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1.OC & SC TEST ON SINGLE PHASE TRANSFORMER

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

NAMEPLATE DETAILS:

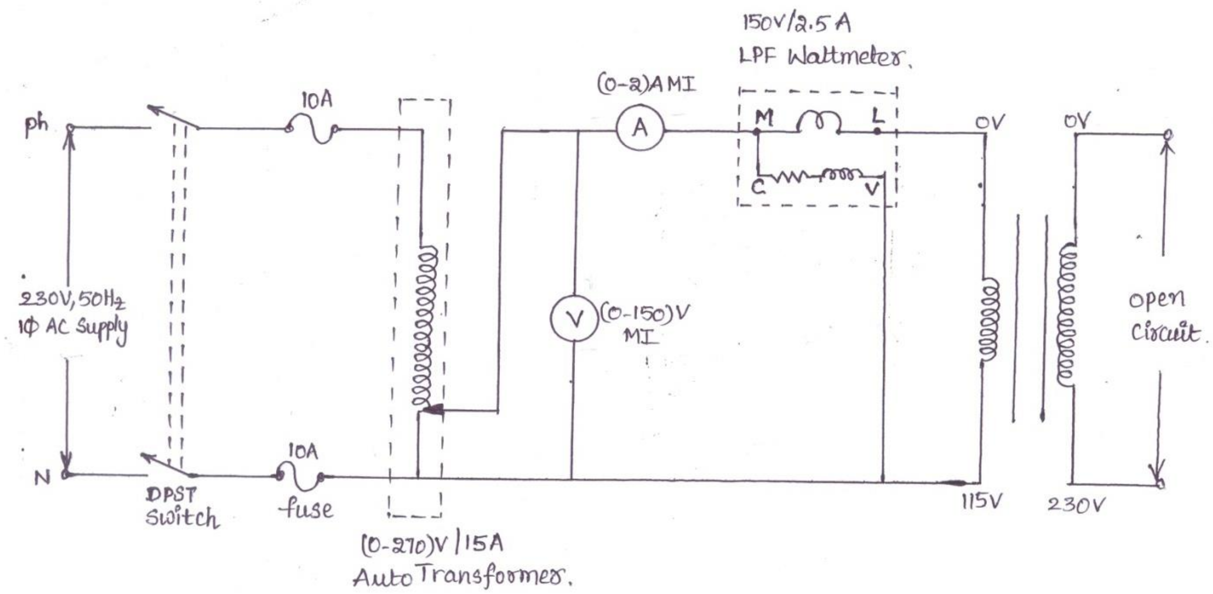
Power	2KVA
No. Of phases	1-ϕ
Voltage	230V
Frequency	50 Hz

APPARATUS:

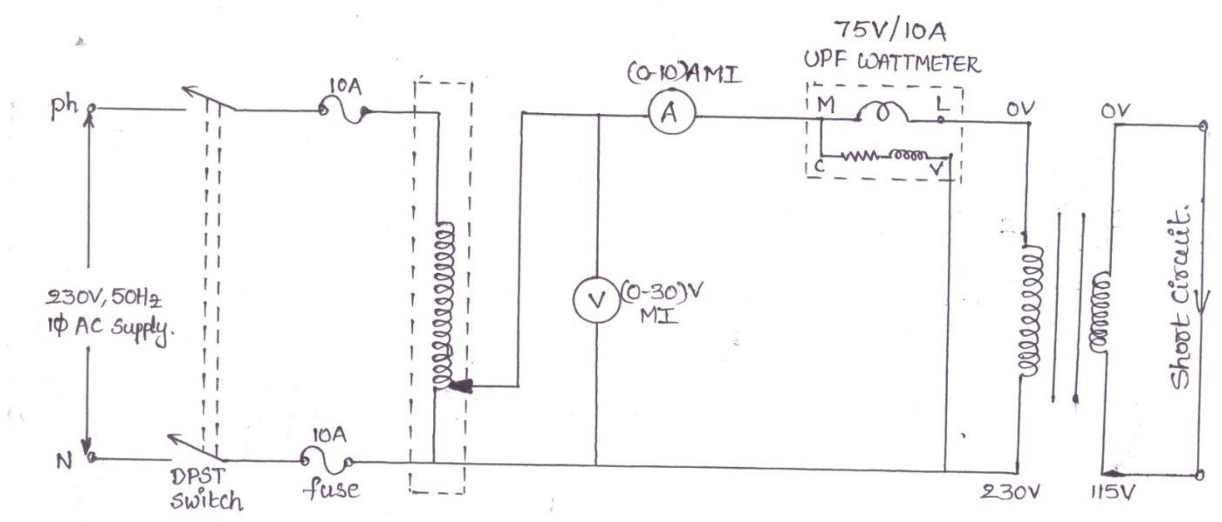
Name	Type	Range	Quantity
Voltmeter	M.I	0-150V	1
		0-30	1
Ammeter	M.I	0-10A	1
		0-2A	1
Wattmeter	LPF	0-150V, 2.5A	1
	UPF	0-75V, 10A	1

CIRCUIT DIAGRAMS:

OPEN CIRCUIT



SHORT CIRCUIT



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 Xo and Ro.

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:

OPEN CIRCUIT TEST:

1. Connect the circuit as per the circuit diagram.
2. Keep the autotransformer at minimum voltage position and switched on the supply.
3. Apply the rated voltage by adjusting the autotransformer.
4. Note down the corresponding wattmeter, ammeter and voltmeter readings.

SHORT CIRCUIT TEST:

1. Connect the circuit as per the circuit diagram.
2. Keep the autotransformer at minimum voltage position and switched on the supply.
3. Slowly vary the autotransformer until rated current flows through the transformer.
4. Note down the corresponding wattmeter, ammeter and voltmeter readings.

CALCULATIONS:

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

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

Input Power = Wattmeter reading X Wattmeter Multiplication factor

1. $Cos\phi_0 = \frac{w_0}{v_0 i_0}$

2. $I_W = I_0$ Cosϕ$_{-o}$

3. $I_m = I_0$ Sinϕ$_{-o}$

4. $R_o = \frac{V_o}{I_w}$

5. $X_m = \frac{V_o}{I_m}$

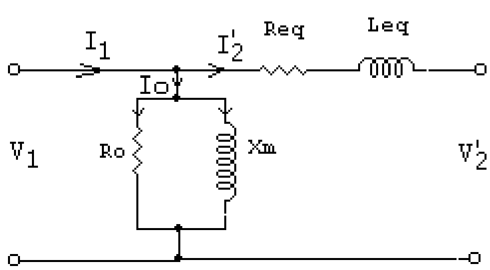
6. $R_{eq} = \frac{W_{sc}}{I_{sc}^2}$

7. $Z_{eq} = \frac{V_{sc}}{I_{sc}}$

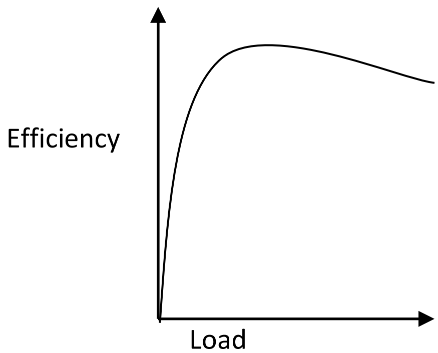
8. $X_{eq} = \sqrt{Z_{eq}^2 - R_{eq}^2}$

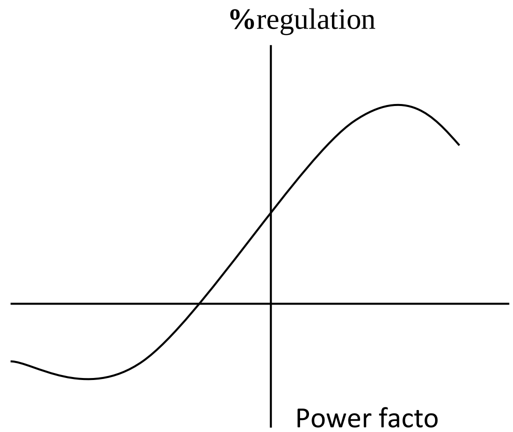
% Efficiency at full load = $\frac{FullloadVA \times Cos\phi}{FullloadVA \times Cos\phi + W_o + W_{sc}} \times 100$

EQUIVALENT CIRCUIT:



GRAPHS: a)Efficiency vs output b)%reg Vs power factor





OBSERVATIONS:

	Open circuit test			Short circuit Test		
S.No	**V_0** (V)	**I_0** (A)	**W_0** (W)	**V_{SC}** (V)	**I_{SC}** (A)	**W_{SC}** (W)

EQUIVALENT CIRCUIT PARAMETERS

S. No	$\cos\Phi_0$	I_W (A)	I_m (A)	R_0 Ω	X_0 Ω	$\cos\Phi_{sc}$	R_{eq} Ω	X_{eq} Ω	W_{sc} (W)

PRECAUTIONS:

1. Loose connection should be avoided.
2. Operate the instruments carefully.
3. Load currents should not be exceeding beyond their rating.

RESULT:

VIVA – VOCE QUESTIONS:

1. What is the purpose of OC & SC test?
2. Why are transformers rated in KVA?
3. Why is the OC test conducted on LV side?
4. Why is the SC test conducted on HV side?
5. Why is an L.P.F wattmeter is used in OC test?
6. Why is a UPF wattmeter is used in SC test
7. What are the advantages of transformer tests?
8. What is the applied voltage V_{Sc} under sc test?
9. Why iron loss are neglected in SC test
10. What is the value of primary current in OC test and why copper losses areneglected?
11. What are the readings of wattmeter obtain practically in OC & SC test
12. What is the output of transformer in SC test and what indicates the input power?

2.REGULATION OF ALTERNATOR BY SYNCHRONOUS IMPEDANCE AND MMF METHODS

AIM:

To find regulation of an Alternator by synchronous impedance and MMF methods.

