Experiment No. 1 : Perform the no load test, measure winding resistance for a single phase induction motor and determine its performance

I. Practical Significance

No load test is routine test carried out on single phase induction motor. This test is intended to find out no load current, core loss, friction and windage losses. Stator of single phase induction motor consist of main winding and starting winding placed at 90° electrically apart to produce rotating magnetic field.

II. Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters.
- Measure electrical quantities & identify motor windings.
- Connect circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain rotating electrical machines.

V Practical Learning Outcome

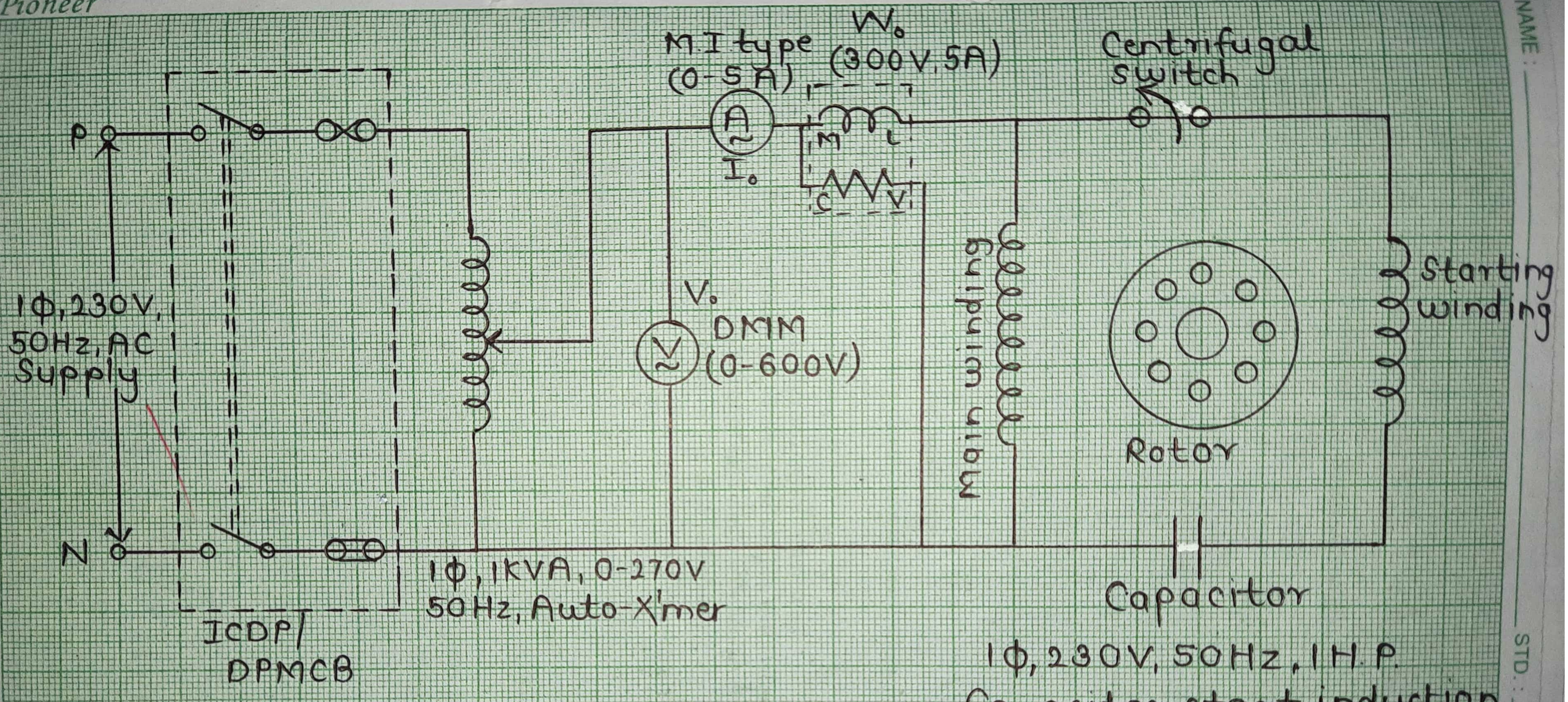
- Perform No load test on given single phase induction motor.
- Identify different windings of single phase induction motor.

VI Minimum Theoretical Background

In single phase induction motor main winding is designed for low resistance and starting winding for high resistance. Phase difference in both winding is produced by connecting capacitor in series with starting winding.

Practical No. 1 MEE (22625)

NAME : STD. : DIV.: DATE : / /



1ϕ, 230V, 50Hz, 1H.P.
Capacitor start induction run motor

Title → Circuit diagram for conducting No load test on 1ϕ Induction motor.

3.	A.C Ammeter	Range- 0 to 5A	01	
4.	A. C Voltmeter	Range- 0 to 300V	01	
5.	Multimeter	-	01	
6.	LPF Wattmeter	Range:0-300/600V, 1A to 2A	01	

IX Precautions to be followed

1. All electrical connections should be neat and tight.
2. Wires used for circuit connections have proper size and insulation cover.
3. Make sure that main switch is in off position while making connections.

X Procedure

Measurement of Winding Resistance

1) Disconnect the single phase, capacitor start induction run motor from the supply.
2) Open the terminal box.
3) Discharge the capacitor.
4) Separate the windings and capacitor terminals.
5) By using Multimeter identify the winding terminal pair by continuity test.
6) Measure the resistance of each winding by Multimeter.
7) Note down the values in the observation table.
8) Reconnect the main and starting winding along with capacitor and centrifugal switch.

