2023

EDITION ONE

ELECTRICAL MACHINE - 1

LAB MANUAL

Department of Electrical Engineering

Government College of engineering, Keonjhar

Prepared By: Dr. Sangram Keshori Mohapatra

Associate Prof, Department of Electrical Engineering

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LIST OF EXPERIMENTS AND RECORD FOR PROGRESSIVE ASSESSMENT

Sl. no.	Name of the Experiment	Page no.	Date of Performance	Date of Submission	Assessment Marks	Sign. Of Teacher & Remarks
1	To perform open circuit and short circuit tests on single-phase transformers and to pre-determine the efficiency, regulation and equivalent circuit of the transformer.					
2	To study the parallel operation of two single phase transformers.					
3	Back-to Back test on two single phase transformers.					
4	Determination of parameters of three phase induction motor from No load Test and Blocked Rotor Test.					
5	Determination of Efficiency, Plotting of Torque-Slip Characteristics of Three Phase Induction motor by Brake Test.					
6	To perform the scott connection of transformer , for 3-ϕ to 2-ϕ connection.					
7	Study of Speed control of 3Φ induction motor using Variable frequency drive.					

EXPERIMENT No.1

Aim of the Experiment:
To perform open circuit and short circuit test on a single-phase transformer and to Pre-determine the efficiency, regulation and equivalent circuit of the transformer.

Apparatus Required:

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Single Phase Transformer	250/0-270 v,15 amp	1no
2	Ammeter	(0-10) amp, AC	1no
3	Ammeter	(0-5) amp, Ac	1no
4	Voltmeter	(0-300) volt, AC	1no
5	Voltmeter	(0-150) volt, AC	1no
6	Wattmeter	(2-5) amp, (75/150/300) volt	1no
7	Connecting Wires	**************************	Required

Transformer Specifications:

Transformer Rating :(in KVA) = 2KVA

Winding Details:

LV (in Volts): 115V

LV side current: 17.8A HV (in Volts): 230V HV side Current: 4.5A Type (Shell/Core): SHELL

Theory:

Transformer Tests

The circuit constants, efficiency and voltage regulation of a transformer can be determined by two simple tests

(i) open-circuit test

(ii) short-circuit test.

Open-Circuit or No-Load Test

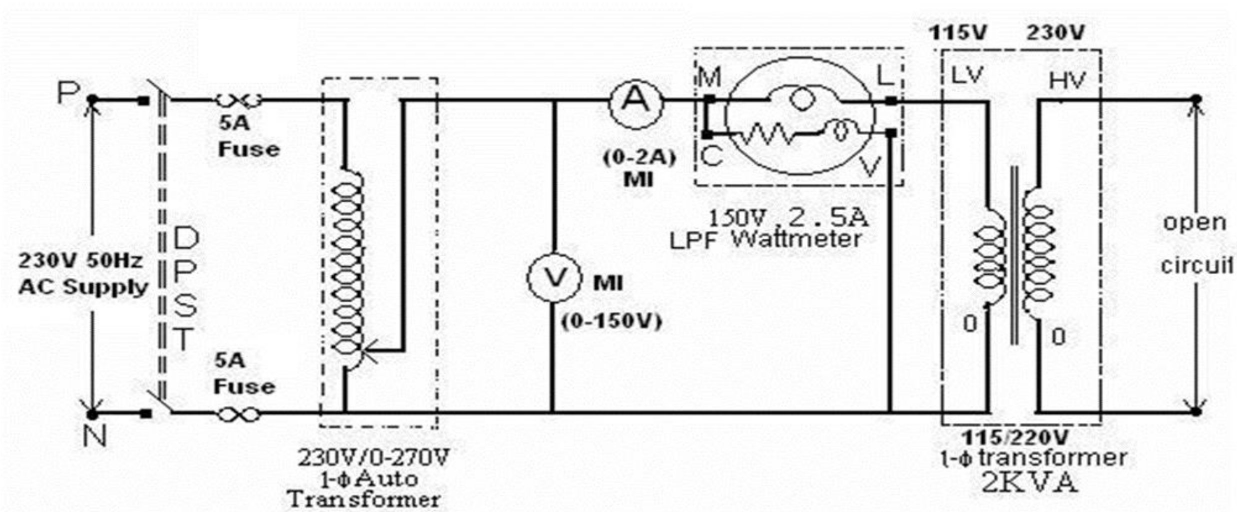
The purpose of the open-circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameters are determined. This test is performed on the primary winding of the transformer. The wattmeter, ammeter and the voltage are connected to their primary winding. This test is conducted to determine the iron losses (or core losses) and parameters R_0 and X_0 of the transformer. In this test, the rated voltage is applied to the primary (usually low-voltage winding) while the secondary is left open circuited. Wattmeter will record the iron losses and small copper loss in the primary. Since no-load current I_0 is very small (usually 2-10 % of rated current). Cu losses in the primary under no-load condition are negligible as compared with iron losses. Hence, wattmeter reading practically gives the iron losses in the transformer.