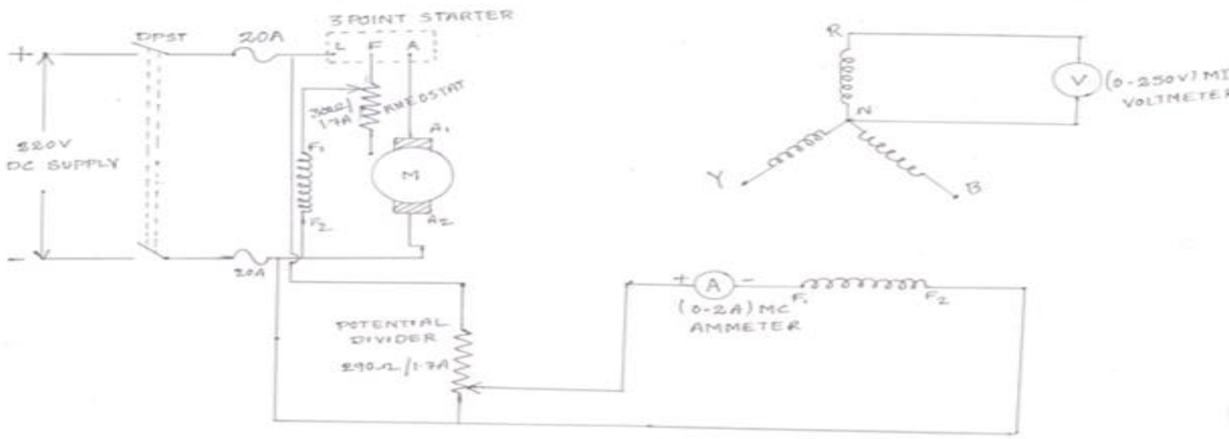
NAMEPLATE DETAILS:

	MOTOR	ALTERNATOR
Power	3.7kw	3.5KVA
Wound	Shunt	3 - Phase
Armature voltage	220V.	415V.
Armature current	20 A	4.9A
Excitation	220V, 0.9A	220V, 1.7A
Speed	1500	1500
Frequency	--------	50 Hz

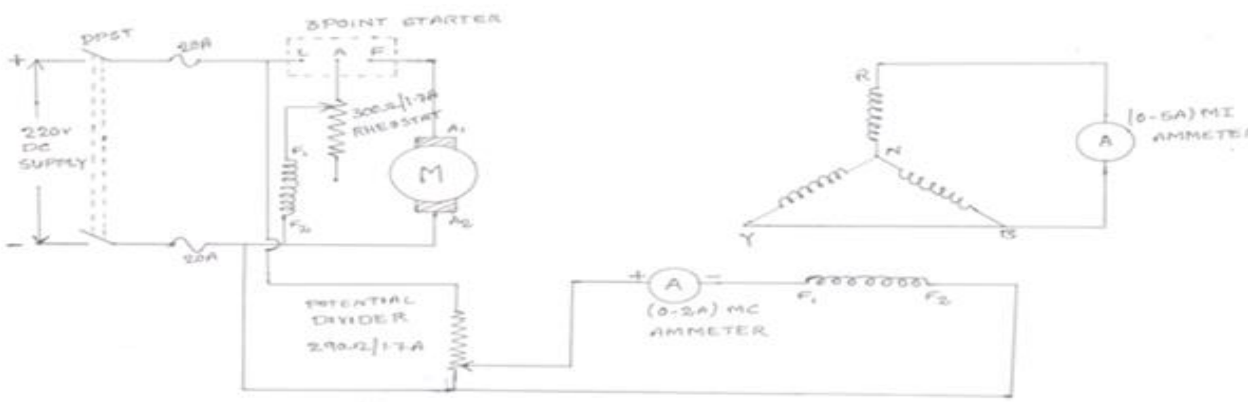
APPARATUS:

Name	Type	Range	Quantity
Voltmeter	M.I	0-300V	1
Ammeter	M.C	0-2A	1
	M.I	0-5A	1
Rheostat	——	0-300 Ω, 1.7A	1
		0-290Ω,1.7A	1
Tachometer		---	1

CIRCUIT DIAGRAMS:



OPEN CIRCUIT TEST



SHORT CIRCUIT TEST

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. Moreover, 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 reactance can be separated as $X_S = \sqrt{Zs^2 - Ra^2}$

PROCEDURE:

OPEN CIRCUIT TEST:

1 Connect the circuit as per the circuit diagram.
2 Keep the motor field rheostat at minimum resistance position and alternator field potential divider rheostat at maximum resistance position.
3 Start the motor with the help of 3- point starter and adjust the motor field rheostat till the motor reaches to its rated speed.
4 Gradually increases the excitation current of alternator by minimize the potential divider rheostat resistance.
5 Note the terminal voltage (V) of alternator at various excitation currents (I_f). Till the alternator attains its rated phase voltages
6 The relationship between no load voltage (V) and excitation current (I_f) gives the open circuit characteristics (OCC).

SHORT CIRCUIT TEST:

1. Connect the circuit as per the circuit diagram.
2. Keep the motor field rheostat at minimum resistance position and alternator field potential divider rheostat at maximum resistance position.
3. Start the motor with the help of 3- point starter and adjust the motor field rheostat till the motor reaches to its rated speed.
4. Gradually increases the excitation current of alternator by minimize the potential divider rheostat resistance.
5. Note the short circuit current (I_{se}) of alternator at various excitation currents (I_f). Till the alternator attains its rated currents.
6. The relationship between short circuit current (I_{se}) and excitation current (I_f) gives the short circuit characteristics (SCC).

TABULAR COLUMN:

O.C TEST:

S.NO	$I_{f\ (A)}$	E_O(volts)

S.C TEST:

S.NO	I_f (A)	I_{SC}(A)

CALCULATIONS:

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 $$X_S = \sqrt{Zs^2 - Ra^2}$$

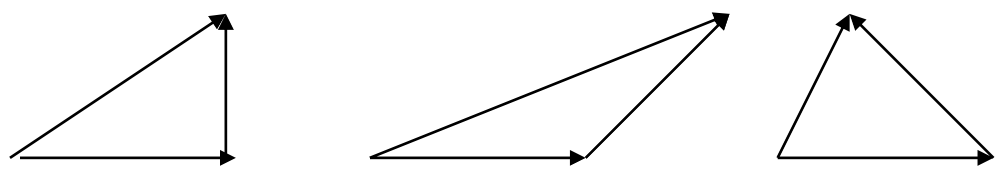
% Regulation = $\frac{E_0 - V}{V} \times 100$

Where V is the rated terminal voltage/phase

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

(+) → 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

For U.P.F:

∴ $E_1 = V + Ia\ Ra$

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 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}

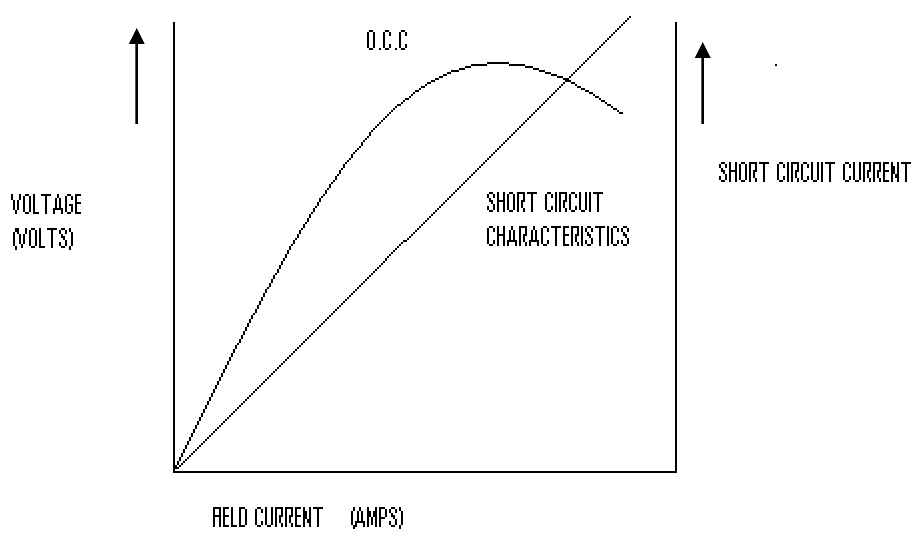
Leading power factor:

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

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

MODAL GRAPH:



PRECAUTIONS:

1. Loose connection should be avoided.
2. Operate the 3- point starter carefully.
3. Loads should not be exceeding beyond their rating.
4. Proper rating meters should be used.
5. Check the connections before giving supply.

RESULT:

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 method of finding out regulation is optimistic method?
7. Which 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.SCOTT CONNECTION OF TRANSFORMERS

AIM:

To connect a 3 – Φ supply into 2 – Φ supply by Scott connection.