No Load Test

1) Make the connections as per the circuit diagram.
2) The motor is run at no-load with the running winding excited at normal frequency and voltage until the power input is constant.
3) Readings are taken of volts, amperes and watts input at rated frequency. The voltage adjustment is accomplished preferably by a variable-voltage transformer.
4) Switch off the supply.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Power supply	-	1ϕ, 230V, 50HZ AC supply	01	
2.	Auto-X'mer	-	1ϕ, 0-270V, 1KVA 50Hz, Auto-X'mer	01	

3.	DMM	Mastech	As voltmeter (0-600V)	01	
4.	Ammeter	Supreme	M.I. type (0-5A)	01	
5.	Wattmeter	Supreme	300V, 5A m.f = 2	01	
6.	1Φ Induction motor	_	1Φ, 230V, 50Hz, 1 HP. capacitor start and run	01	

7. Connecting cables - PVC (2.5mm²) As per Req.

XII Actual procedure followed

① Measured resistance both starting and main winding with DMM ② Connected circuit as per circuit diagram for No load test ③ Applied graually increasing voltage till rated value ④ Noted down reading (I_0, V_0, W_0) in observation table. ⑤ Switched OFF the supply.

XIII Precautions followed

① Made sure that all connections were neat and tight
② Made sure that switch was in OFF position while making connections.
③ Followed all the safety practices

XIV Observations and Calculations:

A) Measurement Of Winding Resistance (Using Multimeter)

Sr. No.	Winding	Resistance(in ohm)	Identification
1.	1	19.5Ω	Main/~~Starting~~
2.	2	60Ω	~~Main~~/Starting

B) No Load Test

Sr. No	V_0 (Volts)	I_0 (Ampere)	W_0 (Watts)	N (rpm)
1	230	0.8	80	1440

Calculations: Written on extra sheet attached →

$\cos \emptyset_0 = \frac{W_0}{V_0 I_0} =$ …………

$Z_0 = \frac{V_0}{I_0} =$ ………… Ω

$X_0 = Z_0 \sin \emptyset_0 =$ ………… Ω

* Calculations →

• From No load test data,

$$W_0 = V_0 I_0 \cos\phi_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$

$$= \frac{80}{230 \times 0.8}$$

$$\cos\phi_0 = 0.4347$$

$$\phi_0 = \cos^{-1}(0.4347)$$

$$\therefore \phi_0 = 64.22^\circ$$

$$\sin\phi_0 = \sin(64.22)$$

$$= 0.9005$$

$$I_w = I_0 \cos\phi_0$$

$$= 0.8 \times 0.4347$$

$$I_w = 0.34776\ A$$

$$I_\mu = I_0 \sin\phi_0$$

$$= 0.8 \times 0.9005$$

$$= 0.7204\ A$$

$$R_0 = \frac{V_0}{I_w} = \frac{230}{0.34776} = 661.3756\ \Omega$$

$$X_0 = \frac{V_0}{I_\mu} = \frac{230}{0.7204} = 319.267\ \Omega$$

XV Results:

→ Resistance of main winding and starting winding is 19.5Ω and 60Ω respectively. From calculation of no load test data, $I_w = 0.34776A$, $I_\mu = 0.7204A$, $R_0 = 661.3756\Omega$ and $X_0 = 319.267\Omega$ is calculated.

XVI. Interpretation of results

→ From result we can interpret that, winding with less resistance is main winding and winding with more resistance is starting winding. This can be used for winding identification. No load current, core loss, friction and windage loss is also found out in no load test.

XVII. Conclusion

→ By performing this practical we acquire necessary skills to perform no load test and measuring winding resistance for a single phase induction motor. As no load test is an essential routine test, necessary knowledge related to it is acquired through the practical.

XVIII. Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) List the IS standard used for routine test of single phase induction motor.
2) Give Reason: Single phase induction motor is not self-starting.
3) State the different losses taking place in a single phase induction motor.
4) State the function of capacitor used in single phase induction motor.
5) State the use of centrifugal switch in single phase induction motor.

(Space for answers)

Que.No.(1) List the IS standard used for routine test of single phase induction motor

Ans → IS-7572-1974 is used for routine test of single phase induction motor.

Que.No.(2) "Single phase induction motor is not self starting" Give reason

Ans → When single phase motor is fed from a single phase supply, its stator winding produces a flux (or field) which is only alternating i.e one which alternates along one space axis only. It is not a synchronously revolving (or rotating). An alterating or pulsating flux ~~cannot produce~~ acting on a stationary squirrel cage rotor cannot produce rotation (only a revolving flux can). That is why, a single-phase motor is non-self starting.

Que.No.(3) State the different losses taking place in a single phase induction motor

Ans→ Losses taking place in single place in single phase induction motor are as fallows→

(i) Core loss in stator and rotor.
(ii) Copper loss in stator and rotor.
(iii) Friction and windage loss.

Que.No.(4) State the function of capacitor used in single phase induction motor.

Ans→ Capacitor used in single phase induction motor produce a greater phase difference between the current in the main and the auxiliary winding. So, in order to start the motor by increasing starting torque capacitor is used.

