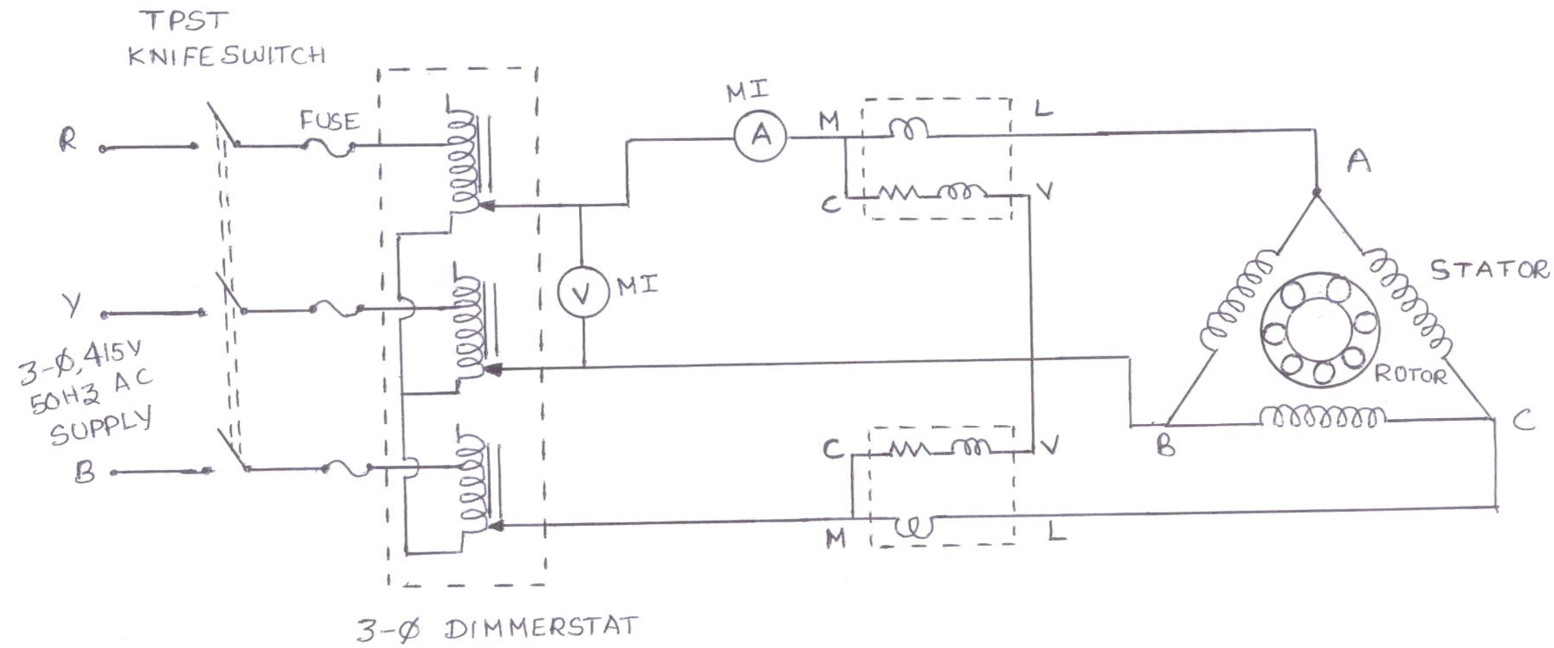
1. The connections are made as in the circuit diagram
2. Keep the dimmerstat at zero output position then close the supply switch.
3. Vary the dimmerstat output to the rated voltage of the induction motor then motor runs at no-load speed. Note down all the meter readings.
4. Adjust the voltage of the dimmerstat to a low value take the meter readings.
5. Step 4 is repeated for different voltages and then bring the dimmerstat to initial position and supply switch is opened

Observations & Calculations:

S.No	V_o Volt	I_o Amps	W_1 Watts	W_2 Watts	W_T Watts	Stator cu loss at no load	W_C	W_i

Result:

CIRCUIT DIAGRAM :



Exp. No.13

MEASUREMENT OF SEQUENCE REACTANCES OF ALTERNATOR

Aim: To measure the +ve, -ve and zero sequence rectances of alternator by making different faults on phases

Apparatus:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I		1
2	Voltmeter	M.I		1
3	Rheostat	Wire wound		2
5	DPST switch			1
6	Alternator set			1
7	Connecting wires	P.V.C insulated		1

Procedure:

1 Connect the circuit as shown in fig.1 and keep field rheostat of motor in cutout position and field rheostat of alternator at zero output position and DPST 2 is open position then close the supply DPST switch

2 Start the motor by using 3 point starter and bring the motor to the rated speed of alternator then DPST 2 switch is closed and supply switch to the field of alternator is closed

3 Adjust the speed rheostat of the alternator so that rated current flows. Under LG fault and maintain the speed at rated value. Note down ammeter reading then after open the faulty phase note down voltmeter reading.