Iron losses, P_i = Wattmeter reading = W_0

No load current = Ammeter reading = I_0

Applied voltaGE=Voltmeter reading = V_1

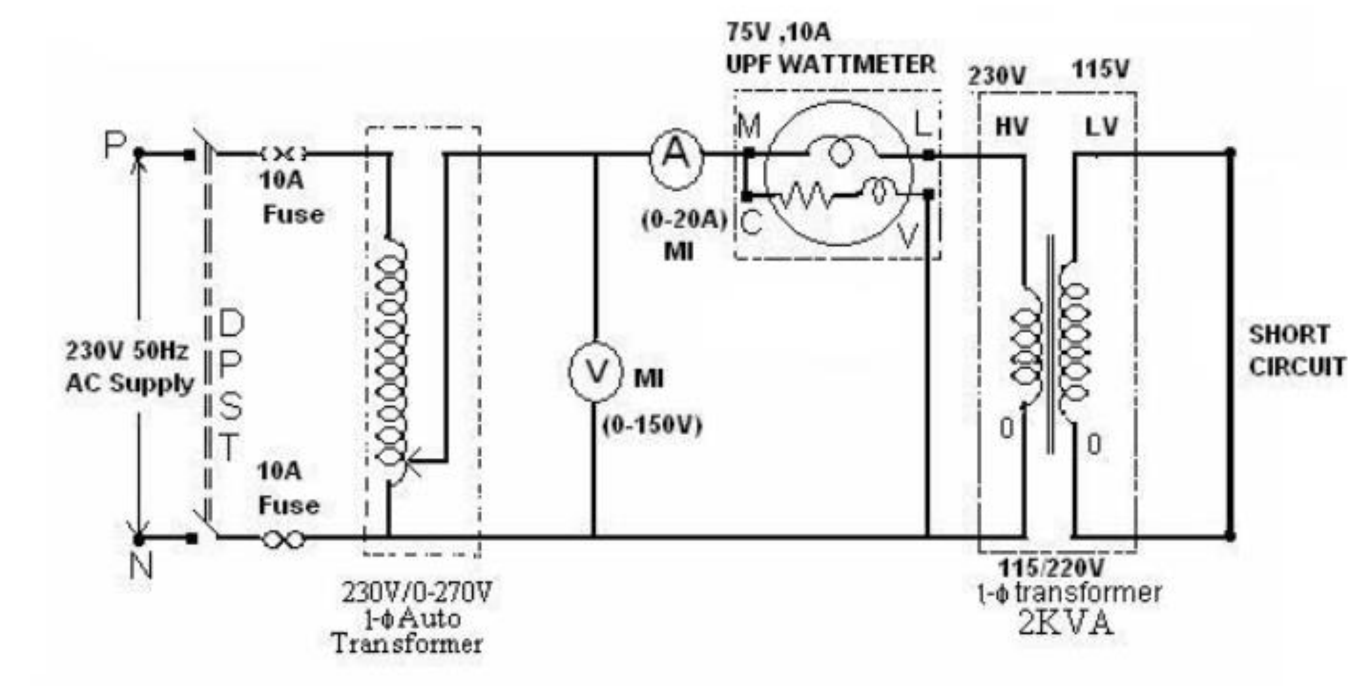
Input power, $W_0 = V_1 I_0 \cos\Phi_0$



Short-Circuit or Impedance Test

The test is conducted on the high-voltage (HV) side of the transformer where the low-voltage (LV) side (or the secondary) is short-circuited. A wattmeter is connected to the primary side. An ammeter is connected in series with the primary winding. This test is conducted to determine R_{01} (or R_{02}), X_{01} (or X_{02}) and full-load copper losses of the transformer . The low input voltage is gradually raised till at voltage V_{SC}, full-load current I_1 flows in the primary. Then I_2 in the secondary also has a full- load value since $I_1/I_2 = N_2/N_2$. Under such conditions, the copper loss in the windings is the same as that on full load. There is no output from the transformer under short-circuit conditions. Therefore, input power is all loss and this loss is almost entirely copper loss. It is because iron loss in the core is negligibly small since the voltage V_{SC} is very small. Hence, the wattmeter will practically register the full-load copper losses in the transformer windings.

Short Circuit:



Efficiency from Transformer Tests

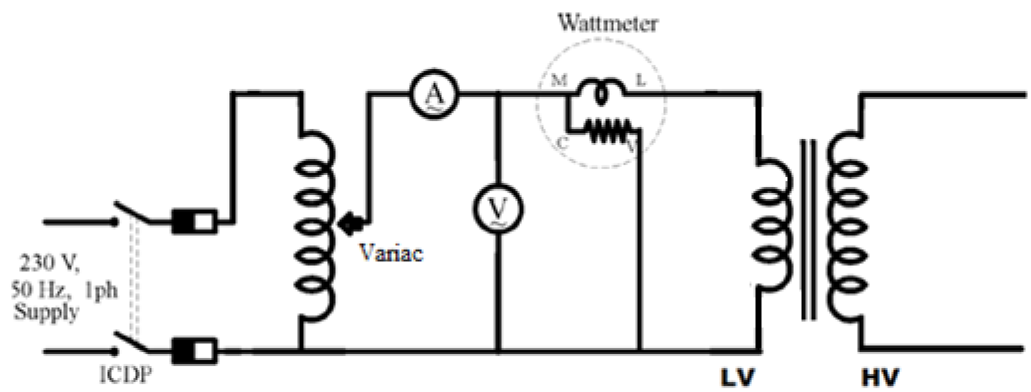
F.L. Iron loss = P_i ...from open-circuit test
F.L. Cu loss = P_c ...from short-circuit test
Total F.L. losses = $P_i + P_c$

$$Efficiency = \frac{Output}{Input} = \frac{Output}{Output + F.L.Losses}$$

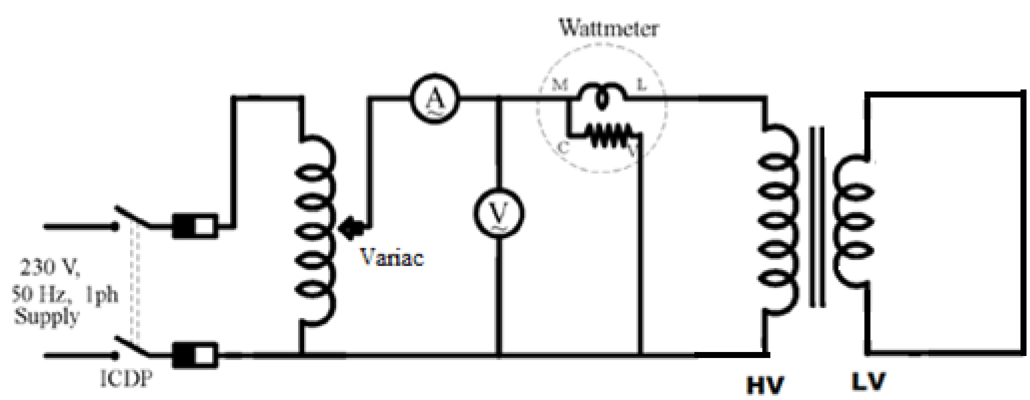
$$\eta\% = \frac{Output}{Input} \times 100 = \frac{Output}{Output + F.L.Losses} \times 100$$

Circuit Diagram:

For open circuit test



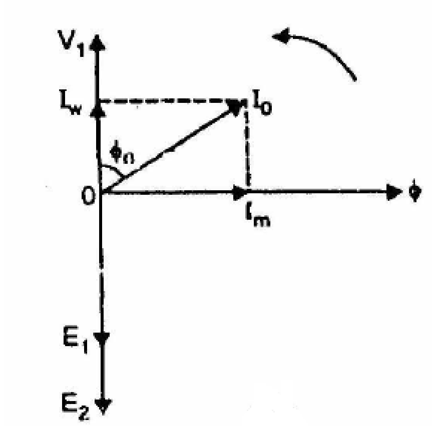
For short circuit test



Circuit diagram for Open circuit & short circuit test of single-phase transformer.

Stepwise Procedure:

For open circuit test



- Select meters/instruments of appropriate range.
- Connect as shown in circuit diagram.
- Switch on the power supply by setting the variac at min position.
- Vary the variac to set the rated voltage as per LV winding rating.
- Observe the reading across voltmeter, ammeter and wattmeter.

For short circuit test

- Select meters/instruments of appropriate range.
- Connect as shown in circuit diagram.
- Switch on the power supply by setting the variac at min position.
- Vary the variac to flow the full load rated current as per HV winding rating.
- Observe the reading across voltmeter, ammeter and wattmeter.

Observations:

For open circuit test

Voltmeter reading (V_1) in Volts	Ammeter reading(I_0) in Amps	Wattmeter reading(W_0) in Watts

For short circuit test

Voltmeter reading (V_{SC}) in Volts	Ammeter reading(I_1) in Amps	Wattmeter reading (W_S) in Watts

Sample Calculation:

For open circuit test

Input power, $W_0 = V_1 I_0 \cos\Phi_0 = P_i =$

No load power p.f. = $\cos\Phi_0$

Core loss component $I_W = I_0 cos\emptyset_0 =$

Magnetizing component $I_\mu = I_0 sin\emptyset_0 =$

$R_0 = \frac{V_1}{I_W} =$ and $X_0 = \frac{V_1}{I_\mu} =$

For short circuit test

Full load Cu loss, P_C = Wattmeter reading = W_S =

Total resistance of transformer referred to primary, $R_{01} = \frac{P_C}{I_1^2} =$

Total impedance referred to primary, $Z_{01} = \frac{V_{SC}}{I_1} =$

Total leakage reactance referred to primary, $X_{01} = \sqrt{{Z_{01}}^2 - {R_{01}}^2} =$

Short-circuit p.f, =

Total F.L. losses = $P_i + P_c$ =

$$\eta\% = \frac{Output}{Input} \times 100$$

$$\eta\% = \frac{Output}{Output + F.L.Losses} \times 100$$

Conclusion:
Write a conclusion under the guidance of the teacher & on the basis of observed value.