Que.No.(5) State the use of centrifugal switch in single phase induction motor.

Ans→ When motor is turned ON, the switch conducts electricity to a capacitor and starting winding of the motor to increa starting torque. When the motor reaches 75% of full speed, the centrifugal S/W 'S' opens and cuts out both starting winding

and capacitor from the supply, thus leaving only running winding across the line.

Experiment No. 2 : To perform no load and blocked rotor test on three phase induction motor to determine the equivalent circuit parameters.

I Practical Significance

No Load test is performed to obtain magnetizing parameters in induction motor's equivalent circuit. A block rotor test is performed to calculate leakage reactance and winding resistance in induction machine motor's circuit.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment- Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters.
- Measure electrical quantities
- Connect the machines as per relevant circuits
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain rotating electrical machines.

V Practical Learning Outcome

- To perform no load test and block rotor test on given three phase squirrel cage induction motor and determine equivalent circuit parameters.

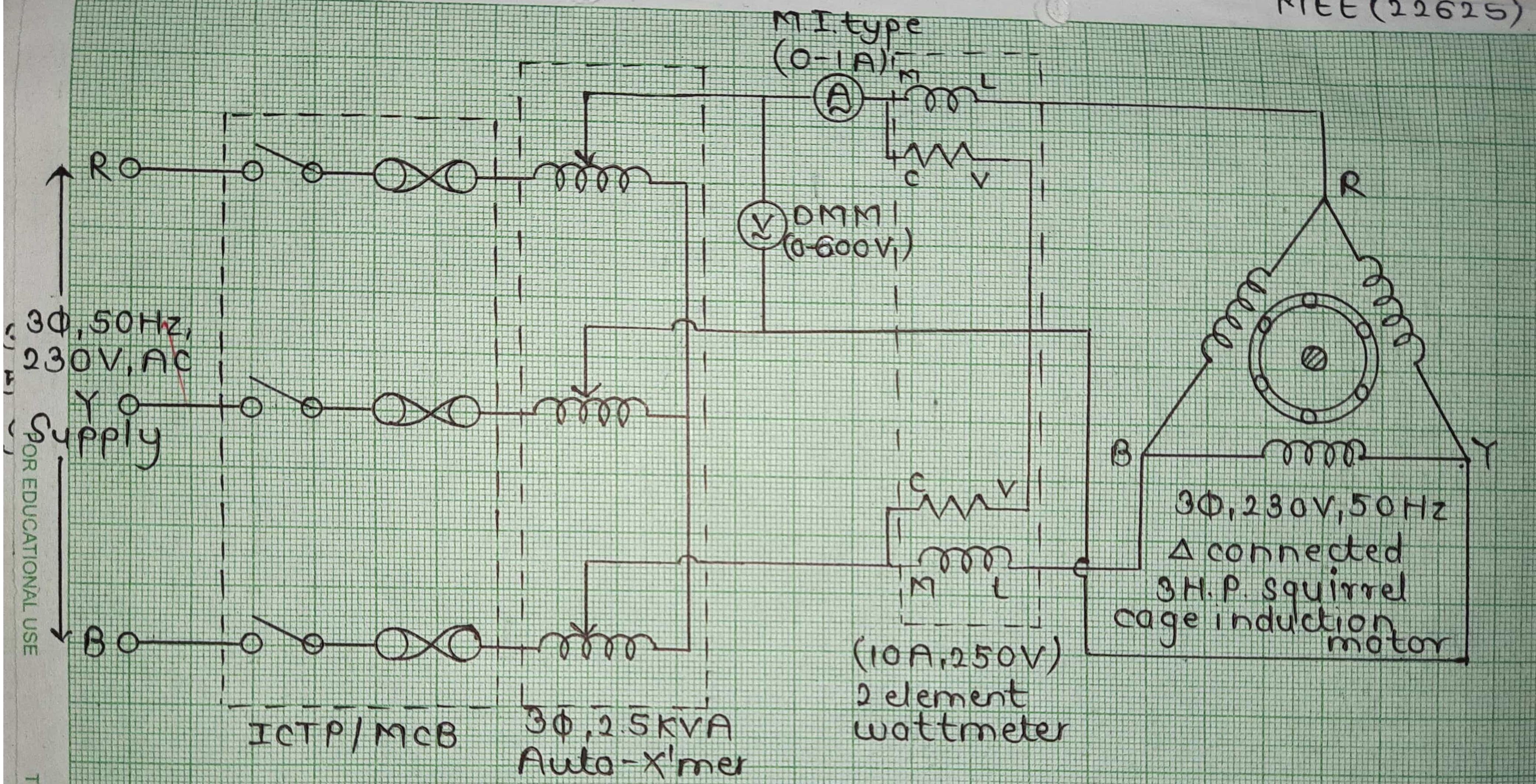
VI Minimum Theoretical Background

No Load Test

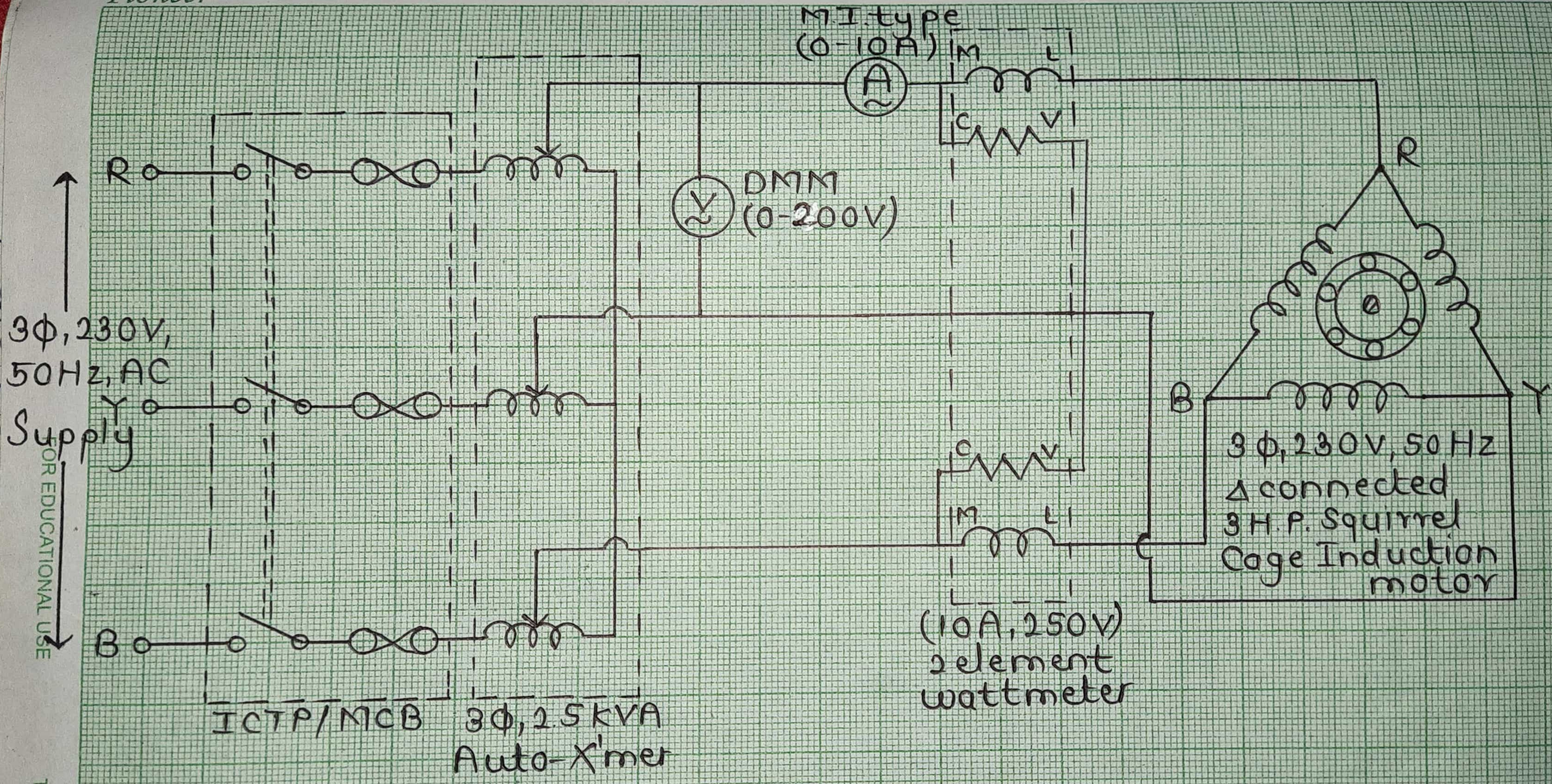
It is a type of Routine test that gives information about core loss or iron loss, friction and windage losses, magnetizing current, no load power factor and parameters of magnetizing branch of equivalent circuit i.e. I_0, I_μ, I_W, R_0, X_0.

