LIST OF EXPERIMENTS AND RECORD FOR PROGRESSIVE ASSESSMENT

Sl. no.	Date of Expt.	Name of the Experiment	Page no.	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 singlephase transformers.		
4		Determination of parameters of three phase induction motor from No load Test and Blocked RotorTest.		
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 3-Φ induction motor using Variable frequency drive.		

Expt. No.: Date:

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,15A	1no
2	Ammeter	(0-10) A, AC	1no
3	Ammeter	(0-5) A, Ac	1no
4	Voltmeter	(0-300) V, AC	1no
5	Voltmeter	(0-150) V, AC	1no
6	Wattmeter	(2-5) A, (75/150/300) V	1no
7	Connecting Wires	-	As per requirement

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 performedon 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 $I_1/I_2 = N_2/N_1$. 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.

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=Output/Input

=Output/[Output + (F.L. Losses)]

%Efficiency= (Output/Input) ×100

Circuit Diagram:

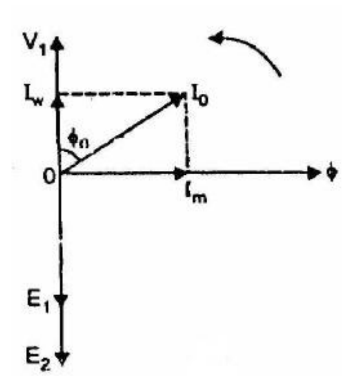
For open circuit test

For short circuit test

Procedure

For open circuit test

1. Meters/instruments of appropriate range were selected
2. Connections were done as shown in circuit diagram.
3. Switched on the power supply by setting the variac at min position.
4. The variac was varied to set the rated voltage as per LV winding rating. The reading across voltmeter, ammeter and wattmeter were noted down and observed.



For short circuit test

- Meters/instruments of appropriate range were selected
- Connections were done as shown in circuit diagram.
- Switched on the power supply by setting the variac at min position.
- The variac was varied to set the rated voltage as per LV winding rating. The reading across voltmeter, ammeter and wattmeter were noted down and observed.

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}) inVolts	**Ammeter reading(I_1) inAmps**	**Wattmeter reading (W_{Sc}) in Watts**

For open circuit test

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

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

Core loss component $I = I_0 cos\emptyset_0$

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

$R_0 = V_1/I_w$ and $X_0 = V_1/I_\mu$

For short circuit test

Full load Cu loss, P_C = Wattmeter reading = W_S

Total resistance of transformer referred to primary, R_{01}

Total impedance referred to primary, $Z_{01} = \frac{V_{sc}}{I_{01}}$

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

Short-circuit p.f. = R_{01}/ Z_{01}

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

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

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

Conclusion

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Exp.: Date:

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

Apparatus Required:
Three ammeters, three watt meters, single phase load, two transformers, autotransformer.

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Single Phase Transformer having 50% and 86.6% tapping	3 kVA, 230V	02 Nos.
2	M.I Voltmeter	(0-600)V	01 No.
3	M.I Voltmeter	(0-300V)	02 Nos.
4	M.I Ammeter	(0-5)A	05 Nos.
5	3-phase Variac	15A,415V	02 Nos.
6	Connecting Wires	3/20SWG,Cu	As per reqd.

Theory:

Parallel operation

Two transformers are said to be connected in parallel if the primary windings are connected to supply bus bars and secondary windings are connected to load bus bars. While connecting two ormore than two transformers in parallel, it is essential that their terminals of similar polarities arejoined to the same bus bars. 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 equalload 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

Procedure

For Parallel operation

- Meters/Instruments of appropriate range were selected.
- Connections were done as per the circuit diagram
- Switched on the power supply by setting the variance at minimum position.
- The rated value of voltage by varying variance across the primary side of each single-phase transformer was set

- After checking polarity, voltage rating across secondary winding switches on the synchronizing switch.
- The load sharing was done by both transformers and it was checked.
- No of readings were taken and observed.

Observations Table

Sl. No	**I_1(Amp)**	**W_1(Watt)**	**I_2(Amp)**	**W_2(Watt)**	**$I_L=I_1+I_2$(Amp)**	**$W_T=W_1+W_2$ (Watt)**

For Parallel operation

Result

The two-transformers connected in parallel share the load equally.

Discussion

The total load current is distributed on two transformers across the load is given by

$I_1+I_2=I_L$

The total wattmeter readings are on two wattmeter accordingly.

$\mathbf{W_1+W_2=W_T}$

Conclusion

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Exp.: Date:

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	Single Phase Transformer	3 kVA,230V	02Nos.
2	1-ϕVariac	15A,(0-270)V	02Nos.
3	M.I Ammeter	(0-1)A &(0-15)A	01No.(Each)
4	M.I Voltmeter	(0-300)V	01No.
5	L.P.F Wattmeter	20A,150V	01No.
6	DPST switch	15A,230V	01No.
7	Connecting Wires	3/20SWG,Cu	As per Required.