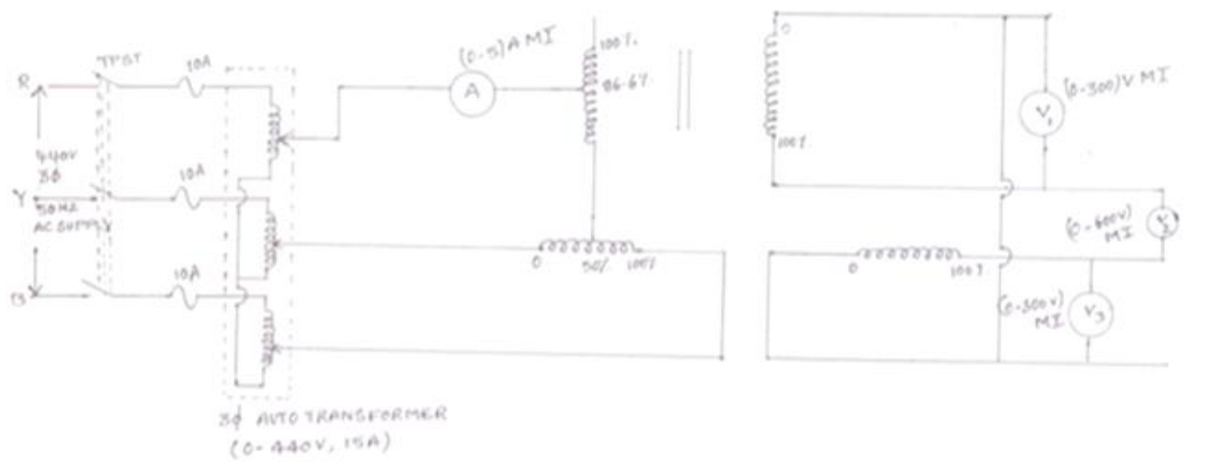
NAMEPLATE DETAILS:

Power	2KVA
No. Of phases	1-ϕ
Voltage	230V
Frequency	50 Hz

APPARATUS:

Name	Type	Rage	Quantity
Volt meter	M.I	0-600V 0-300V	1 2
Ammeter	M.I	0-5A	1
Tachometer	---	-------	1

CIRCUIT DIAGRAM:



THEORY:

In some cases, we may require 2- ϕ power instead of 3-ϕ or 1-ϕ power. For that it is necessary to convert 3- ϕ to2- ϕ power (since 3-ϕ power is available at every nook and corner). Scott connection is one by which 3-phase to 2-phase transformation is accomplished with the help of two identical 1-ϕ T/Fs having same current rating. One T/F has a center tap on primary side and it is known as Main transformer. It forms the horizontal member of the connection. Another T/F has 0.866 tap on primary side and known as Teaser transformer. The 50% tap point on primary side of the main T/F is joined to 86.6% tap on primary of the teaser T/F.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. First verify the Secondary windings are properly connected or not.
3. Now fix the autotransformer at low voltage output position and switch on the supply .
4. Apply the voltage with the help of autotransformer and note the all meters readings.
5. Repent the experiment for deferent values of V_L.
6. Verify the values with theoretical values.

OBSERVATION :

S. no	V1 volts	V2 volts	Theoretical value V3(volts)	Practical value V3(volts)

PRECAUTIONS:

1. Loose connections should be avoided.
2. Operate the instruments carefully.
3. Rated voltage should not be exceeding beyond their rating.

RESULT:

VIVA-VOCE:

1. In Scott connection 3-phase supply can be converted to 2-phase, is it balanced? How?
2. In Scott connection, how will you check that the supply is 2-phase?
3. Define Scott connection?

4.SUMPNER’S TEST ON 1-Φ TRANSFORMERS

AIM:

To find the regulation and efficiency of two similar transformers under load condition by conducting Sumpner’s test.

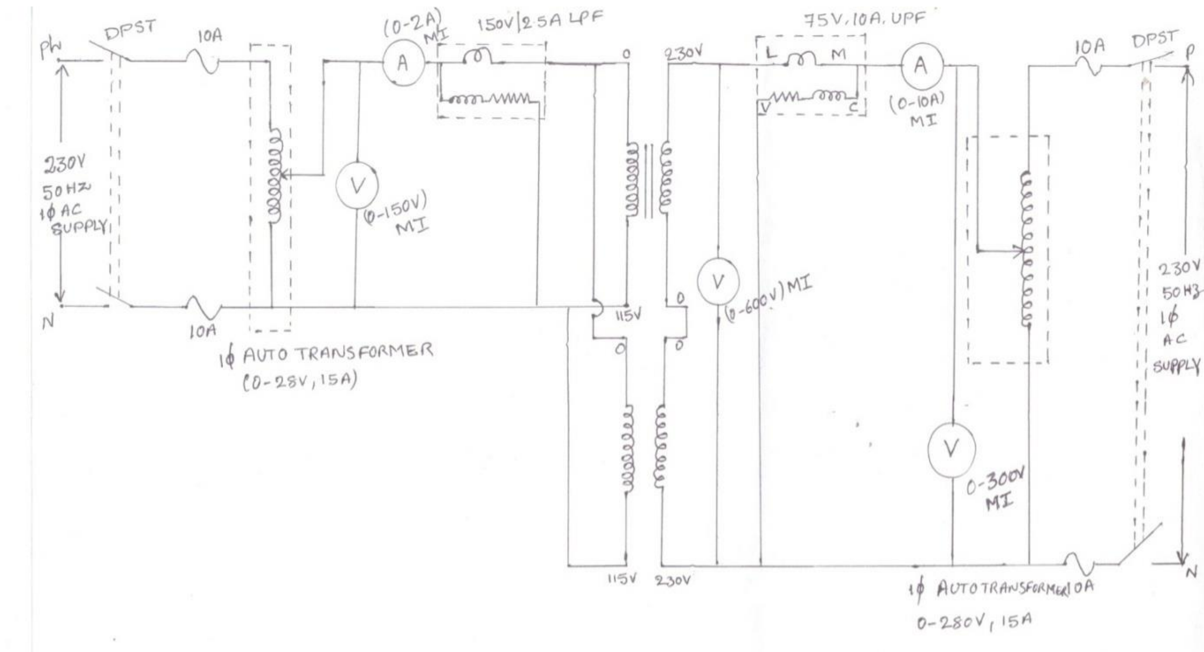
NAMEPLATE DETAILS:

Power	2KVA
No. Of phases	1-ϕ
Voltage	230V
Frequency	50 Hz

APPARATUS:

NAME	TYPE	RANGE	QUANTY
Volt meter	M.I	0-150V 0-600V 0-300V	1 1 1
Ammeter	M.I	0-2A	1
Rheostat	---	0-150V, 2.5A,LPF	1
		0-75V,10A,UPF	1
Taco meter	---		1

CIRCUIT DIAGRAM:



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:

O.C test:

1. Connect the circuit as per the circuit diagram.
2. Set the autotransformer at low voltage position.
3. Switch on the low voltage side autotransformer supply.
4. Apply rated voltage by adjusting the autotransformer.
5. Note the values of applied voltage, current & power reading is given by wattmeter.
6. The reading of wattmeter will give the iron losses.

S.C test:

1. Keep the switch S in open position and autotransformer at minimum voltage position. Switch on the autotransformer supply.
2. Secondary windings are connected in correct polarities if not voltmeter shows zero value.
3. S.C test is done at rated current so adjust the autotransformer to rated current.
4. Note the values of applied voltage, current & power reading is given by wattmeter.

TABULAR COLUMN:

O.C TEST**:**

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

S.C TEST:

(Vsc) (Volts)	Isc (Amps)	Wsc (Watts)	$Cos\phi_{sc}$	Loss per transformer (Watts)

CALCULATIONS:

Core loss per Transformer $=W_i = W_o/2$

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

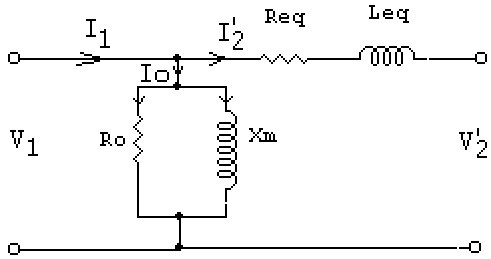
Efficiency (%) $= \dfrac{X \text{ x KVA x } Cos\phi}{X \text{ x KVA x } Cos\phi + W_i + X^2.W_{CU}}$

% Regulation $= \dfrac{I.R.Cos\phi \pm I.X.Sin\phi}{V} X 100$

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

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

Equivalent Circuit:-



R_o, X_m – are referred to L.V Side

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

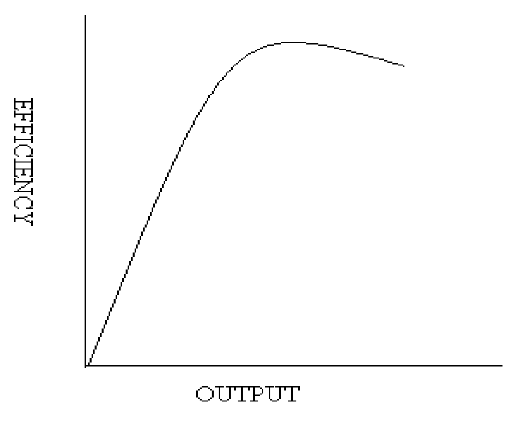
These values referred to L.V Side are

$$R_{eq} = a^2 R_{eq}^{\;1}$$
$$X_{eq} = a^2 X_{eq}^{\;1}$$

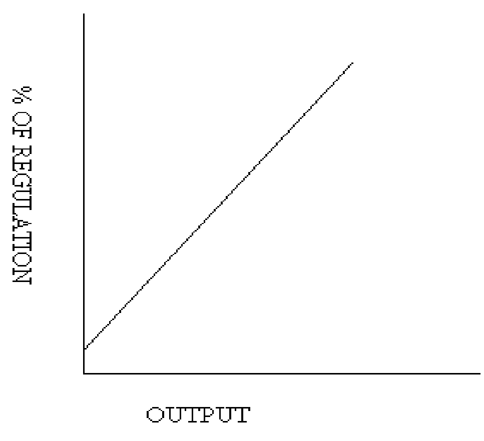
where a = $\dfrac{N_1}{N_2} = \dfrac{L.V}{H.V}$

MODEL GRAPH:

A Graph Plot output Vs Efficiency



A Graph Plot Output Vs %regulation



PRECAUTIONS:

1. Loose connection should be avoided.
2. Operate the instruments carefully.
3. Load currents should not be exceeding beyond their rating.

RESULT:

VIVA-VOCE:

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 sumpner's 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?

5.BRAKE TEST ON 3- Φ INDUCTION MOTOR

AIM: To conduct load test on 3 – Φ squirrel cage Induction motor.