If the motor is run at rated voltage and frequency without any mechanical load, it will draw power necessary to supply the no load losses. The no load current will have two components. The active component and the magnetizing component, the former being very small as the no load losses are small. The power factor at no load is therefore very low. The no load power factor is always less than 0.5 and hence at no load one of the wattmeter at input side reads negative.

MEE(22625)



Title → Circuit diagram for No load test on 3Φ Induction Motor



Title → Circuit diagram for Blocked Rotor Test of 3ϕ Induction Motor.

X Procedure

A) For No Load Test

1) Select the instruments and meter ranges as per the resources required table.
2) Make the connections as per the circuit diagram shown in Fig.
3) Switch ON the 3 phase supply, start the motor at reduced voltage and then run at rated voltage with the help of Autotransformer.
4) Note down all meter readings.
5) Switch OFF the power supply.

B) For Blocked Rotor Test

1) Select meter ranges required for blocked rotor test.
2) Hold rotor by hand or brake system
3) Switch ON the 3 phase supply and apply voltage slowly with the help of autotransformer so that rated current flows to motor.
4) Note down all meter readings.
5) Reduce voltage and switch OFF the power supply.
6) Using appropriate method measure stator resistance across the motor terminals and determine per phase AC value.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Power Supply	—	3ϕ, 230V, 50 Hz, AC Supply	01	
2.	3ϕ Auto-transformer		3ϕ, 0.5KVA, ~, Auto-x'mer	01	
3.	Wattmeter		2 element (10A, 250V)	01	
4	DMM	Mastech	As voltmeter (0-600V)	01	
5.	Ammeter	Supreme	M.I. type (0-5-10A)	01	
6.	Induction motor		3ϕ, 230V, 50Hz Δ, 3 H.P.	01	
7	Connecting cables	—	PVC, 2.5mm^2	As per Req.	
8					

XII Actual procedure followed

Ⓐ No load test → Made the connections as per circuit diagram. Started the motor at reduced voltage and then applied the rated voltage at No load. Noted down all the readings.