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 as back-to-back test, regenerative test.

Circuit

Fig. shows the connections for back-to-back tests on two identical transformers T_1 and T_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 secondary 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

(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

- The connections were done as per the circuit diagram.
- The secondary winding terminals of the two transformers were connected in series with polaritiesin phase opposition which can be checked by means of a voltmeter.
- Before starting the experiment, the variac's in minimum output voltage position was checked.
- The first DPST-1was closed switch and switch ON the supply was switched ON.
- The variac slowly increased and applied rated voltage to the primary windings of 1- ϕ transformers and checked the voltmeter reading connected across the secondary terminals.
- If the voltmeter reading is Zero, continue with step 8.
- If the voltmeter reading is not zero, interchange the secondary terminals.
- Now close the DPST-2 switch and vary the variac-2 slowly till rated current flows in the two series-connected secondaries.
- Note down the readings of V_1, V_2, I_1, I_2, W_1, and W_2 and enter them in a tabular column.
- $W_1 = 2P_c$, $W_2 = 2P_{sc}$. Losses of each transformer = $(W_1+W_2)/2$
- Now the Variacs are brought to zero voltage position and open DPST switches.

Observations

V_1 in Volts	V_2 in Volts	I_1 in Amps	I_2 in Amps	W_1 in watts	W_2 in watts

Calculations

Iron loss of each transformer

$W_o = V_1 I_1 \cos \Phi_o$ $\Phi_o = \cos^{-1} W_0 / V_1 I_1$

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

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

$Z_{o2} = V_2 / I_2$ $X_{02} = \sqrt{Z_{02}^2 - R_{02}^2}$

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

PERCENTAGE REGULATION:

1. Upf: $[I_2(R_{o2} \cos \Phi_o) \times 100] / V$
2. Lagging pf : $[I_2(R_{o2} \cos \Phi_o + X_{o2} \sin \Phi_o) \times 100] / V$
3. Leading pf : $[I_2(R_{o2} \cos \Phi_o - X_{o2} \sin \Phi_o) \times 100] / V$
4. Output Power (1) UPF : 3Kw
   (2) LPF : 3Kw

Input Power = Output Power + Core loss + Cu loss

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

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

Conclusion

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Exp.: Date:

Aim of the Experiment: Determination of parameters of three phase induction motor from Noload Test and Blocked Rotor Test.

Apparatus Required

Serial No.	Name of the Equipment	Ratings/Range	Quantity
1	Three phase Induction Motor	400V,3-ϕ,7A,5hp,0.85P.F,1440rpm	01No.
2	Ammeter (M I type)	(0-10)A	01No.
3	Voltmeter (M I type)	(0-300)V	01No.
4	Wattmeter	600/300/150V,05/10A	02Nos.
5	3 – ø Variac	5A,200Ω	01No.
6	Connecting Wires	3/22SWG,Cu	As per reqd.

Theory

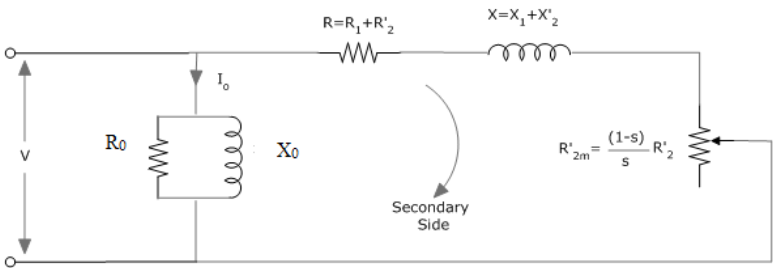
A 3-phase induction motor consists of stator, rotor & other associated parts. In the stator, a 3- phase winding (provided) is displaced in space by 120 electrical degrees. A 3- phase current is fed to the winding so that a resultant rotating magnetic flux is generated. The rotor starts rotating due to 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 secondaryis 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 themotor 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 anyload and power input to machine W_0 , no load current I_0 and full supply voltage V are measured.

$W_0=3VI_0Cos\phi_0$ = no load losses = 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

Stepwise procedure

For No Load Test

- Connections were made as per the circuit diagram.
- Ensured that the 3- ϕ variac was kept at minimum output voltage position and belt was freely suspended.
- Switched ON the supply.
- Increased the variac output voltage gradually until rated voltage is observed in voltmeter.
- Noted that the induction motor takes large current initially, so keep aneye on the ammeter such that the starting current should not exceed 7 Amp.
- By the time speed gains rated value, noted down the readings of voltmeter, ammeter and wattmeter.
- Brought back the variac to zero output voltage position and switched OFF the supply.