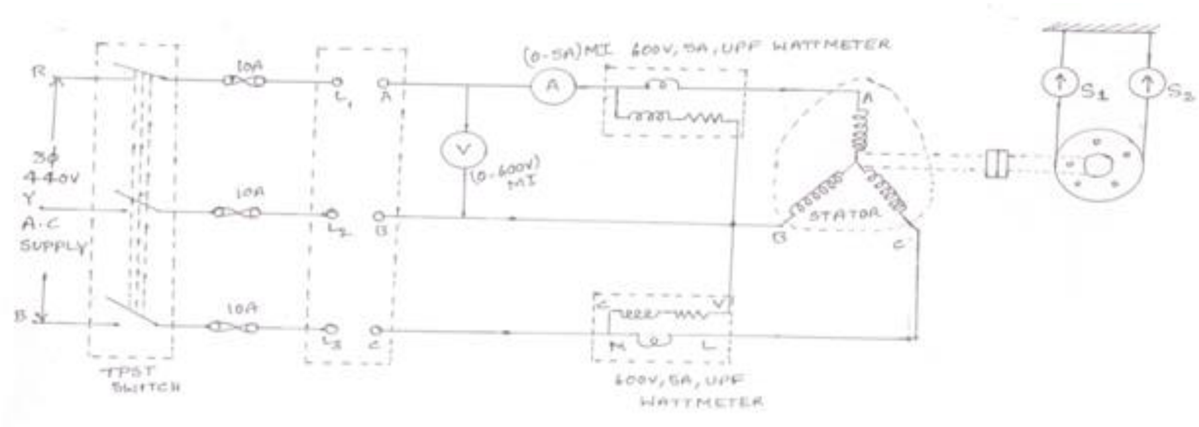
NAMEPLATE DETAILS:

Power	3 KVA
Voltage	415V
Current	4.5A
Phase	3-ϕ
Frequency	50 Hz
Speed	1440 rpm

APPARATUS:

Name	Type	Rage	Quantity
Volt meter	M.I	0-5A	1
Ammeter	M.I	0-600V	1
Wattmeter	UPF	600V, 5A	2
Tachometer	---	-------	1

CIRCUIT DIAGRAM:



BRAKE TEST ON 3PHASE INDUCTION MOTOR

THEORY:

As a general rule, conversion of electrical energy to mechanical energy takes place in to the rotating part on electrical motor. In DC motors, electrical power conduct directly to the armature, i.e., rotating part through brushes and commutator. Hence, in this sense, a DC motor can be called as ‘conduction motor’. However, in AC motors, rotor does not receive power by conduction but by induction in exactly the same way as secondary of a two winding T/F receives its power from the primary. So, these motors are known as Induction motors. In fact an induction motor can be taken as rotating T/F, i.e. one in which primary winding is stationary and but the secondary is free. By applying Brake to induction motor directly using pully arrangement ,output of motor can be brought.

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, $T = \omega \times \frac{d}{2} kg - m$

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

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: ϕ is the power factor angle, then

$$\cos\phi = \frac{\omega}{\sqrt{3}VI}$$

Where ω is the input power.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Make sure there is no load on the pulley of the motor.
3. Close the TPST and start the motor with the help of DOL starter.
4. Gradually apply the load on the motor by tightening the belt on the pulley.
5. Note the values of voltage, current, speed, spring balances, power in wattmeters W1 and W 2.
6. Repeat the above steps for deferent readings below full load current.

CALCULATIONS:

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

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

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

3. Out put Power = $\frac{2\prod NT}{60}$ wattsω

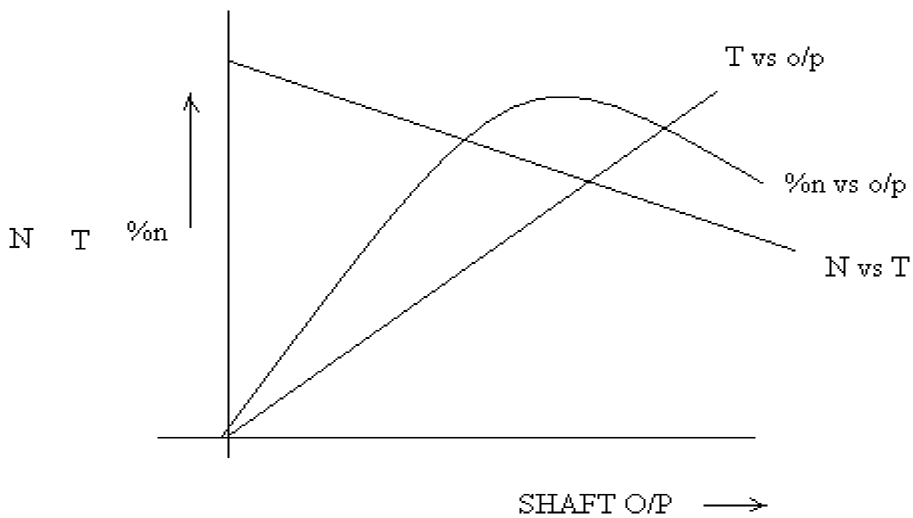
4. % Efficiency = $\frac{Output\ power}{Input\ power} \times 100$

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

OBSERVATIONS:

S.NO	VOLTAGE (VOLTS)	LINE CURRENT (AMPS)	S1	S2	SPEED (N)	INPUT		SHAFT TORQUE	ω	SHAFT OUTPUT	EFFICIENCY
						W1	W2				

GRAPH:



PRECAUTIONS:

1 Loose connection should be avoided.
2 Operate the starter carefully.
3 Loads should not be exceeding beyond their rating.
4 Proper rating meters should be used.
5 Check the connections before giving supply.

RESULT:

VIVA VOCE:

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

6.PARALLEL OPERATION OF TRANSFORMERS

AIM: To operate two transformers in parallel.

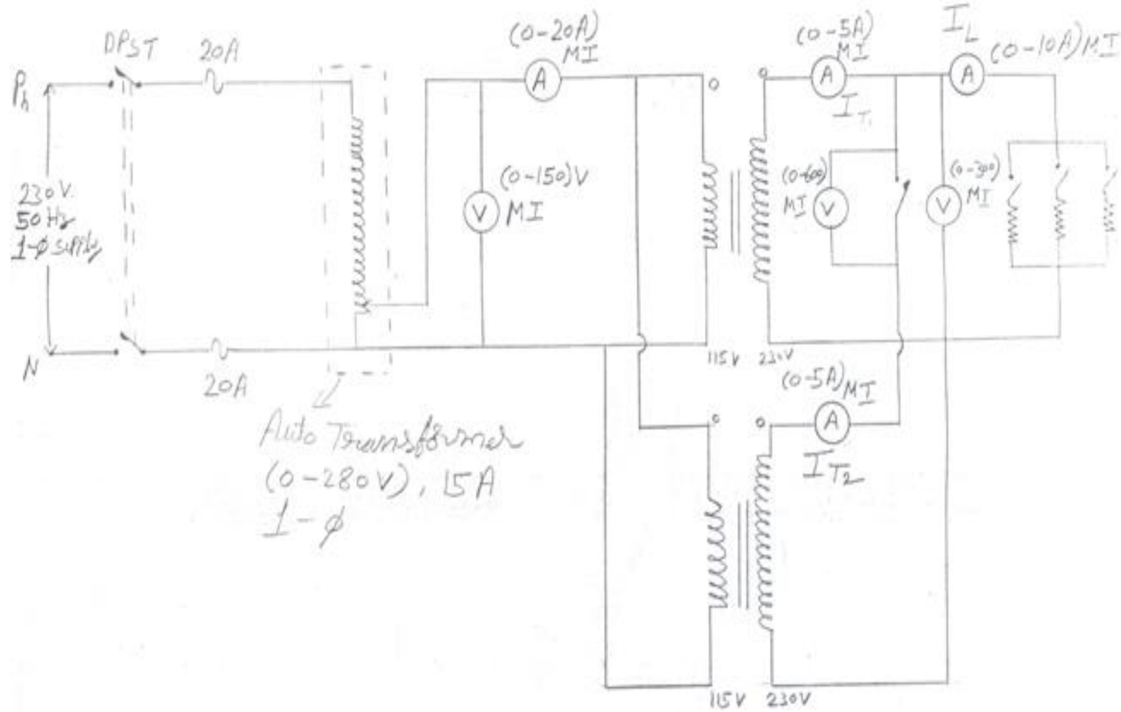
NAMEPLATE DETAILS :

Power	2KVA
No. Of phases	1-ϕ
Voltage	230V
Frequency	50 Hz

APPARATUS:

Name	Type	Range	Quantity
Voltmeter	M.I	0-600V	1
		0-300V	1
		0-150V	1
Ammeter	M.I	0-20A	1
		0-10A	1
		0 -5A	2
Autotransformer	-------	0 -280V, 15A	1

CIRCUIT DIAGRAM :



THEORY:

The various conditions, which must be fulfilled for the satisfactory parallel operation of two or more single-phase transformers, are as follows:

a) The transformers must have the same voltage ratios, i.e, with the primaries connected to the same voltage source; the secondary voltages of all transformers should be equal in magnitude.
b) The equivalent leakage impedances in ohms should be inversely proportional to their respective KVA ratings. In other words, the per unit leakage impedances of the transformers based on their own KVA ratings must be equal.
c) The ratio of equivalent leakage reactance to equivalent resistance, i.e X_e / R_e should be same for all the transformers.
d) The transformers must be connected properly, so far as their polarities are concerned.

If the secondary terminals are connected with wrong polarities large circulating currents will flow and the transformer may get damaged. Therefore, condition (d) must be strictly fulfilled.

Figure shows two single phase transformers in parallel, connected to the same voltage source on the primary side. A further check on the polarities can be applied by connecting a voltmeter V in series with the two secondaries. Zero voltmeter reading indicates proper polarities. If the voltmeter reads the sum of two secondary voltages, the polarities are improper and can be connected by reversing the secondary terminals of any one transformer.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Keep the autotransformer at minimum voltage position and switched on the supply.
3. Apply the rated voltage by adjusting the autotransformer.
4. Observe the voltmeter, which is connected across switch ‘S’. If it is indicts zero that means same polarities are connected. Other wise reveres the connection.
5. Close the switch ‘S’ carefully.
6. Connect the load in step-by-step up to rated value and each step note the load current I_L, I_{T1} and I_{T2}.

PRECAUTIONS:

1. The Transformers must have same voltage ratio.
2. The Transformers must be connected with correct polarities .
3. Load currents should not be exceeding beyond their rating.