Ⓑ Blocked Rotor test → Made the connections as per circuit diagram. Holded rotor by hand. Gradually increased voltage with the help of 3ϕ Auto-x'mer till the rated

current flows through the stator. Noted down all the readings.
(c) Measured resistance of stator winding with the help of DMM.

XIII Precautions followed

→ (1) Ensured Auto-transformer is at zero position at start. (2) All electrical connections should be neat and tight. (3) Gradually increased the voltage till the rated current flows through the stator winding in blocked rotor test.

XIV Observations and Calculations:

Stator Resistance

Not applicable [Calculation for Ra on extra sheet]

Sr. No	Current(A)	Voltage(V)	Resistance $R_S(\Omega)$
1			
2			
3			
		R_{SMean}	………… Ω

$R_{S(eff)} = (1.2 \times R_{SMean})$=………… Ω

No Load Test

Motor input $V_{(rated)}$ Volts	Motor current I_0 Amps	Motor No Load Power W_0 Watts
$V_{(rated)}$	I_0	(in W)
230	1.0	70

Blocked Rotor Test

Motor Voltage V_{SC} Volts	Motor current I_{rated} Amps	Motor blocked rotor Power W_{SC} Watts
V_{SC}	I_{rated}	(in W)
107	8.1508	500

* Observations → (A) No load test

Sr. No.	No load Current (I_0) (in A)	No load Power (W_0) (in W)	Line Voltage (V_L) (in V)
1.	1.0	70	230

(B) Blocked Rotor Test

Sr. No.	Short circuit current (I_{sc}) (in A)	Power (W_{sc}) (in W)	Line voltage (V_{sc}) (in V)
1.	8	500	107

η (Efficiency of motor) $= 85\%$, $\cos\phi = 0.8$ (lag)

3 H.P. motor;

$\therefore P_{out} = 3 \times 736$

$= 2208$

$$\eta = \frac{P_{out}}{P_{in}}$$

$$P_{in} = \frac{2208}{0.85}$$

$\therefore P_{in} = 2597.647 W$

$P_{in} = \sqrt{3} V_L I_L \cos\phi$

$$I_L = \frac{2597.647}{\sqrt{3} \times 230 \times 0.8}$$

$I_L = 8.1508 A$ —— (Rated line current of motor) current flows through the stator. Noted down all the readings.

Date: / /20

Resistance betn two terminals of motor $(R_m) = 1.6\Omega$

As, motor is delta connected

$$R_a = R_m \times \frac{3}{2}$$

$$= 1.6 \times 1.5$$

$$R_a = 2.4\Omega$$

*Calculations →

(A) No load test →

$$W_o = \sqrt{3} V_L I_o \cos\phi_o$$

$$\cos\phi_o = \frac{W_o}{\sqrt{3} V_L I_o}$$

$$= \frac{70}{\sqrt{3} \times 230 \times 1}$$

$$\cos\phi_o = 0.1757$$

$$\therefore \phi_o = \cos^{-1}(0.1757)$$

$$\therefore \phi_o = 79.87^\circ$$

$$I_w = I_o \cos\phi_o$$

$$= 1 \times \cos(79.87)$$

$$= 0.1757 A$$

$$I_H = I_o \sin\phi_o$$

$$= 1 \times \sin(79.87)$$

$$= 0.9844 A$$

$$R_o = \frac{V_L}{I_w} = \frac{230}{0.1757} = 1309.0495\Omega$$

$$X_0 = \frac{V_1}{I_H} = \frac{230}{0.9844} = 233.6448\,\Omega$$

$$I_{sc} = \frac{I_L}{\sqrt{3}} = \frac{8}{\sqrt{3}} = 4.6188\,A$$

(B) Blocked Rotor Test →

$$W_{sc} = 3 I_{sc}^2 R_{01}$$

$$500 = 3 \times (4.6188)^2 \times R_{01}$$

$$R_{01} = \frac{500}{3 \times (4.6188)^2}$$

$$\therefore R_{01} = 7.8152\,\Omega$$

$$R_{01} = R_1 + R_2'$$

$$7.8125 = 2.4 + R_2'$$

$$R_2' = 7.8125 - 2.4$$

$$R_2' = 5.4125\,\Omega$$

$$R_L' = R_2'\left(\frac{1}{S} - 1\right)$$

$$N_S = \frac{120 f}{P}$$

$$= \frac{120 \times 50}{4}$$ —— (4 Pole motor, f = 50Hz given on nameplate)