4 By creating different faults LL, LLG and symmetrical 3Φ faults, note down ammeter and voltmeter readings.

5 Keep the field rheostat of the alternator at zero output and field rheostat of motor at cutout position then supply switch is opend

Precautions:

1 Do not build up the voltage of alternator, fault is applied first and then pass rated current

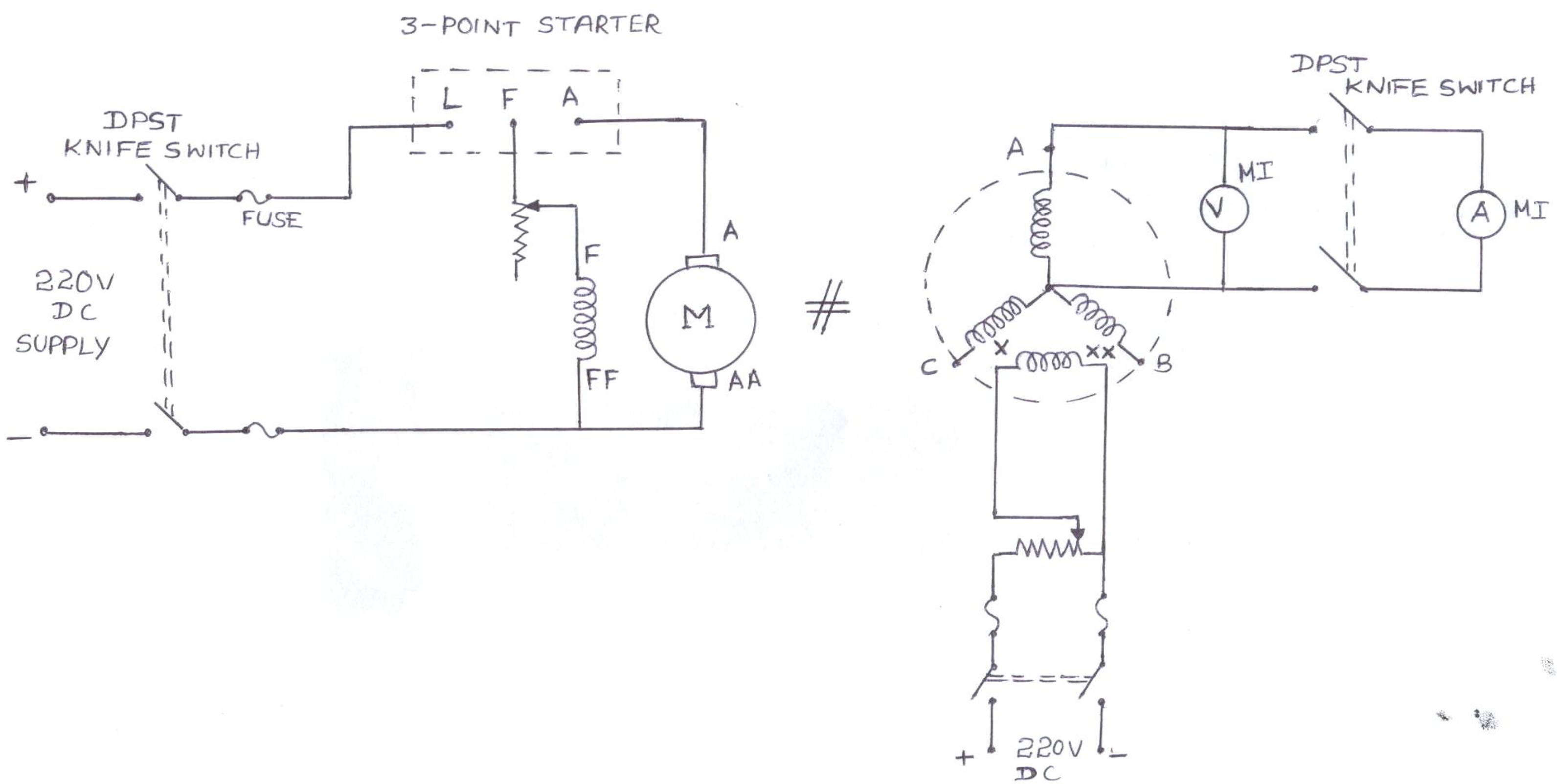
2 Always maintain rated speed during the faults