OBSERVATIONS:

S.no	I_L(Amps)	I_{T1}(Amps)	I_{T2}(Amps)

RESULT:

VIVA VOCE:

1. Why is parallel operation of transformers necessary?
2. What are the conditions to be satisfied for parallel operation of transformers?
3. If the two secondaries of the transformers in parallel are not connected with proper polarity and a voltmeter is connected in series with the winding then the reading will be?
4. Why is the rating of the transformer expressed in KVA?

5. If a 100KVA transformer has Z_{eq}=2Ώ, then the other transformer of 500KVA in parallel must have $Z_{eq}$of?
6. Can two transformers of different sizes be operated in parallel?
7. At no-load if E_a and $E_b$are the secondary voltages of transformers A nd B and their equivalent impedances are $Z_a$andZ_b then circulating current is ?
8. When is the circulating current produced in the parallel operation of two transformers?

7.EQUIVALENT CIRCUIT OF A 1 –Φ INDUCTION MOTOR

AIM: To conduct no load & blocked rotor test on a 1 – Φ induction motor and draw the equivalent circuit.

NAMEPLATE DETAILS:

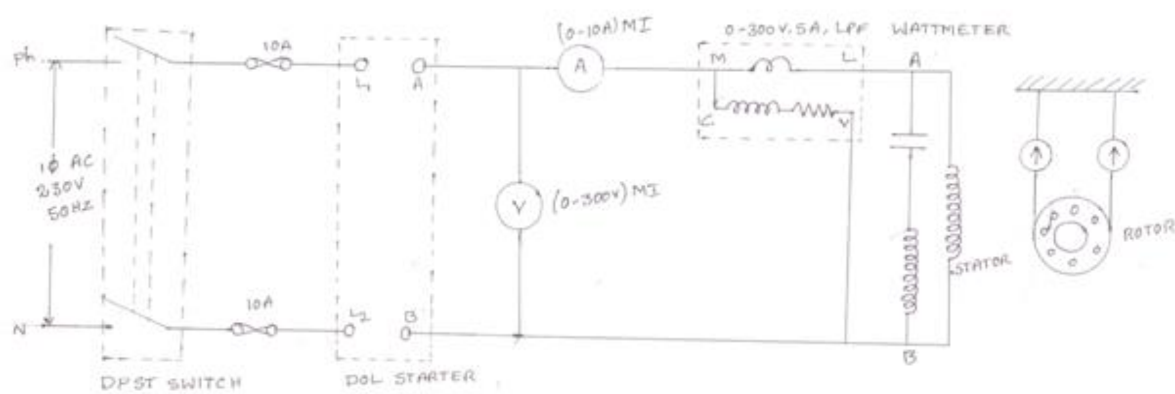
Power	1.5 KW
Voltage	230V
Current	9.9A
Phase	1-ϕ
Frequency	50 Hz
Speed	1440 rpm

APPARATUS :

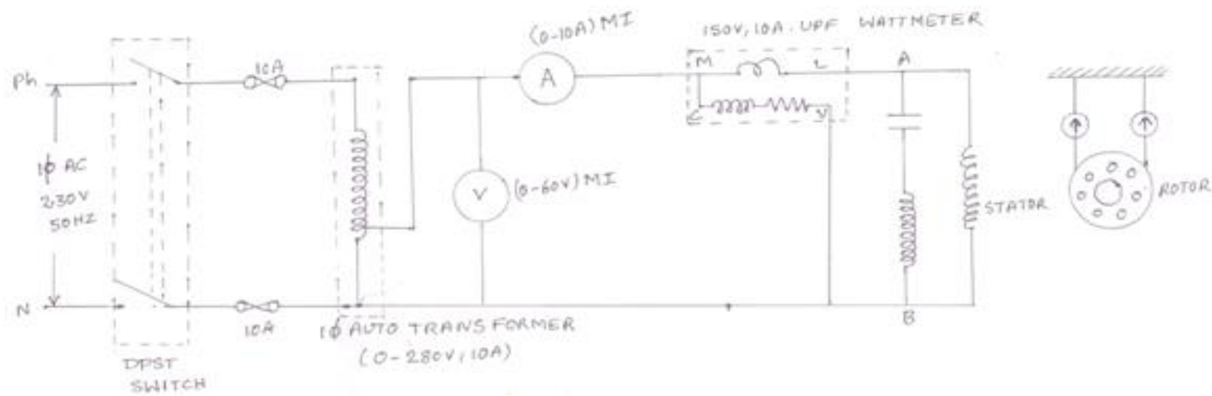
Name	Type	Rage	Quantity
Volt meter	M.I	0-300V 0-60V	1 1
Ammeter	M.I	0-10A	1
Wattmeter	M.I M.I	300V, 5A UPF 150V,10A,LPF	1 1
Tachometer	---	-------	1

CIRCUIT DIAGRAM:

NO LOAD CIRCUIT



BLOCKED ROTAOR CIRCUIT



THEORY:

A single-phase induction 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 $T = T_f - T_b$.

PROCEDURE:

NO LOAD TEST

1. Connect the no load circuit as per the circuit diagram.
2. Close the DPST and start the motor with the help of DOL starter.
3. Note down the voltage, no load current, power in wattmeter.
4. Switch off the starter and open the DPST

BLOCKED ROTOR TEST

1. Connect the blocked rotor circuit as per the circuit diagram.
2. Keep the autotransformer at minimum position and blocked the rotor by tightening the belt over the pulley.
3. Close the DPST and apply the rated current by increasing voltage with the help of autotransformer.
4. Note down the voltage, load current, power in wattmeter.
5. Minimize the autotransformer and open the DPST.

OBSERVATIONS:

	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

CALCULATIONS:

No load test:

Iron losses (W_0) =(VI_0 Cos$\O_0$) Watts

$$Cos\phi_0 = \frac{w_0}{v_0 i_0}$$

Loss component $= I_W = I_0$ Cosϕ_o Amps

Magnetizing current $I_m = I_0$ Sinϕ_o Amps

Loss component (shunt resistance) $R_o = \frac{V_o}{I_w}\ \Omega$

Magnetizing reactance $X_m = \frac{V_o}{I_m}\ \Omega$

Blocked rotor test:

Equivalent Impedance $Z_{eq} = \frac{V_{sc}}{I_{sc}}\ \Omega$ Total resistance $= R_{eq} = \frac{W_{sc}}{I_{sc}^2}\ \Omega$

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

PRECAUTIONS:

1. Loose connection should be avoided.
2. Operate the instruments carefully.
3. Load currents should not be exceeding beyond their rating.

RESULT:

VIVA VOCE:

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?

8.SLIP TEST ON SALINET POLE ALTERNATOR

AIM:

To determine the Xd & Xq of salient machine by slip test.

NAMEPLATE DETAILS:

	MOTOR	ALTORNATOR
Power	3.7kw	3.5KVA
Wound	Shunt	---
Voltage	220V.	415V.
Current	20.5A	4.5A
Excitation	220V, 0.9A	220V, 1.7A
Speed	1500.	1500.

APPARATUS:

Name	Type	Rage	Quantity
Volt meter	M.I	0-100V	1
Ammeter	M.I	0-5A	1
Rheostat	---	0-300Ω, 1.7A	1
		0-50Ω, 5A	1
Tachometer	---		1

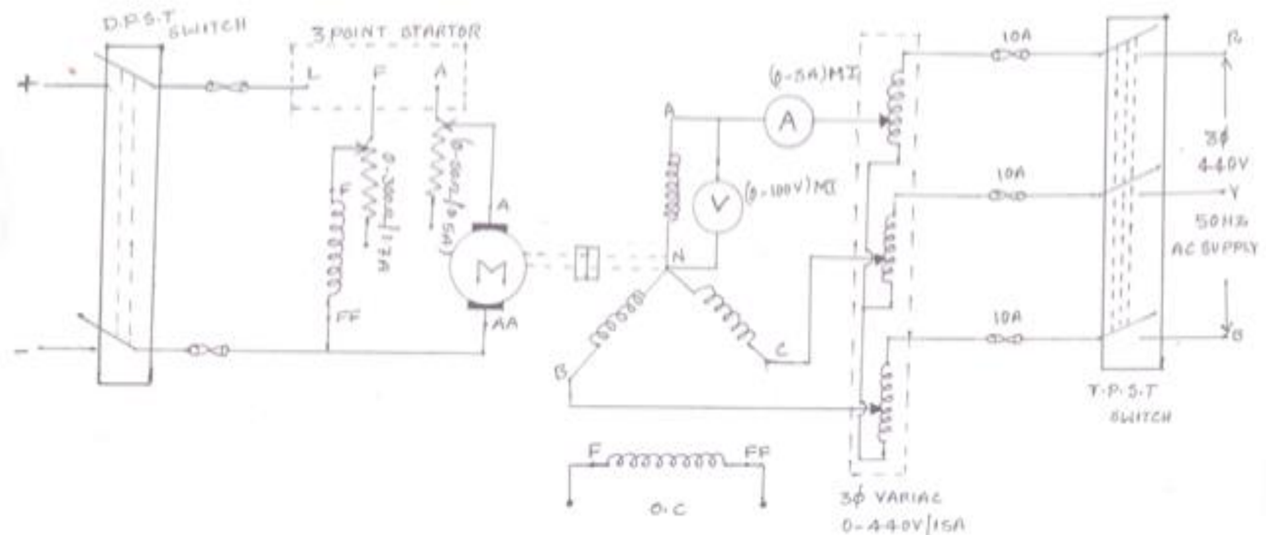
THEORY:

The values of X_d & X_q are determined by conducting the slip-test.The syn. machine is driven by a separate prime mover at a speed slightly different from synchronous speed. The field winding is left open and positive sequence balanced voltages of reduced magnitude (around 25% of the rated value) and of rated frequency and impressed across the armature terminals. Here, the relative velocity b/w the field poles and the rotating armature mmf wave is equal to the difference b/w syn. speed and the rotor speed i.e, the slip speed . When the rotor is along the d-axis, then it has a position of minimum reluctance, minimum flux linkage and maximum flux produced links with the winding. then X_d = (max. armature terminal voltage/ph) / (min. armature current/ph)As the current is small then V_t will be high as drop will be small. When the rotor is along q-axis, then reluctance is max, then the flux linkage would be max.Then The min flux produced links with winding. So minimum emf. X_q = (min. armature terminal voltage/ph) / (max. armature current/ph)

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Set all rheostats at minimum resistance position and 3-phase autotransformer at zero position.
3. Put on the D.C supply and start the D.C motor by 3- point starter.
4. Adjust the D.C motor speed lessthan synchronous speed (to get less slip)
5. Put on A.C supply and apply small voltage by varying the 3- phase variac.
6. Observe the oscillations in voltmeter and ammeter. Note down the maximum and minimum values of oscillations.
7. Repent the above process for different values.