Questions:

1. What information do you get from open circuit tests on single phase transformers?
2. Which side has to be kept open in case of an open circuit test and why?
3. Why is indirect testing of transformers necessary?
4. How does the copper loss vary with variation of load on the transformer?
5. What is all day efficiency?
1. Why do we perform short circuit tests on transformers?
2. Which side is short circuited in the short circuit test and why?
3. What are the different losses in the transformer?
4. Which kinds of losses are found in short circuit tests?
5. What are the different parts of the transformer?

SPACE FOR ANSWERS

Students Details **Teachers Signature**

EXPERIMENT No. 2

Aim of the Experiment: To study the parallel operation of two single phase transformers.

Apparatus Required:
Three ammeters, three Wattmeter's, single phase load, two transformers, autotransformer.

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Single Phase Transformer		
2	Ammeter		
3	Voltmeter		
4	Wattmeter		
5	Variac		
6	Connecting Wires		

Theory:

Parallel operation

Two transformers are said to be connected in parallel if the primary windings are connected to supply busbars and secondary windings are connected to load busbars. While connecting two or more than two transformers in parallel, it is essential that their terminals of similar polarities are joined to the same busbars.

There are three principal reasons for connecting transformers in parallel.

- The standard method of connecting transformers in parallel is to have the same turn ratios, connecting transformers in parallel with the same parameters result in equal load sharing and no circulating currents in the transformer windings.
- Secondly, when the load on the substation becomes more than the capacity of the existing transformers, another transformer can be added in parallel.
- Thirdly, any transformer can be taken out of the circuit for repair/routine maintenance without interrupting supply to the consumers.

Conditions for satisfactory parallel operation

In order that the transformers work satisfactorily in parallel, the following conditions should be satisfied:

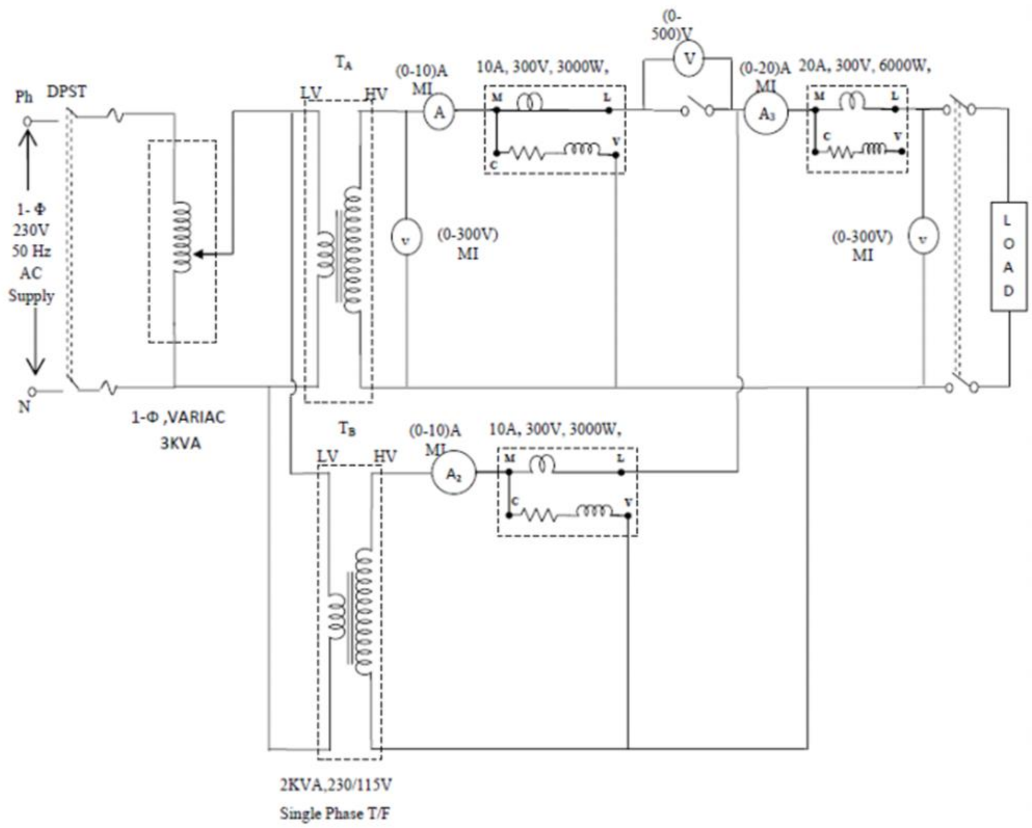
(i) Transformers should be properly connected with regard to their polarities.

(ii) The voltage ratings and voltage ratios of the transformers should be the same.

(iii) The per unit or percentage impedances of the transformers should be equal.

(iv) The reactance/resistance ratios of the transformers should be the same.

Circuit Diagram.
For Parallel operation



Circuit diagram for parallel operation of two single-phase transformers

PROCEDURE:

For Parallel operation

- Select meters/instruments of appropriate range.
- Connect the circuit as shown in the diagram.
- Switch on the power supply by setting the variance at minimum position.
- Set the rated value of voltage by varying variance across the primary side of each single-phase transformer.

- After checking polarity, voltage rating across secondary winding switches on the synchronizing switch.
- Check the load sharing is done by both transformers.
- Take at least three readings.

Observations Table:

S.NO.	I_1(AMPS)	W_1(WATTS)	I_2(AMPS)	W_2(WATTS)	$I_L=I_1+I_2$(AMPS)	$W_L=W_1+W_2$(WATTS)
1.						

For Parallel operation
RESULT; The two-transformers connected in parallel share the load equally.
DISCUSSION:

The total load current is distributed on two transformers accordingly.

11+12=I 1

The total wattmeter readings are distrusted on two wattmeter accordingly.

W1+W2=W1

PRECAUTION: -

1. Transformers should be connected in such a way that they have the same polarity.
2. All connections should be correct, neat and tight.
3. Connecting leads should be perfectly insulated.
4. All the connections should be made right and tight.
5. Power supply must be switched off during the connecting circuit.
6. No touching of live wires.

Conclusion:

Write a conclusion under the guidance of the teacher & on the basis of observed value.

QUESTIONS: -

1. What information do you get from a polarity test on a single-phase transformer?
2. What is the turns ratio of a single-phase transformer?
3. What is the transformation ratio of a single-phase transformer?
4. What are the necessities of parallel operation on a transformer?
5. What are the conditions for parallel operation on a transformer?
6. What is the effect of circulating current in the circuit having two transformers in parallel?
7. When does circulating current flow in the circuit having two transformers in parallel?
8. What is a dead short circuit on a transformer?
9. Why are transformers rated as KVA?
10. What do you mean by load sharing on a transformer?

SPACE FOR ANSWERS

Student Details **Teachers Signature**

EXPERIMENT No. 3
Aim of the Experiment: Back-to Back test on two single phase transformers.