For Block Rotor Test

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

Observations For No Load test

V_0 (volts)	I_0 (Amps)	$W_0=W_1+W_2$

For Block Rotor test

V_{sc} (volts)	I_{sc} (Amps)	$W=W_1+W_2$

Calculations

Conclusion

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Exp.: Date:

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	1500rpm,415V,50Hz	01No.
2	Ammeter (M I type)	(0-20A)	02Nos.
3	Voltmeter (M I type)	(0-300V)	03Nos.
4	Wattmeter	LPF,5A,750Watts	02Nos.
5	3 – ø Variac	15A,200Ω and 5A,100Ω	O2 Nos.
6	Connecting Wires	3/20 SWG,Cu	As Per Required

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 = 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 T_{sh} developed by the motor is

$$T_{sh} = (S_1 - S_2) \times 9.81 \times r\ N_2 - m$$

Circuit Diagram

Procedure

- Connections were made as shown in circuit diagram.
- 3-Φ induction motor was started with starter.
- If the pointer of one of the wattmeter readings shown reversed, interchanged the current coilterminals and take the reading as negative.
- No load readings were taken.

The motor was loaded step by step till we got the rated current and the readings of thevoltmeter, ammeter, wattmeter and spring balance were noted.

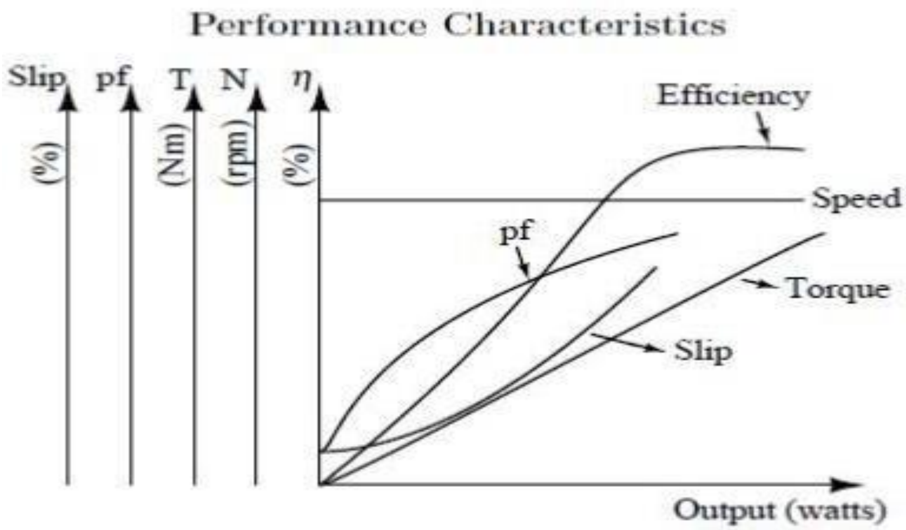
Observations

Serial No.	V_L (Volts)	I_L (Amp.)	Wattmeter Reading (In Watts)		Spring Control		Speed (In RMS)
			W1	W2	S1	S2	

Calculations

Speed	$S_1 - S_2$	$T_{sh}=(S_1-S_2)\times 9.81\times r$	Output Power	Input Power = W_1+W_2	Power Factor $=W_1+W_2/\sqrt{3}VI$	η

Model Graph



Conclusion

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Exp.: Date:

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,440/220V
- 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	3/20SWG, Cu	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 90^0 giving the two phase voltage.

Circuit Diagram

Procedure

- Connections were done as per the circuit diagram.
- Ensured that the output voltage of variac was set in zero position before starting the experiment.
- Switched 'ON' the supply.
- The input voltage of variac was gradually increased on steps rated voltage of 1-phase, main transformers and readings were correspondingly taken steps.
- The readings in the tabulation were entered.
- After observation the variac was brought to zero position and switched 'off' the supply.

Observation Table

Sl. No.	**Voltmeter Reading (V_2)**	**Voltmete rReading (V_{2T})**	**Voltmete rReading (V_{2m})**	**Voltmete rReading (V_{2tm})**	**Theoretical Observation**	**% error**
1						
2						
3						
4						

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

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Exp.: Date:

Aim of the Experiment

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

Apparatus Required

Sl. No.	Name of the equipment	Specification	Quantity
01	Panel for speed control of IM by VVVF Controller.	415V,3-Phase	01No.
02	3 phase sq. cage IM	1H.P,415V,1440rpm,1.5 Amp,50Hz	01No.
03	Digital Multimeter as a Voltmeter	0-750V (M.I) &0-1000V(M.C)	01No.

Theory

The Variable Frequency Drive has 3 parts like an AC motor, a controller and an operating interface. TheAC 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 electricmotors 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 half load and then full load.
- Then we draw a graph between frequency and speed.

Circuit Diagram

Tabulation

At No Load

Frequency (Hz)	Current (Amp)	Speed(rpm)

At Half Load

Frequency (Hz)	Current (Amp)	Speed(rpm)

At Full Load

Frequency (Hz)	Current (Amp)	Speed (RPM)

Conclusion

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