CIRCUIT DIAGRAM:



OBSERVATIONS:

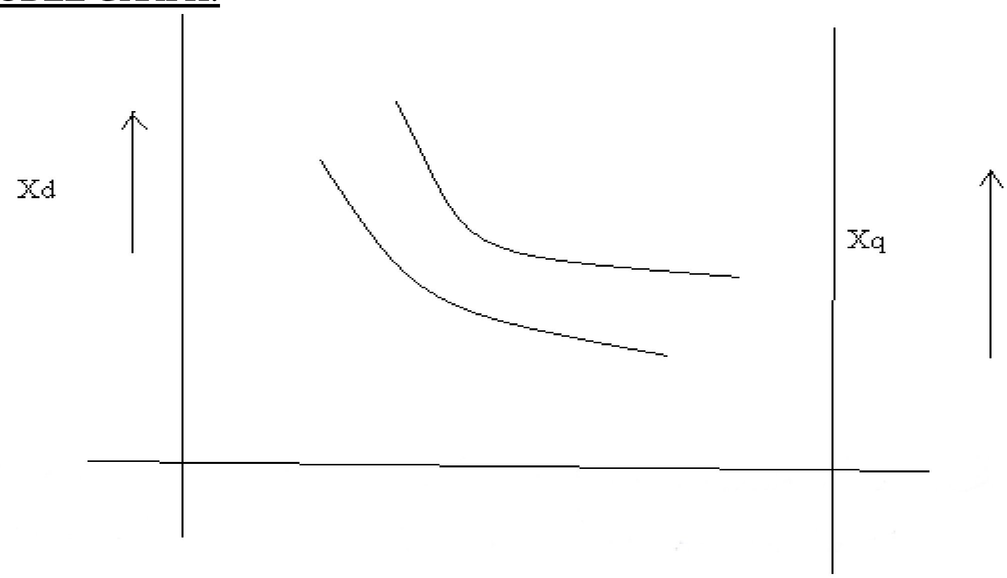
S.no	Speed	Voltage		Current		X_d	X_q	X_d / X_q
		Min	Mix	Min	Mix			

CALCULATIONS:

$$X_d = V_{max} / I_{min}$$

$$X_q = V_{min} / I_{max}$$

MODEL GRAPH:



RESULT :

VIVA VOCE:

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.V & INVERTED V CURVES OF A 3 – Φ SYNCHRONOUS MOTOR

AIM:

To plot V & inverted V curves of a synchronous motor.

NAMEPLATE DETAILS:

Power	3.5 KVA
Voltage	415V
Current	4.5A
Phase	3-ϕ
Frequency	50 Hz
Speed	1440 rpm
Excitation	220V, 1.7A

APPARATUS :

Name	Type	Rage	Quantity
Volt meter	M.I	0-600V	1
Ammeter	M.I	0-5A	1
Wattmeter	UPF	0-600V/10A	2
Rheostat	W.W	0-290Ω, 2.4A	1
Tachometer	---		1

THEORY:

When the field current of a synchronous motor is reduced, a lagging armature current is produced and that exceeds the minimum armature 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 for both no load and full load.

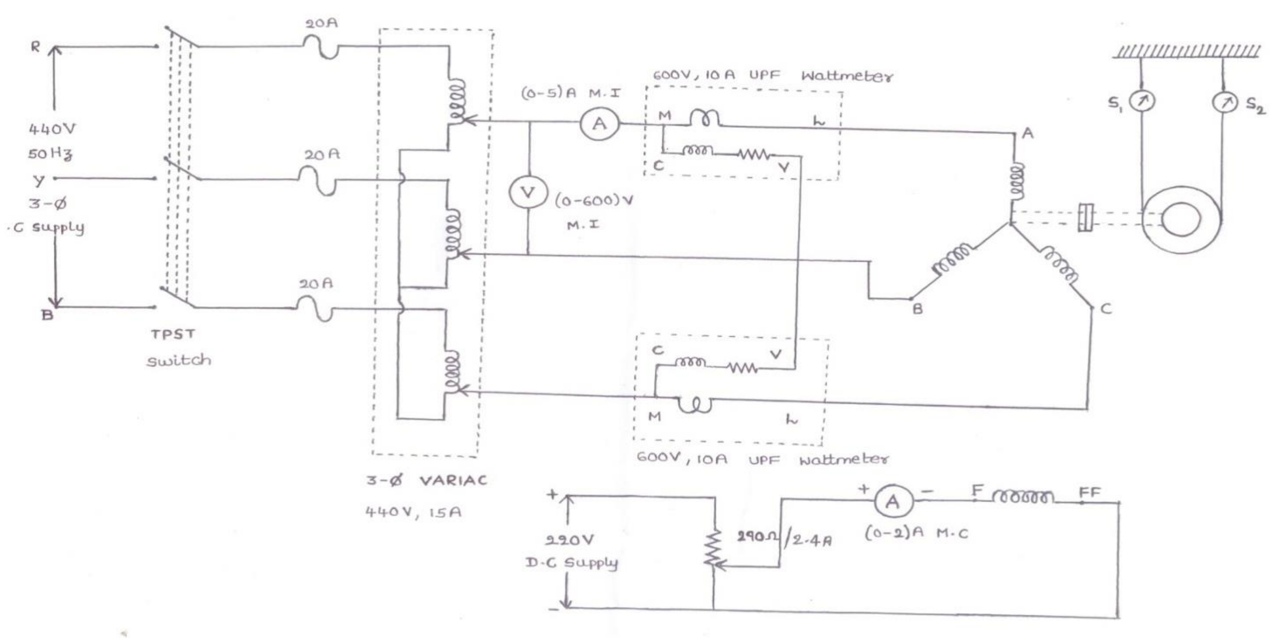
The power factor is plotted against the DC field current for no-load and full load also

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 rotational losses.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Keep the synchronous starter in start position than close the TPST and switch on the motor with the help of starter.
3. Now keep the synchronous starter in run position and vary the field exaction.
4. Note down the values of the voltage, load current, field current, and power in watt meters.
5. Repeat the process for different values of load currents.

CIRCUIT DIAGRAM:



OBSERVATIONS:

Voltage	I_f AMPS	I_a AMPS	W_1 WATTS	W_2 WATTS	Power (W_1+W_2)	Cosϕ

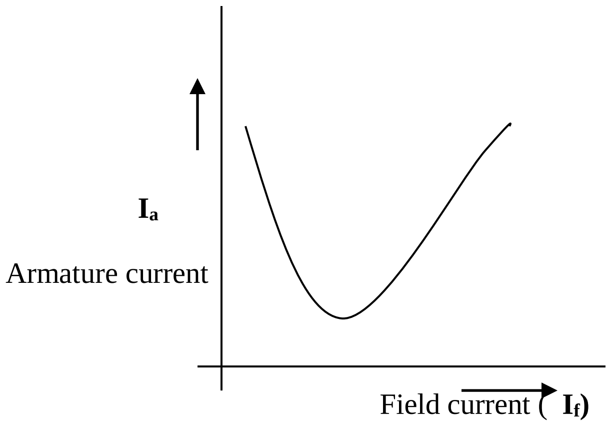
CALCULATIONS:

Power = $(W_1 + W_2)$ Watts

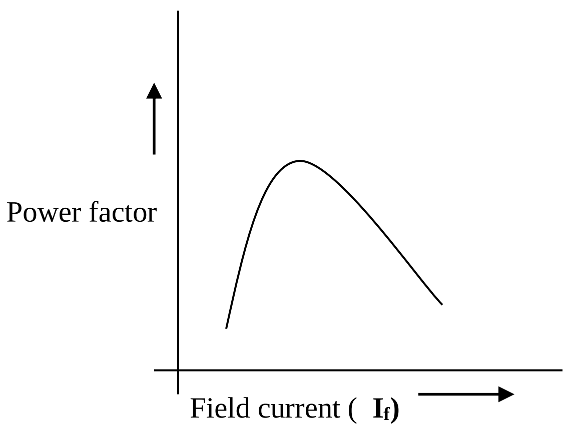
$\text{Cos}\phi = (W_1 + W_2) / \sqrt{3}\ VI_a$

MODAL GRAPHS:

I_f Vs I_a for V curves



I_f Vs P.f for inverted V curves



RESULT:

VIVA VOCE:

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?

10.NO LOAD & BLOCKED ROTOR TEST ON 3-Φ INDUCTION MOTOR

AIM:

To conduct no load & blocked rotor test on a 3 – Φ induction motor and draw the equivalent circuit.