Apparatus Required:

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Transformer		
2	Variac		
3	Ammeter		
4	Voltmeter		
5	Wattmeter		
6	SPST switch		
7	Connecting Wires		

Theory:

Back-to-Back Test

The full load test on a small transformer is very convenient, but on the large transformer, it is very difficult. The maximum temperature rise in a large transformer is determined by the full load test. This test is called, back-to-back test, regenerative test or Sumner's test.

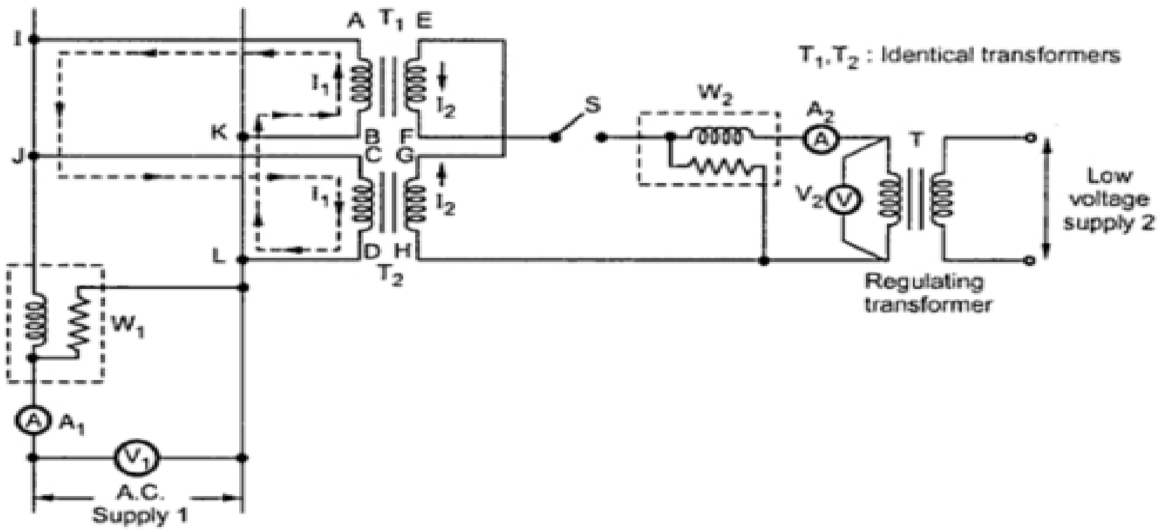
Circuit

Fig. shows the connections for back-to-back tests on two identical transformers T_1 andT_2.The primaries of the two transformers are connected in parallel across the rated voltage V_1 while the two secondaries are connected in phase opposition. Therefore, there will be no circulating current in the loop formed by the secondaries because their induced e.m.f.s are equal and in opposition. There is an auxiliary low-voltage transformer which can be adjusted to give a variable voltage and hence current in the secondary loop circuit. A wattmeter W_1, an ammeter A_1 and voltmeter V_1 are connected to the input side. A wattmeter W_2 and ammeter A_2 are connected in the secondary circuit.

Operation

(i) The secondaries of the transformers are in phase opposition. With switch S_1 closed and switch S_2 open (i.e., regulating transformers not in the circuit), there will be no circulating current ($I_2 = 0$) in the secondary loop circuit. It is because the induced e.m.f's in the secondaries are equal and in opposition. This situation is just like an open-circuit test. Therefore, the current drawn from the supply is $2I_0$ where I_0 is the no-load current of each transformer. The reading of wattmeter W_1 will be equal to the core losses of the two transformers.

W_1 = Core losses of the two transformers



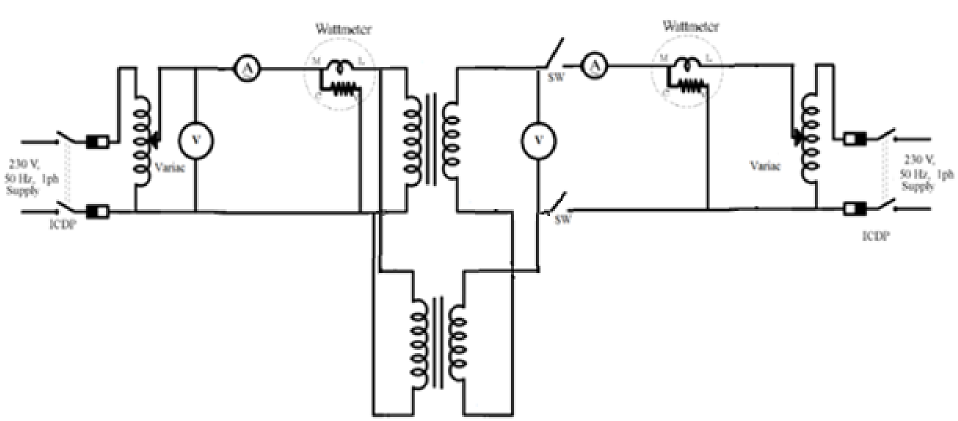
Circuit diagram for back-to-back test on two single phase transformers.

(ii) Now switch S_2 is also closed and output voltage of the regulating transformer is adjusted till full-load current I_2 flows in the secondary loop circuit. The full-load secondary current will cause full-load current I_1 (= KI_2) in the primary circuit. The primary current I_1 circulates in the primary winding only and will not pass through W_1. Note that full-load currents are flowing through the primary and secondary windings. Therefore, reading of wattmeter W_2 will be equal to the full-load copper losses of the two transformers.

W_2 = Full-load Cu losses of two transformers

$W_1 + W_2$ = Total losses of two transforms at full load

Circuit Diagram



Stepwise Procedure

1. Make the connections as per the circuit diagram.
2. The secondary winding terminals of the two transformers are connected in series with polarities in phase opposition which can be checked by means of a voltmeter.
3. Before starting the experiment, check the variac's are in minimum output voltage position.
4. Close the first DPST-1 switch and switch ON the supply.
5. Increase the variac slowly, and apply rated voltage to the primary windings of 1- ϕ transformers and check the voltmeter reading connected across the secondary terminals.
6. If the voltmeter reading is Zero, continue with step 8.
7. If the voltmeter reading is not zero, interchange the secondary terminals.
8. Now close the DPST-2 switch and vary the variac-2 slowly till rated current flows in the two series-connected secondaries.
9. Note down the readings of V1, V2, I1, I2, W1, and W2 and enter them in a tabular column.
10. W1 = 2Pc, W2= 2Psc. Losses of each transformer = (W1+W2)/2
11. Now the Variac's are brought to zero voltage position and open SPST switches.

Observations

Voltmeter reading (V_1) in volts	**Voltmeter reading (V2) in volts**	**Ammeter reading (I1) in amperes**	**Ammeter reading (I_2) in amperes**	**Wattmeter reading (W_1) in watts**	**Wattmeter reading (W_2) in watts**

Calculations

Core loss of each transformer $W_0 = \frac{W_1}{2}$ watts

Full load copper loss of each transformer $W_c = \frac{W_2}{2}$ watts

$W_o = V_1 I_1 \cos \Phi_o$ $\Phi_o = \cos^{-1} \frac{W_o}{V_1 I_1}$ $I_1 = \frac{I_o}{2}$ A

$I_w = I_1 \cos \Phi_o$ $I_\mu = I_1 \cos \Phi_o$ $V_2 = V_s/2$

$R_o = V_1 / I_w$ $X_o = V_1 / I_\mu$ $R_{o2} = W_c / I_2^2$ $Z_{o2} = V_2 / I_2$

$X_{o2} = \sqrt{Z_{o2}^2 - R_{o2}^2}$

Copper loss at various loads = $I_2^2 R_{o2}$.