$$N_S = 1500\,rpm$$

$$Slip(S) = \frac{N_S - N}{N_S}$$

$$= \frac{1500 - 1440}{1500}$$

$$\therefore S = 0.04$$

$$R_L' = R_2'\left(\frac{1}{s} - 1\right)$$

$$= 5.4125\left(\frac{1}{0.04} - 1\right)$$

$$R_L' = 129.9\,\Omega$$

$$Z_{sc} = \frac{V_{sc}}{I_{sc}} = \frac{107}{4.6188} = 23.1661\,\Omega$$

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

$$= \sqrt{(23.1661)^2 - (7.8152)^2}$$

$$X_{01} = 21.8081\,\Omega$$

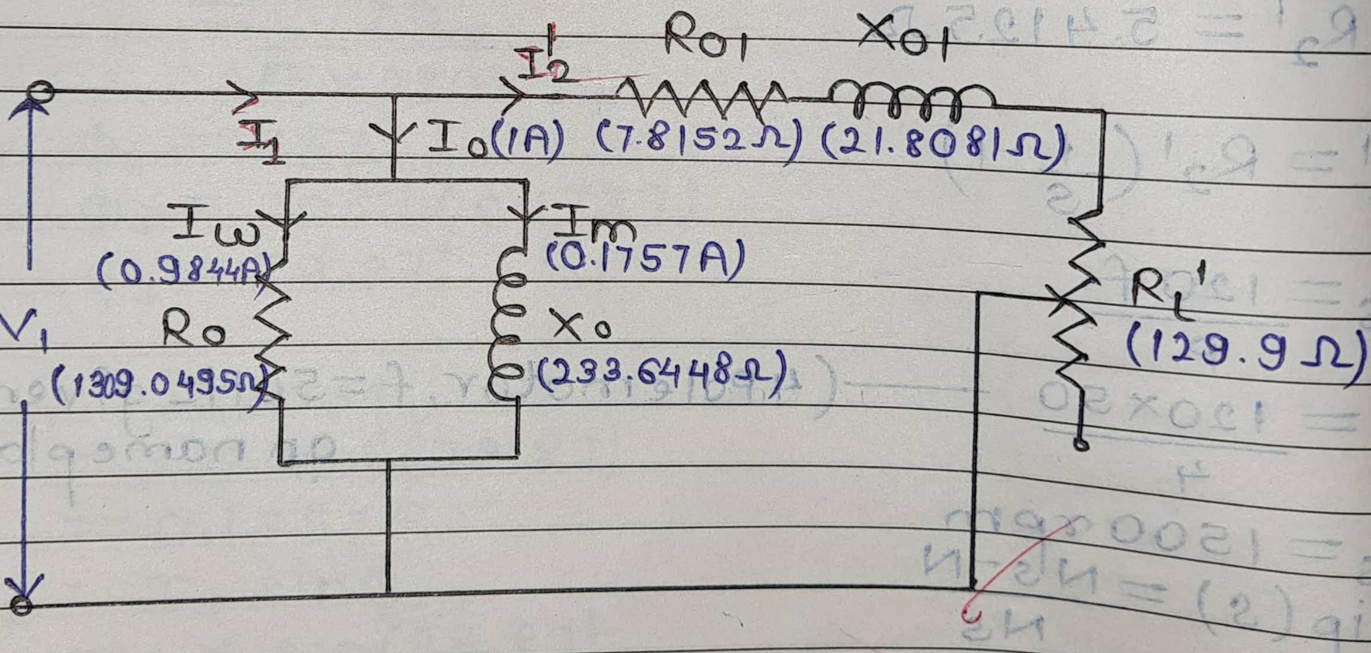


Fig. Equivalent Circuit of 3φ Induction motor

Calculations: [Written on extra sheet attached]

Determination of Equivalent Circuit Parameters

From No Load Test

- Wattmeter reading W_0=..70...............W
- Voltmeter reading V_0=..230.............V
- Ammeter reading I_0=...1.0..................A
- $\cos \varnothing_0 = \frac{W_0}{\sqrt{3}V_0 I_0}$ = .0.1757.....
- $\varnothing_0 = {}^1\cos^{-1} \varnothing_0$=.79..87°...degree
- $\sin \varnothing_0$ =...0.9844..........
- R_0 per phase= $\frac{\textit{perphase no load voltage}}{\textit{per phase no load current } \times \cos\varnothing_0}$ =1309.04Ω
- X_0 per phase = $\frac{\textit{per phase no load voltage}}{\textit{per phase no load current } \times \sin\varnothing_0}$ =233.644Ω

From Blocked Rotor Test

- Wattmeter reading Wsc =..500..............W
- Voltmeter reading V_{SC}=....107...............V
- V/phase = V_{SC}~~/√3~~=........107.......................V—(Δ connected motor)
- Ammeter reading I_{SC}/√3=...4.6188..........A
- $\cos \Phi_{SC}$=W_{SC} = $\frac{W_{SC}}{\sqrt{3}V_{SC}I_{SC}}$ = 0.5841.....
- $\Phi_{SC} = \cos^{-1} \Phi_{SC}$=.54.25°.......degree
- Mean stator resistance R_{Smean}=..2.4.............. Ω
- Total winding resistance and impedance as referred to the stator side R_{01} and Z_{01}(per phase)
- $Z_{01} = \frac{\text{V/phase}}{\text{I/phase}}$ 23.1661Ω
- $R_{01} = Z_{01} \times \cos \Phi SC$=7.8152.........Ω
- Total leakage reactance as referred to the stator side $X_{o1} = \sqrt{(Z_{01}^2 - R_{01}^2)}$ =21.8081Ω
- $R_{S(eff)}$=(1.2xR_{Smean})/2=.........—.........Ω
- Rotor resistance as referred to the stator side $R'_2 = R_{01} - R_{S(eff)}$=..5.4125......Ω

- Electrical equivalent of the mechanical load $R_L = R'_2 \left[\frac{1-S}{S}\right]$ = 129.9 Ω

XV Results:

→ From calculation of no load test we calculated the value of parameters of magnetizing branch of equivalent circuit I_0, I_μ, I_w, R_0 and X_0. Also from short circuit test calculated the equivalent circuit parameters such as R_{01}, X_{01}, Z_{01} and R_L'.