NAMEPLATE DETAILS:

Power	3.5 KW
Voltage	415V
Current	4.5A
Phase	3-ϕ
Frequency	50 Hz
Speed	1440 rpm

APPARATUS:

Name	Type	Rage	Quantity
Volt meter	M.I	0-150V 0-600V	1 1
Ammeter	M.I	0-5A	1
Wattmeter	---	600V, 5A,LPF 150V,10A,UPF	2 2
Tachometer	---	-------	1

THEORY:

The performance aspects of induction motor under steady state conditions are variations in 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 air gap from the stator is `

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

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

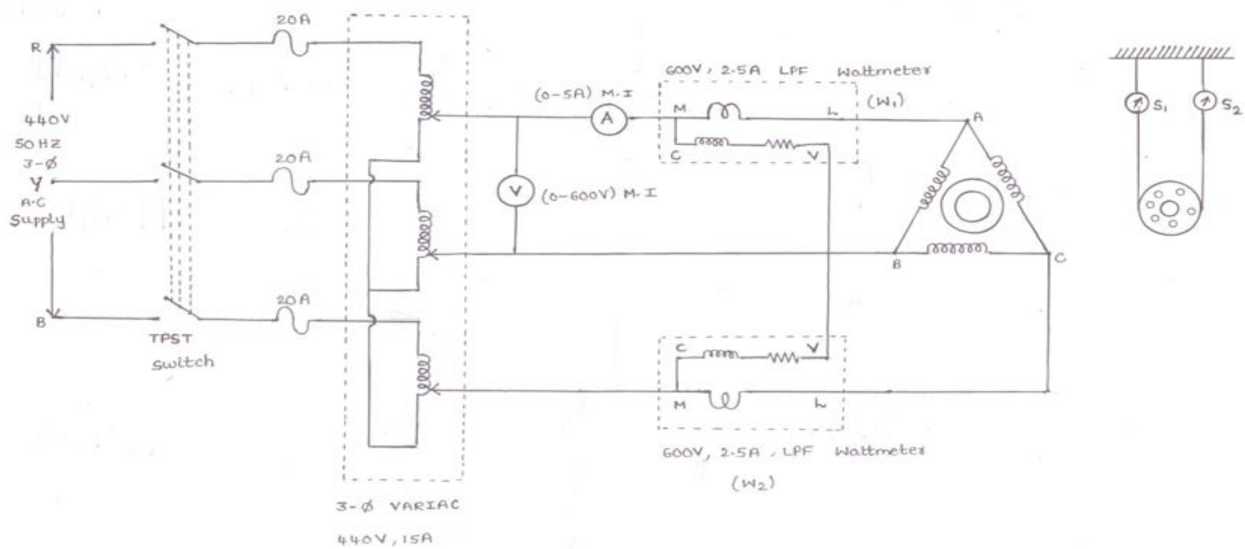
The internal mechanical power 'ρ' developed by the motor is there fore

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

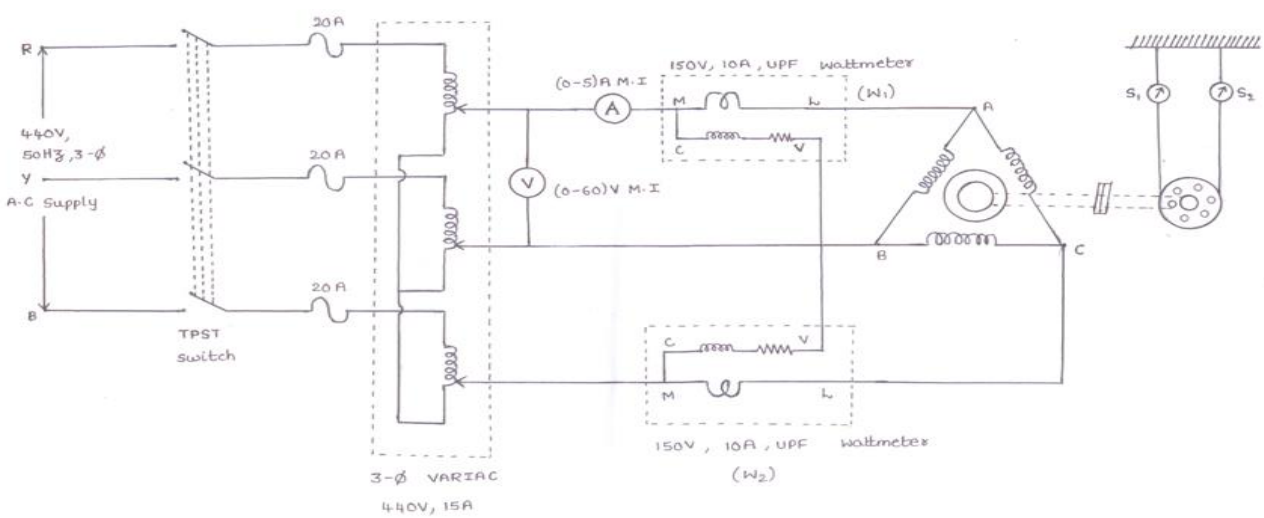
$$= 3I_2^{\,2}R_2\left(\frac{1-s}{s}\right) \quad \text{or} \quad P = (1 - s)\, Pg$$

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

CIRCUIT DIAGRAM:



NO-LOAD CIRCUIT



BLOCKED ROTOR CIRCUIT

PROCEDURE:

NO LOAD TEST:

1 Connect the no load circuit as per the circuit diagram.
2 Close the DPST and start the motor with the help of DOL starter.
3 Note the voltage, no load current, power in wattmeter.
4 Switch off the starter and open the DPST

BLOCKED ROTOR TEST:

1 Connect the blocked rotor circuit as per the circuit diagram.
2 Keep the autotransformer at minimum position and blocked the rotor by tightening the belt over the pulley.
3 Close the DPST and apply the rated current by increasing voltage with the help of autotransformer.
4 Note down the voltage, load current, power in wattmeter.
5 Minimize the autotransformer and open the DPST.

OBSERVATIONS:

Voltage (V)	**Current (I_0)**	**Power (W_1)**	**Power (W_2)**	**Total Power ($W_0 = W_1 + W_2$)**

CALCULATIONS:

No load P.f = $\frac{P_{NL}}{\sqrt{3}V_{BL}I_{NL}}$

Blocked rotor p.f $= \frac{P_{BL}}{\sqrt{3}V_{BL}\,I_{BL}}$

CONSTRUCTION OF CIRCLE DIAGRAM:

1. Draw a line representing the applied voltage per phase V_I (reference phasor)

2. Draw the no load current I_O at no load pf angle Φ_o (line OA) with the reference phasor V_I current scale may be suitably chosen ,keeping in mind the short-circuit current at rated voltage .

3. Draw short-circuit or block rotor current corresponding to the rated phase voltage (line OB) at power factor angle Φ_b with the reference phasor $V_{1.}$

4. Join AB, which represents the out put line of the motor.

5. Draw the horizontal line AF and erect a perpendicular bisector on the out put line, so as the meet the line AF at the point O^1. Then with O^1 as the center and AO^1 as the radius, draw the semicircle ABF.

6. Draw the vertical line from the point B, so as to meet the line AF at the point D. Drive line BD in the ratio of rotor copper losses to stator copper losses at the point E, i.e.

$$\frac{BE}{DE} = \frac{Rotorcopperlosses}{Statorcopperlosses}$$

Then AE represents the torque line.

Determination of performance:-

The performance of motor can be calculated base on the circle diagram as follows.

(i)Output scale can be found out from the current scale.

Output in watts per cm =V_1*current per cm.

(ii) Full load current and its power factor: Draw the vertical line BC representing the rated out put of the motor as per the output scale. From point C, draw a line parallel to the out put line, so as to cut the circle at the point P. Join OP which represents to full load current of the motor to current scale. Corresponding power factor angle, Φ_1 gives the power factor at which the motor is operating.

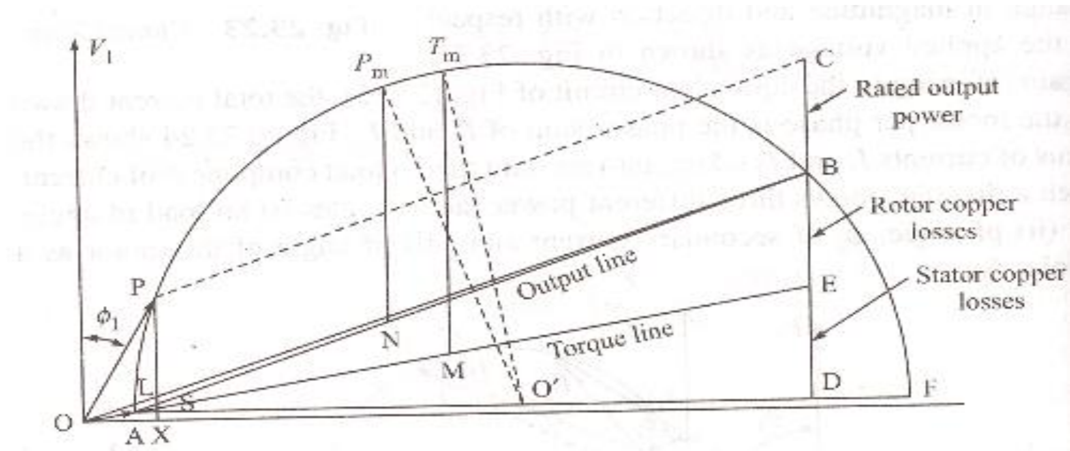
(iii) Full load efficiency: Draw a vertical line from the point P. Then PL and PX, respectively represent the output and the input of the motor.

(iv) Full load slip

$$Slip = \frac{Rotorcopperlosses}{Rotorinput} = \frac{LS}{Ps}$$

(v) Maximum torque:- Draw a line O^1T_m perpendicualr to the torque line .From the point Tm draw a vertical line so as to meet the torque line at the point M. Then the line MTm represents the maximum torque developed by the motor .

(vi) Maximum output: Draw a line O^1P_m perpendicular to the output line and bisecting it. From the point P_m, draw a vertical line so as to meet the output line at N. Then NP_m represents the maximum output of the motor to output scale.



PRECAUTIONS:

1. Loose connection should be avoided.
2. Operate the instruments carefully.
3. Load currents should not be exceeding beyond their rating.

RESULT:

VIVA VOCE:

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. If the fuse in one of the phases burn, what happens to the running motor?
5. Why core losses are neglected in blocked rotor test and copper losses are neglected in no load test?
6. Why we multiply DC resistance to get AC resistance with a value of 1.2 to 1.6?
7. Why we are using LPF wattmeters incase of no load test?
8. What precautions we have to take before switching on the supply in case of no-load test and blocked rotor test.
9. 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.SEPARATION OF CORE 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.