PERCENTAGE REGULATION:

1. Upf: $[I_2 (Ro_2 \cos \Phi_o) \times 100] / V$

2. Lagging pf : $[I_2 (Ro_2 \cos \Phi_o + Xo_2 \sin \Phi_o) \times 100] / V$

3. Leading pf : $[I_2 (Ro_2 \cos \Phi_o - Xo_2 \sin \Phi_o) \times 100] / V$

Output Power (1) Upf : 3Kw
(2) LPf : 3Kw Cos Φ_o

Input Power = Output Power + Core loss + Cu loss

$$\text{Efficiency } \eta\% = \frac{\text{Output power}}{\text{Input Power}} \times 100\%$$

Result

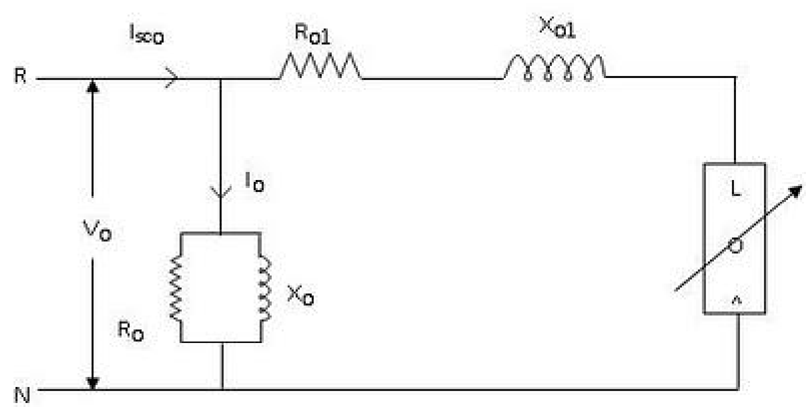
The regulation for the transformer is found to be –

i) ……… at 0.8 p.f. leading

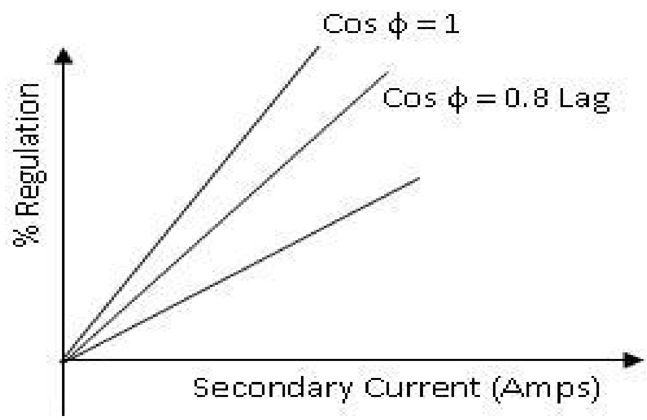
ii)……..... at 0.8 p.f. lagging

iii) ………. at unity p.F. load

EQUIVALENT CIRCUIT:



MODEL GRAPHS:



Conclusion:

Write a conclusion under the guidance of the teacher & on the basis of observed value.

Questions:

1. How can you determine the efficiency of a transformer?
2. How the secondary winding of transformers are connected for conducting the Sumpner's test?
3. What happens if the rated values of voltage and frequency of supply vary?
4. How much current flows on the primary side and secondary side of the transformer while performing the experiment?
5. How much voltage is applied on the primary side while conducting the Sumpner's test?
6. How much voltage is applied on the secondary side while performing the experiment?
7. What are the differences between back to back tests, open circuit tests and short circuit tests?
8. Why conduct the test on identical transformers?
9. What do mean by phase opposition in reference to Sumpner's test on the transformer?
10. What does the reading of the wattmeter on the primary side indicate?

SPACE FOR ANSWERS

Students Details **Teachers Signature**

EXPERIMENT No. 4

Aim of the Experiment: Determination of parameters of three phase induction motor from No load Test and Blocked Rotor Test.

Apparatus Required:

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Three phase Induction Motor		
2	Ammeter (M I type)		
3	Voltmeter (M I type)		
4	Wattmeter		
5	3 – ø Variac		
6	Connecting Wires		

Theory:

A 3-phase induction motor consists of stator, rotor & other associated parts. In the stator ,a 3- phase winding (provided) is displaced in space by 120 electrical degrees. A 3- phase current is fed to the winding so that a resultant rotating magnetic flux is generated. The rotor starts rotating due to the induction effect produced due the relative velocity between the rotor Winding & the rotating flux. As a general rule, conversion of electrical energy to mechanical energy takes place into the rotating part of the electrical motor.

In DC motors, electrical power is conducted directly to the armature, i.e, rotating part through brushes and commutator. Hence, in this sense, a DC motor can be called a 'conduction motor'.

However, in AC motors, the rotor does not receive power by conduction but by induction in exactly the same way as the secondary of a two winding Transformer receives its power from the primary. So, these motors are known as Induction motors. In fact, an induction motor can be taken as a rotating Transformer, i.e, one in which primary winding is stationary but the secondary is free.

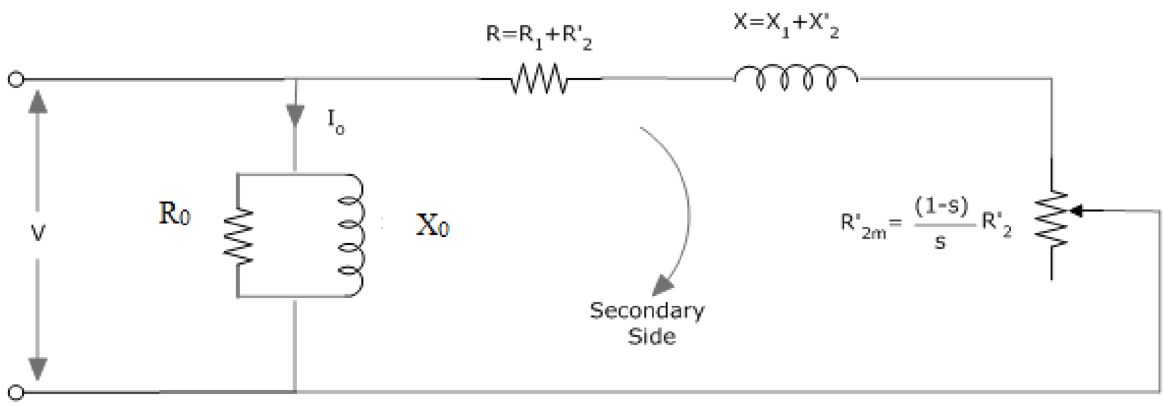
The starting torque of the Induction motor can be increase by improving its p.f by adding external resistance in the rotor circuit from the stator connected rheostat, the rheostat resistance being progressively cut out as the motor gathers speed. Addition of external resistance increases the rotor impedance and so reduces the rotor current. At first, the effect of improved p.f predominates the current decreasing effect of impedance. So, starting torque is increased. At time of starting, external resistance is kept at maximum resistance position and after a certain time, the effect of increased impedance predominates the effect of improved p.f and so the torque starts decreasing. By this during the running period the rotor resistance is progressively cut-out as the motor attains its speed. In this way, it is possible to get good starting torque as well as good running torque.

Stator resistance test:

The stator winding resistance is measured between any two terminals, using direct current. This gives the resistance of two phases in series which must be divided by 2, in order to obtain stator winding resistance per phase.