Observations & Calculations:

S.No	Fault	I(Amps)	V (volts)
1	LG		
2	LL		
3	LLG		
4	3Φ		

Result:

CIRCUIT DIAGRAM :



Exp. No.14

STUDY OF TURBO 2000

Aim: To run turbo 200 as 3Φ slip ring induction motor and alternator

Apparatus:

1. Turbo 2000
2. Stator no.2
3. connecting wires
4. Lamp load

Procedure:

Induction motor

1 Connections are made as shown in fig1. i.e connecting R-Y-B link to form rotor, A_2,B_2,C_2 link to form neutral connection for stator

2 Close the supply switch (TPST) to the turbo 2000

3 Vary the 3Φ dimmerstat output to the rated voltage of induction motor, note down the no load speed

4 Bring the dimmerstat to zero output position and open the supply switch

Alternator (Rotating field)

1 Connections are made as shown in fig 2 i.e A to 9, AA to 10, R to 13, Y to 14 and field is given at F & FF join A_2B_2,C_2 to form neutral for armature.

2 Ensure that dimmer D_1, D_2 are at initial position and then close the TPST supply switch

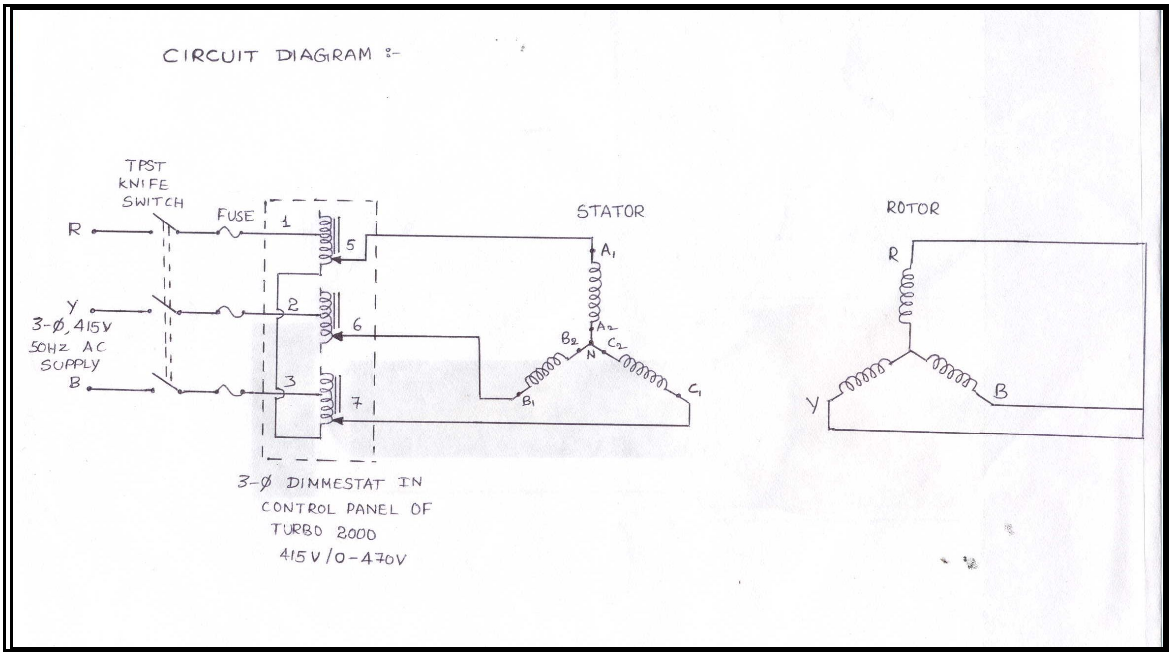
3 Vary the voltage across the armature slowly to the rated voltage then bring the speed to rated speed of alternator

4 By using dimmer D_2 vary the field current, note down the voltages. Repeat the procedure up to the rated voltage and apply load (bulb) then note down current

5 Remove the load then field excitation to alternator and switch is opened

Result:

Circuit diagram for induction motor (fig.1)



Circuit diagram for alternator (fig2)