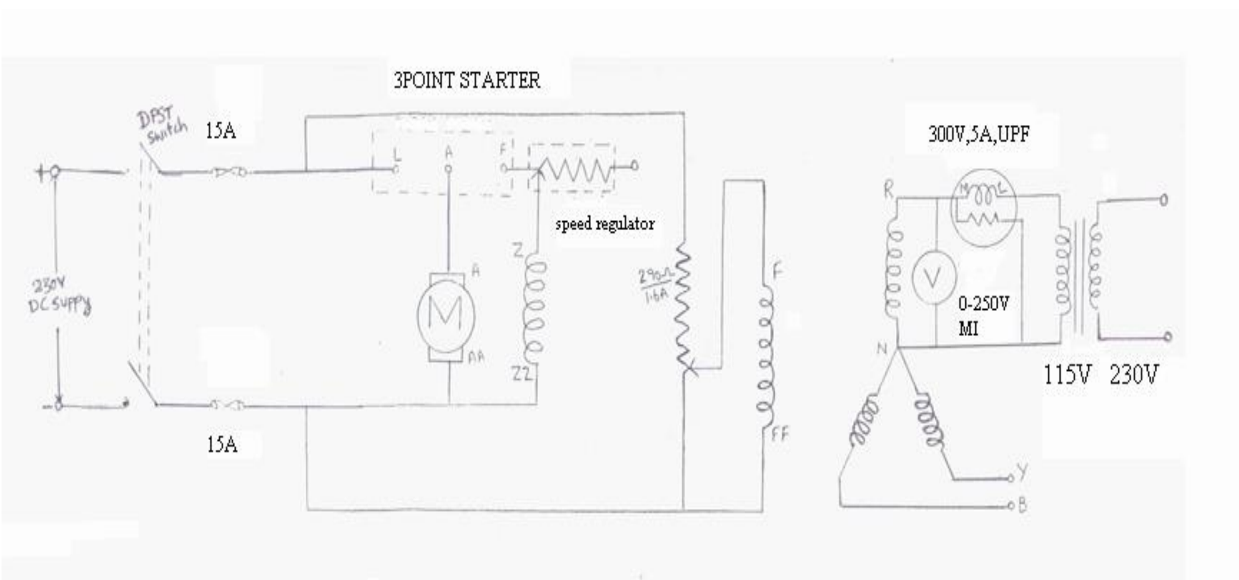
NAMEPLATE DETAILS:

DESCRPTION	3KVA
No.of phases	1phase
Voltage	230V
Frequency	50Hz

APPARATUS:

S.NO	DESCRIPTION	RANGE	TYPE	QUANTITY
1	Voltmeter	0-250V	M.I	1
2	Rheostat	250Ω/1.6A	Wire wound	1
3	Tachometer	0-50000rpm	Digital	1
4	Wattmeter	5A/300V	LPF	1
5	Fuses	10A	-	2

CIRCUIT DIAGRAM:



THEORY:

There are two types of losses present in a Transformer. One is core losses & another one is Cu loss. The Core losses depends upon the frequency and max flux density when the volume and thickness of the core laminations are given. The coreloss is made up of two parts.

a) Hysterisis loss : $W_h = P\, B^{1.6}_{max} f$ as given by Steinmetz's empirical relation and
b) Eddy current loss : $W_e = Q\, B^2_{max}\, f^2$

Where Q is constant.

The total core loss is given by $W_i = W_h + W_e$

If we carry out two experiments using two different frequencies, but the same max flux density, we should be able to find P and Q , constants and hence calculate hysterisis and eddy current losses separately.

PROCEDURE:

1. Connect the circuit as per the circuit diagram.
2. Take different frequencies to separate the core losses of 1phase transformer
3. Give supply to the motor, which is coupled to the alternator with the speed control the motor for variable frequency.
4. Adjust the speed of the motor at particular frequency, adjust the rated primary voltage by using voltage regulator.
5. Note down the readings of wattmeter, voltmeter, ammeter, speed .
6. Continue the above procedure at another particular frequency by varying speed.
7. With the help of the above data calculate eddy current and hysteresis losses.

OBSERVATIONS:

f Hz	V Volt	I Amps	W_i Watts	N RPM	V/f	W_i/f	We	Wh

CALCULATIONS:

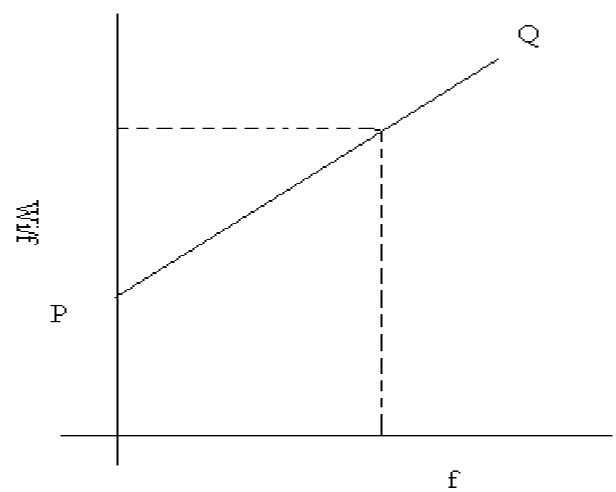
Frequency(F)=(PN/120)HZ

Total core losses(Wi)=Pf+Qf^2

Pf=Hysteresis losses

Qf^2=Eddy current losses

MODEL GRAPH:



RESULT:

VIVA VOCE:

1 What is e.m.f(rms) equation of transformer?
2 Why should we maintain v/f ratio constant while conducting test on transformer for separation of core losses?
3 What are the methods to reduce core loss in transformer?

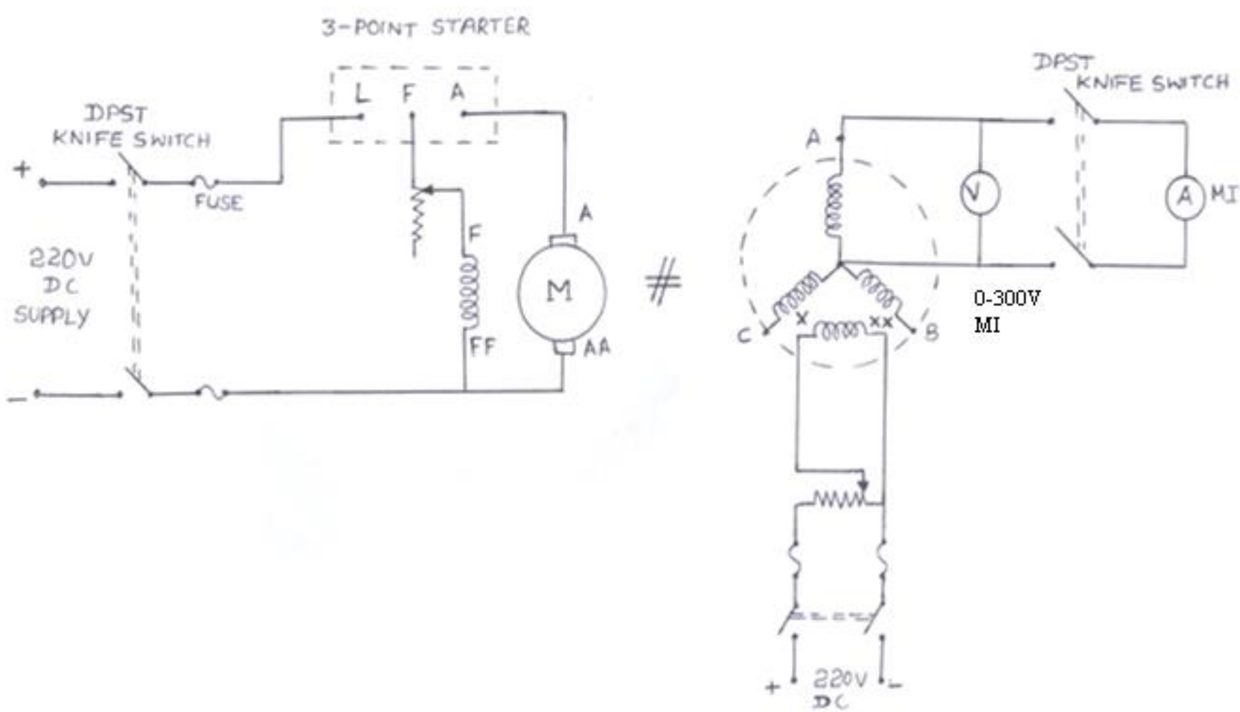
12.MEASUREMENT OF SEQUENCE REACTANCES OF ALTERNATOR

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

APPARATUS:

S.No	Apparatus	Type	Range	Quantity
1	Ammeter	M.I	(0-10)A	1
2	Voltmeter	M.I	(0-300)V	1
3	Rheostat	Wire wound	270Ω/1.5A	2
5	DPST switch			1
6	Alternator set			1

CIRCUIT DIAGRAM:



THEORY:

In power system when loads are balanced under normal and abnormal conditions be solved on per phase basis. When loads are unbalanced the current can not be solved on per phase basis, because in each phase voltage, current and power are different. To solve this circuits the method of symmetrical components is used. This method expresses the each unbalanced vector into three balanced vectors called positive sequence, negative sequence and zero sequence vectors. Using this balanced vectors unknown parameters can be obtained.

Sequence impedance: Sequence impedances offered against respective sequence currents. These are three types;Positive sequence impedance: It is the impedance offered against the positive sequence current.

(i) Negative sequence impedance: It is the impedance offered against the negative sequence current.

(ii) Zero sequence impedance: It is the impedance offered against the zero sequence current.

PROCEDURE:

1. Connect the circuit as shown in fig. 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 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 of motor so that alternator takes rated current . 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 opened.

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:

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

RESULT:

VIVA-VOCE:

1. What is the phase sequence of positive sequence components with respect to phase sequence of power system?
2. What is the phase sequence of negative sequence components with respect to phase sequence of power system?
3. What is the phase sequence of zero sequence components with respect to phase sequence of power system?
4. In transmission line positive and negative sequence impedance are same, then how its zero sequence impedance related to value of positive sequence impedance?
5. In transformer positive, negative and zero sequence impedances are identical, then how its leakage reactance related to positive sequence impedance?