Effective AC resistance = 1.5 X DC resistances

No load Test:



No circuit test is done to determine parameters R_0 and X_0. In this test machine is run without any load and power input to machine W_0 , no load current I_0 and full supply voltage V are measured.

$$W_0=3VI_0\cos\phi_0 = \text{no load losses} = \text{iron + friction and windage losses.}$$

From this equation R_0 and X_0 can be calculated by neglecting friction and windage losses., $Z_0 = \frac{V_0}{I_0/\sqrt{3}}$,

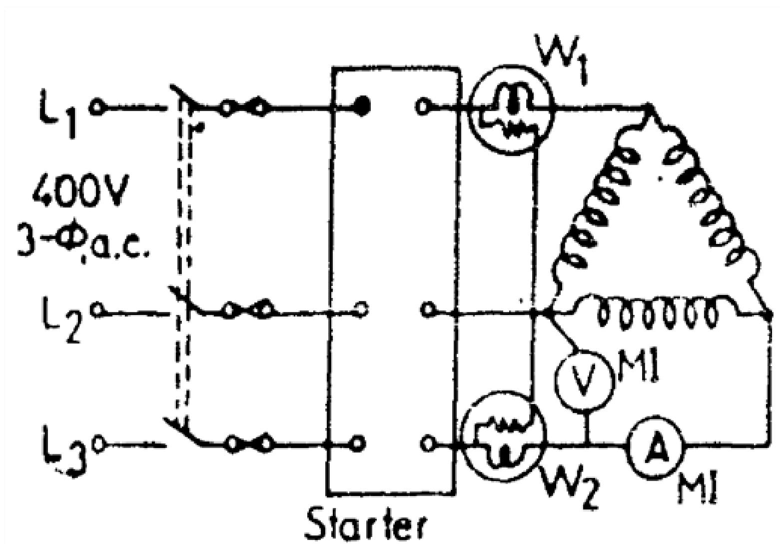
Blocked rotor Test:

Block Rotor Test (Short circuit test): (to determine $R=R_1+R'_2$ and $x=x_1+x'_2$)

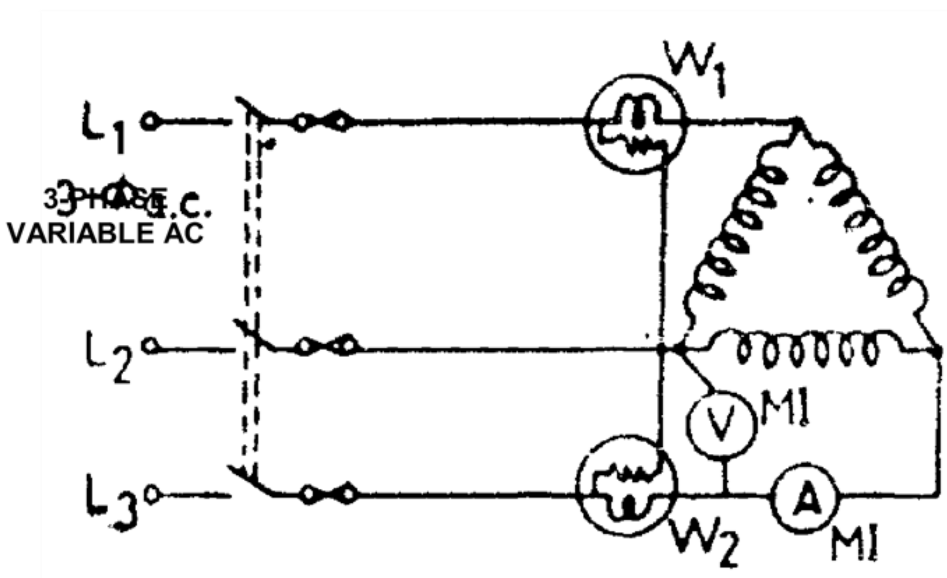
The machine is blocked by some external means and a reduced voltage is given to the stator. This voltage is adjusted so that full load armature current flows through the stator. Stator is an armature (in an inductive machine). Reading of wattmeter, ammeter and voltage input are taken $Z = R = R_1 + R_2 = X = \sqrt{(Z^2 - R^2)}$

Circuit Diagram

For No load test



For Blocked Rotor Test



Circuit diagram for no load test and block rotor test of three phase induction motor

Stepwise procedure

For No Load Test

- Connections are made as per the circuit diagram.
- Ensure that the 3- ϕ variac is kept at minimum output voltage position and belt is freely suspended.
- Switch ON the supply. Increase the variac output voltage gradually until rated voltage is observed in voltmeter. Note that the induction motor takes large current initially, so, keep an eye on the ammeter such that the starting current should not exceed 7 Amp.
- By the time speed gains rated value, note down the readings of voltmeter, ammeter, and wattmeter.
- Bring back the variac to zero output voltage position and switch OFF the supply.

For Block Rotor Test

- Connections are as per the circuit diagram.
- The rotor is blocked by tightening the belt.
- A small voltage is applied using 3- ϕ variac to the stator so that a rated current flows in the induction motor.
- Note down the readings of Voltmeter, Ammeter and Wattmeter in a tabular column.
- Bring back the Variac to zero output voltage position and switch OFF the supply.

Observations

For No Load test

Voltage (volts) V_0	Current (Amps) I_0	Power (Watts) $W_0=W_1+W_2$

For Block Rotor test

Voltage (volts) V_{sc}	Current (Amps) I_{sc}	Power (Watts) $W=W_1+W_2$

Calculations

Conclusion

Write conclusions under the guidance of the teacher & on the basis of observed value.

Questions:

1. What do you understand about the performance of an induction machine?
2. Why no-load speed of the machine less than the synchronous speed?
3. Why do you use a low power factor wattmeter in no load tests?
4. Why don't you take into account the iron losses in short circuit tests?
5.What are the reasons in conducting no-load test with rated voltage and blocked rotor test with rated current?
8. How do you reverse the direction of rotation of an induction motor?
9. What are the various applications of this motor?

SPACE FOR ANSWERS

Students Details **Teachers Signature**

EXPERIMENT No. 5

Aim of the Experiment: Determination of Efficiency, Plotting of Torque-Slip Characteristics of Three Phase Induction motor by Brake Test.