XVI Interpretation of results

→ From result we can interpret that no load test is carried out to measure the core losses or iron losses and blocked rotor test is carried out to measure copper losses or variable losses.

XVII Conclusion

→ By performing this practical we aquired necessary knowledge about determining equivalent circuit parameters from no load test and blocked rotor test data.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the precaution to be taken in performing blocked rotor test.
2) Draw the equivalent circuit diagram of three phase induction motor.
3) Wattmeter reading in no load test is considered as iron loss. Justify.

(Space for answers)

Que.No.(1) State the precaution to be taken in performing blocked rotor test.

Ans- Precautions taken while performing the blocked rotor test are as follows →

(i) Gradually increased the input voltage to motor with the help of 3ϕ Auto-transformer till the rated current flows through the stator with the rotor blocked and short-circuited.

(2) Ensure Auto-transformer is at zero position at start.

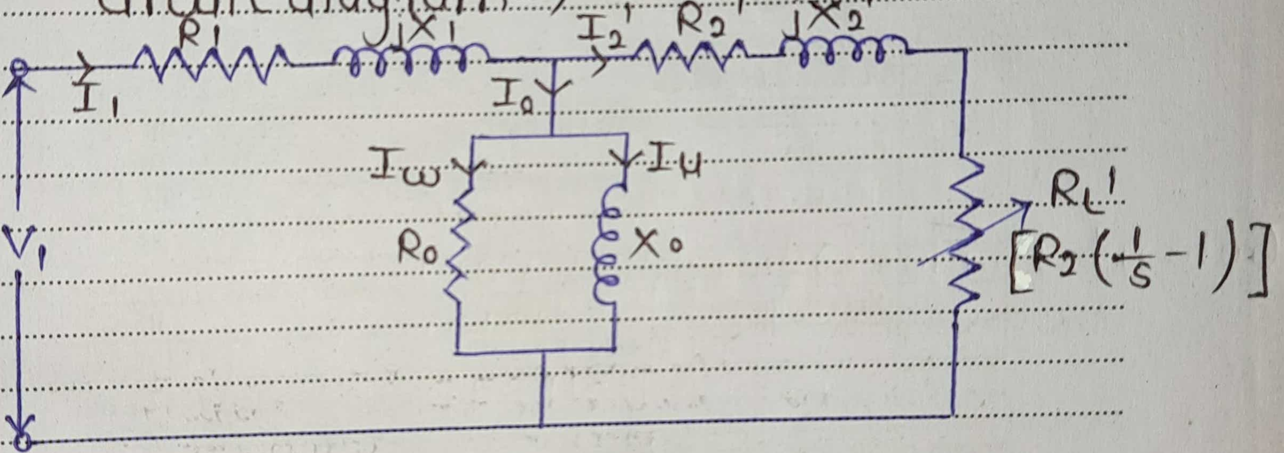
(3) In blocked rotor test while blocking the rotor, it should not be holded loosely.

(4) All connections should be neat and tight.

(5) Proper range measuring instruments should be selected as per rated current and low voltage.

Que.No.(2) Draw the equivalent circuit diagram of three phase induction motor.

Ans → Three phase induction motor equivalent circuit diagram →



Que.No.(3) Wattmeter reading in no load test is considered as iron loss, Justify.

Ans – During no load test of induction motor, the current flowing through motor is negligible (As there is no load, only magnetizing current is present). As the current is negligible, copper losses taking place on account of current in winding also becomes negligible.

But the voltage applied during no load condition is rated voltage. So iron losses depending upon voltage takes place in the core which is measured by wattmeter Therefor, wattmeter reads iron losses during no load test.

XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. IS 4029-2010: Guide for testing three phase induction motor

XX Assessment Scheme

	Performance indicators	Weightage
	Process related (15 Marks)	**60 %**
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
	Product related (10 Marks)	**40 %**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Bhavesh Gurav
2. Aadil Khatik
3. Rohan Joshi

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	
15	10	25	

Experiment No. 3 : For the motor tested in practical at S. no. 2 plot the circle diagram and judge its performance

I **Practical Significance**

The circle diagram of an induction motor is very useful to study its performance under all operating conditions. We get information about its power output, power factor, torque, slip, speed, copper loss, efficiency, starting and maximum quantities etc.

II **Relevant Program Outcomes (POs)**

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment- Maintain various types of rotating and static electrical equipment.

III **Competency and Skills**

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters.
- Measure electrical quantities
- Connect the machines as per relevant circuits
- Follow safe practices.