Apparatus Required:

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Three phase Induction Motor		
2	Ammeter (M I type)		
3	Voltmeter (M I type)		
4	Wattmeter		
5	3 – ø Variac		
6	Connecting Wires		

Theory:

A 3-phase induction motor consists of stator, rotor & with the other associated parts. In the stator, a 3-phase winding is provided. The space (gap) between the three windings is 120^0.
A 3-phase current is fed to the 3-phase winding. These windings produce a resultant magnetic flux. And it rotates in space like a solid magnetic pole which is rotated magnetically.
The efficiency of a 3-phase induction motor is given by;

$$Efficiency = \frac{Output}{Input}$$

Brake Test

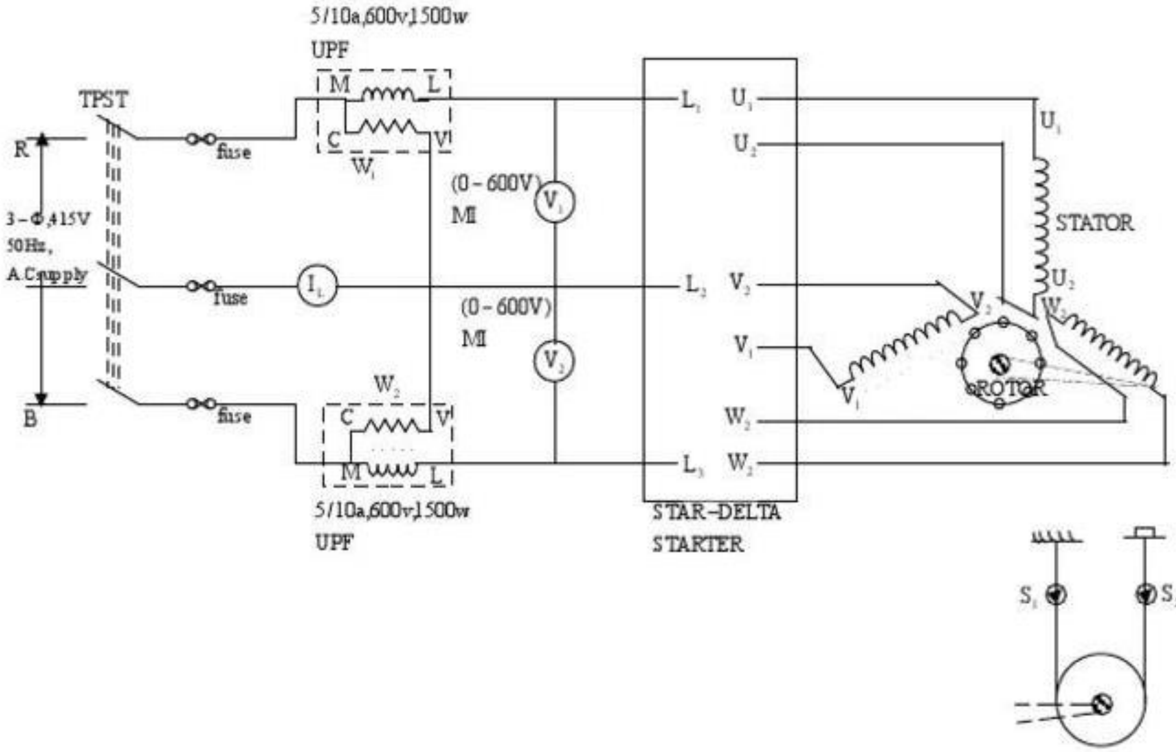
In this method, a brake is applied to a water-cooled pulley mounted on the motor shaft. On both ends of the rope spring balance S_1 and S_2 suspended. If the spring balance reading is S_1 kg-Wt and the suspended mass has a weight of S_2 kg-Wt, then, Net pull on the rope = $(S_1 – S_2)$ kg-Wt = $(S_1 – S_2)$ X 9.81 newtons. If r is the radius of the pulley in metres, then the shaft torque Tsh developed by the motor is

Tsh = $(S_1 – S_2)$ X 9.81 X r N_2 - m

If the speed of the pulley is n (R.P.M.) then,

$$Output\ Power = \frac{2\pi NTsh}{60} = \frac{2\pi N(S1 - S2)\ X\ 9.81\ X\ r}{60} watts$$

Circuit Diagram



Circuit diagram for brake test of three phase induction motor

Stepwise Procedure

- Connect circuit as shown in circuit diagram.
- 3-Φ induction motor is started with starter.
- If the pointer of one of the wattmeter readings reverses, interchange the current coil terminals and take the reading as negative.
- Take the no load readings.
- The motor is loaded step by step till we get the rated current and the readings of the voltmeter, ammeter, wattmeter and spring balance are noted.

Observations

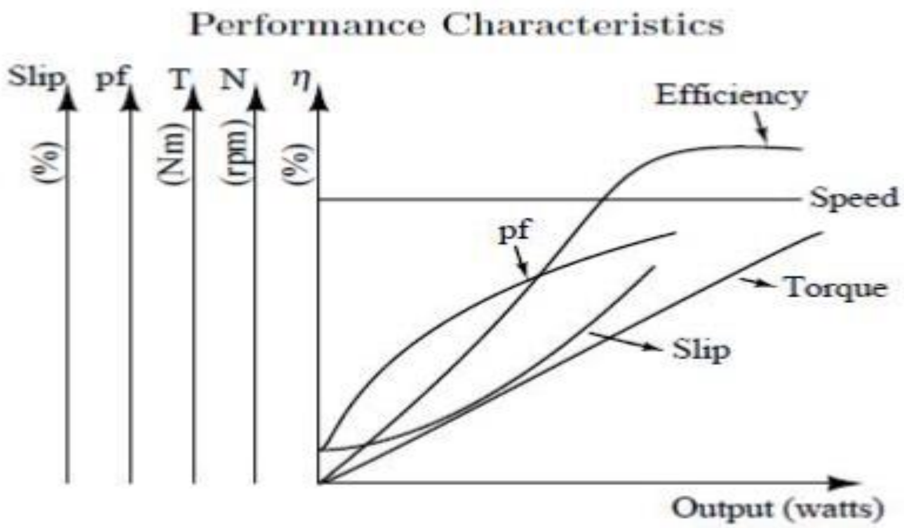
Serial No.	Line voltage (In Volts)	Current (In Amperes)	Wattmeter Reading (In Watts)		Spring Control		Speed (In RMS)
			W_1	W_2	S_1	S_2	

Calculations

Speed	$S_1 - S_2$	T_{sh}= $(S_1 - S_2)x9.81xr$	Output Power $=\frac{2\pi NTsh}{60}$	Input Power = W_1+W_2	Slip = $(N_s - N)/N_s$	Power Factor = $W_1+W_2/\sqrt{3}VI$	η

GRAPHS:

1) Output Power vs Efficiency
2) Output Power vs Torque
3) Output Power vs Speed
4) Output Power vs %s



Conclusion

Write conclusions under the guidance of the teacher & on the basis of observed value of slip and efficiency.

Questions:

1. State, why does the rotor of an induction motor always run behind a revolving field?
2. Why is the power factor of the induction motor very low and lagging at no load?
3. Why cannot a three phase induction motor run at synchronous speed?
4. What is the importance of slip in a three phase induction motor?
5. What is an induction generator? Under what condition does an induction motor act as an induction generator? What will be the value of slip in the case of an induction generator?
6. Why does the power factor of an induction motor improve with increase in load?
7. Why does the efficiency of an induction motor increase with increase in load?
8. Define slip?
9. What is the condition for maximum efficiency of an induction motor?

10. Why does the efficiency of the induction motor start falling after reaching maximum value and load increased further?
11. Why does the input stator current of the induction motor increase as load is increased?
12. State the relation between rotor current and supply frequency when the motor is at stand still.
13. What is the slip of a three-phase induction motor, when its rotor is blocked?
14. What happens to the rotor speed and rotor current when load on an induction motor increase?
15. Can the slip of the induction motor become negative? If yes, under what condition?

SPACE FOR ANSWERS

Students Details **Teachers Signature**

EXPERIMENT No. 6

Aim of the experiment:- To perform the scott connection of transformer , for 3-ϕ to 2-ϕ connection.

TRANSFORMER SPECIFICATION

-Main transformer -single phase ,1kVA,440/220v

-Teaser transformer-single phase ,1kva,440/220.

-Auto transformer- three phase, 0-415v.

APPARATUS REQUIRED: -

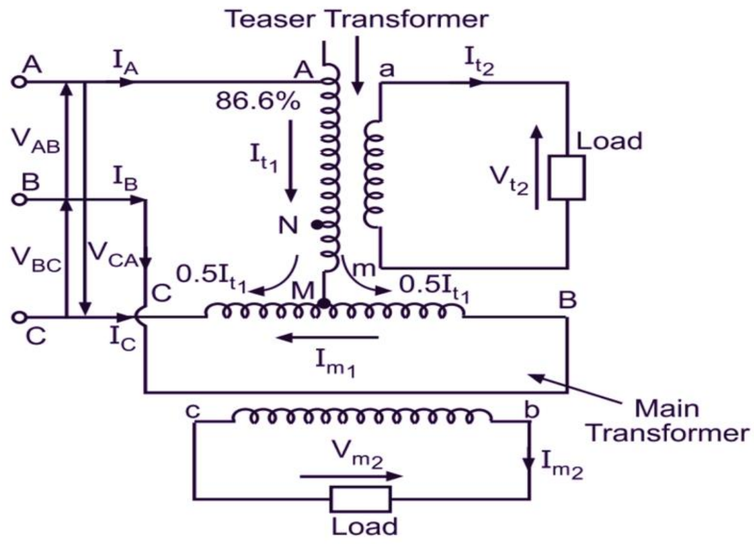
SL.NO	NAME OF THE EQUIPMENT	SPECIFICATION	QUANTITY
1.	Voltmeter	0-300v	2nos
		0-600v	2nos
2.	Ammeter	(0-50)A	1NO
3.	Connecting wires		As per required

THEORY

In same case we may require two phase power instead of three phase or one phase -power that it is necessary to convert three- phase to two phase transformation is accomplished with the help of two identical 1-ϕ transformer having the same current rating. One transformer has a center-tap on the primary side and it is known as the main transformer. It forms the horizontal members of the connection. Another transformer has 0.866 tap on primary side and known as Teaser Transformer. The 50% tap point on primary side of the main transformer is joined to 86.6% tap on primary of teaser transformer. Obviously full ratting of the transformer is not at all used.(referred to the figure). The main transformer primary winding center tap point ‘p’ is connected to one end of the primary of the teaser transformer on the secondary side, both the main transformer and teaser transformer turns are used (not only 86.6%). Hence, the voltage per turn will be equal for both transformers. The two secondary voltages are phase displaced by 90º giving the two phase voltage. Hence

$$V2Tm = \sqrt{V2T^2 + V2M^2}$$

CIRCUIT DIAGRAM



PROCEDURE

- Connection is done as per the circuit diagram.
- Ensure that the output voltage of variac is set in zero position before starting the experiment.
- Switch 'ON' the supply.
- The input voltage of variac is gradually increased on steps rated voltage of 1-phase, main transformers and readings are correspondingly taken steps.
- Enter the readings in the tabulation.
- After observation the variac is brought to zero position and switches 'off" the supply.

CALCULATION

OBSERVATION TABLE

Sl. No.	Voltmeter Reading (V_1)	Voltmeter Reading (V_2t)	Voltmeter Reading (v_2m)	Voltmeter Reading ($v_2$tm)	Theoretical Observation	% error
1						
2						

3						
4						

PRECAUTION

- Loose connection must be avoided.
- Properly rated & required range meter must be used.
- The tappings ratio must be properly observed.
- All connections must be done under supervision.
- No wire should be touched while the AC supply ‘ON’.

RESULT ANALYSIS

Using the above-mentioned formula we calculate the **(V_2Tm)** value (Theoretical) which is approximately equal to voltmeter reading **(V_2Tm)** (Practical) and some % of error due to instrumental error.

CONCLUSION

From the above experiment we performed the Scott connection of a transformer for a three phase and two phase conversion.

QUESTIONS

1. Discuss and number the advantages and disadvantages of Scott-T connections transformers configurations.?

2. Why are Scott-T connections of transformers not recommended as a connection for 3φ-3φ applications?

3. How is scott connection used to obtain two- phase supply from three- phase supply?

4. How did the scott connection perform?

5. What is the purpose of the scott transformer?

SPACE FOR ANSWER

Students Details **Teacher's Signature**

EXPERIMENT NO:7

Aim of the Experiment

Study of Speed control of 3Φ induction motor using Variable frequency drive.

APPARATUS REQUIRED

SL.NO	NAME OF THE EQUIPMENT	SPECIFICATION	QUANTITY

MOTOR SPECIFICATION

SL.NO	NAME OF THE EQUIPMENT	SPECIFICATION	QUANTITY

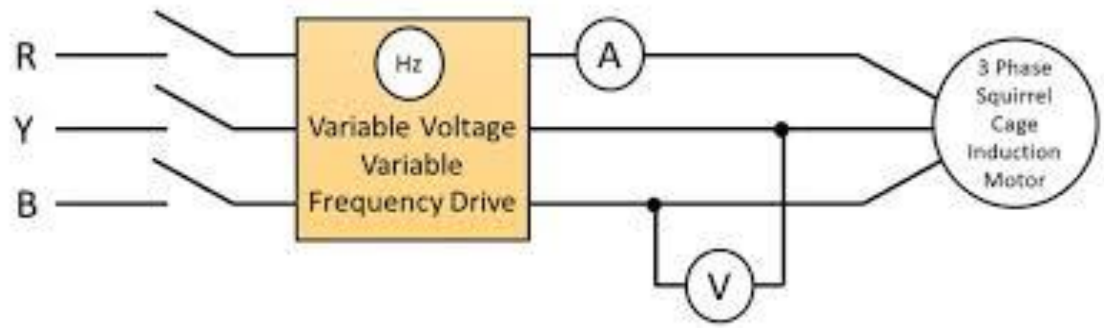
THEORY

The Variable Frequency Drive has 3 parts like an AC motor, a controller and an operating interface. The AC motor is used in variable frequency drive is generally 3ϕ induction motor ever though 1ϕ motor is used in some system. Variable frequency drive is a type of adjustable speed drive used to control electric motors drives by an alternating current(AC).The two basic type of AC motor used in industries are synchronous motor and induction motor.

PROCEDURE

- Connect the circuit as per the circuit diagram.
- Then by varying frequency measure the speed of the motor.
- In this test we take 3 conditions first at no load, second we take ½ load and then full load.
- Then we draw a graph between frequency and speed.

Circuit Diagram



Tabulation

At No Load

FREQUENCY	CURRENT	SPEED

At ½ Load

FREQUENCY	CURRENT	SPEED

At Full Load

FREQUENCY	CURRENT	SPEED

Precaution

- Loose connection must be avoided.
- Properly rated & required range meter must be used.
- The tapings ratio must be properly observed.
- All connections must be done under supervision.
- No wire should be touched while the AC supply ‘ON’.

Conclusion

From the above experiment we studied speed control of the 3ϕ induction motor using variable frequency control.

QUESTIONS

1. What is a VFD?
2. How does a variable frequency drive work?
3. What is the difference between VFD and Soft Starters?
4. What are the different types of braking methods used in a VFD?
5. What is meant by dynamic braking?
6. What is meant by regenerative braking?
7. What are the different types of loads?
8. Constant torque curve vs Variable torque curve
9. How do you select a VFD?
10. What are the advantages of VFD?

SPACE FOR ANSWER

Students Details **Teacher's Signature**