IV **Relevant Course Outcomes**

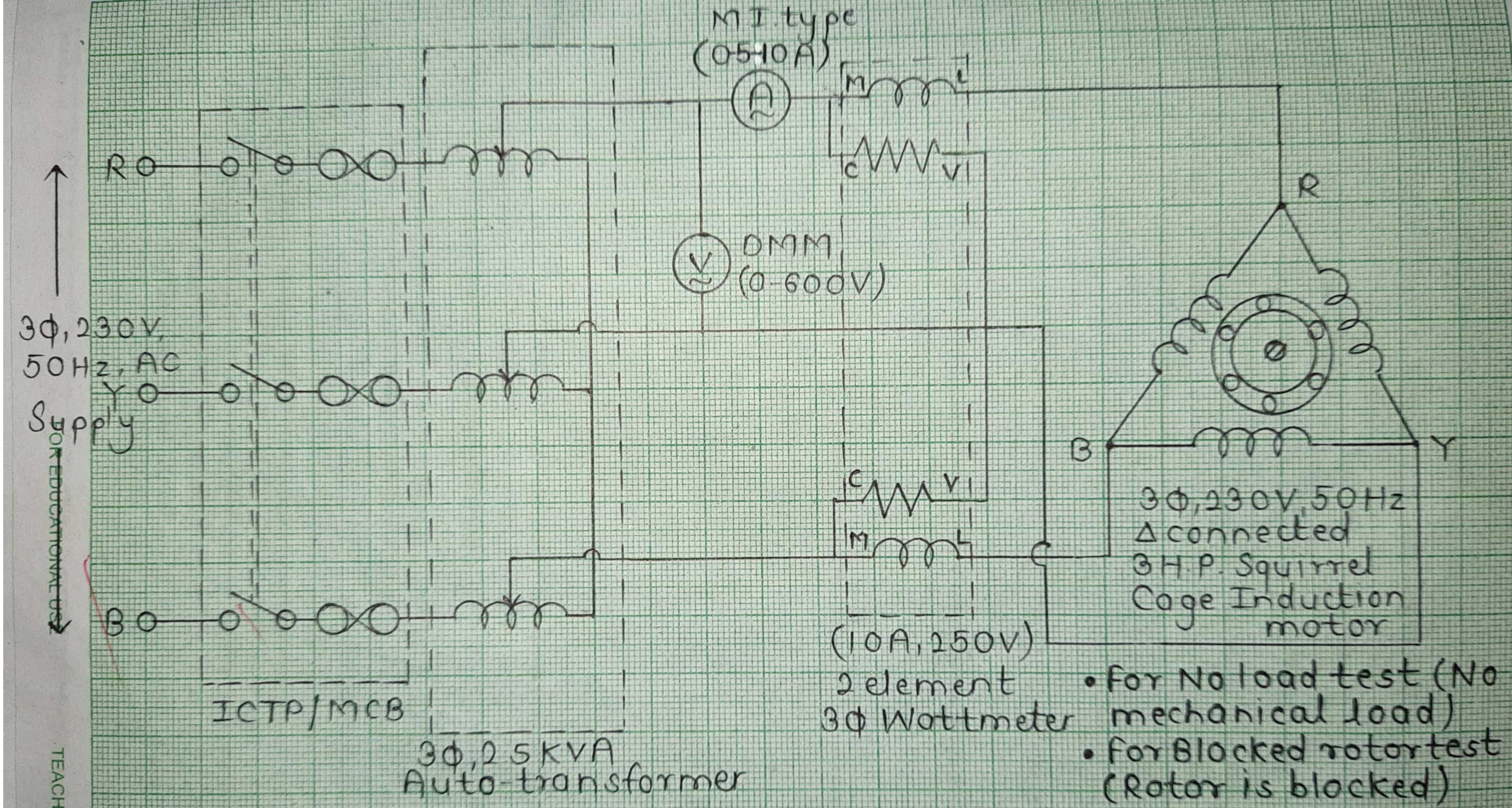
- Maintain rotating electrical machines.

V **Practical Learning Outcome**

- For the motor tested in practical at S. no. 2 plot the circle diagram and judge its performance

VI **Minimum Theoretical Background**

The circle diagram is the graphical representation of the performance of the electrical machine drawn in terms of the locus of the machines input voltage and current. Equivalent circuit for rotor of Induction motor is series R-L circuit with variable load resistance, so locus of rotor current for changing load is circle. As motor current is vector sum of constant no load current and rotor current referred to stator, locus of motor current is also circle with changing load which is shifted by no load current as shown in diagram.



Title → Practical set-up for No load test and blocked rotor test on 3Φ Induction motor to plot the circle diagram.

B) For Blocked Rotor Test

1) Select meter ranges required for blocked rotor test.
2) Hold rotor by hand or brake system
3) Switch ON the 3 phase supply and apply voltage slowly with the help of autotransformer so that rated current flows to motor.
4) Note down all meter readings.
5) Reduce voltage and switch OFF the power supply.
6) Using appropriate method measure stator resistance across the motor terminals and determine per phase AC value.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Power Supply	—	3ϕ, 230V, 50HZ, ~ Supply	01	
2.	3ϕ Auto-X'mer		3ϕ, 0.5KVA, ~, Auto-X'mer	01	
3.	Wattmeter		2 element (10A, 250V)	01	
4.	DMM	Mastech	As voltmeter (0-600V)	01	
5.	Ammeter	Supreme	M.I. type (0-5-10A)	01	
6.	Induction motor		3ϕ, 230V, 50Hz Δ, 3H.P	01	
7.	Connecting cables	—	PVC (2.5mm²)	As per Req.	
8.					

XII Actual procedure followed

→ (A) No load test – (i) Made the connections as per circuit diagram, started the motor at reduced voltage and then applied rated voltage at no load (ii) Noted down the readings.

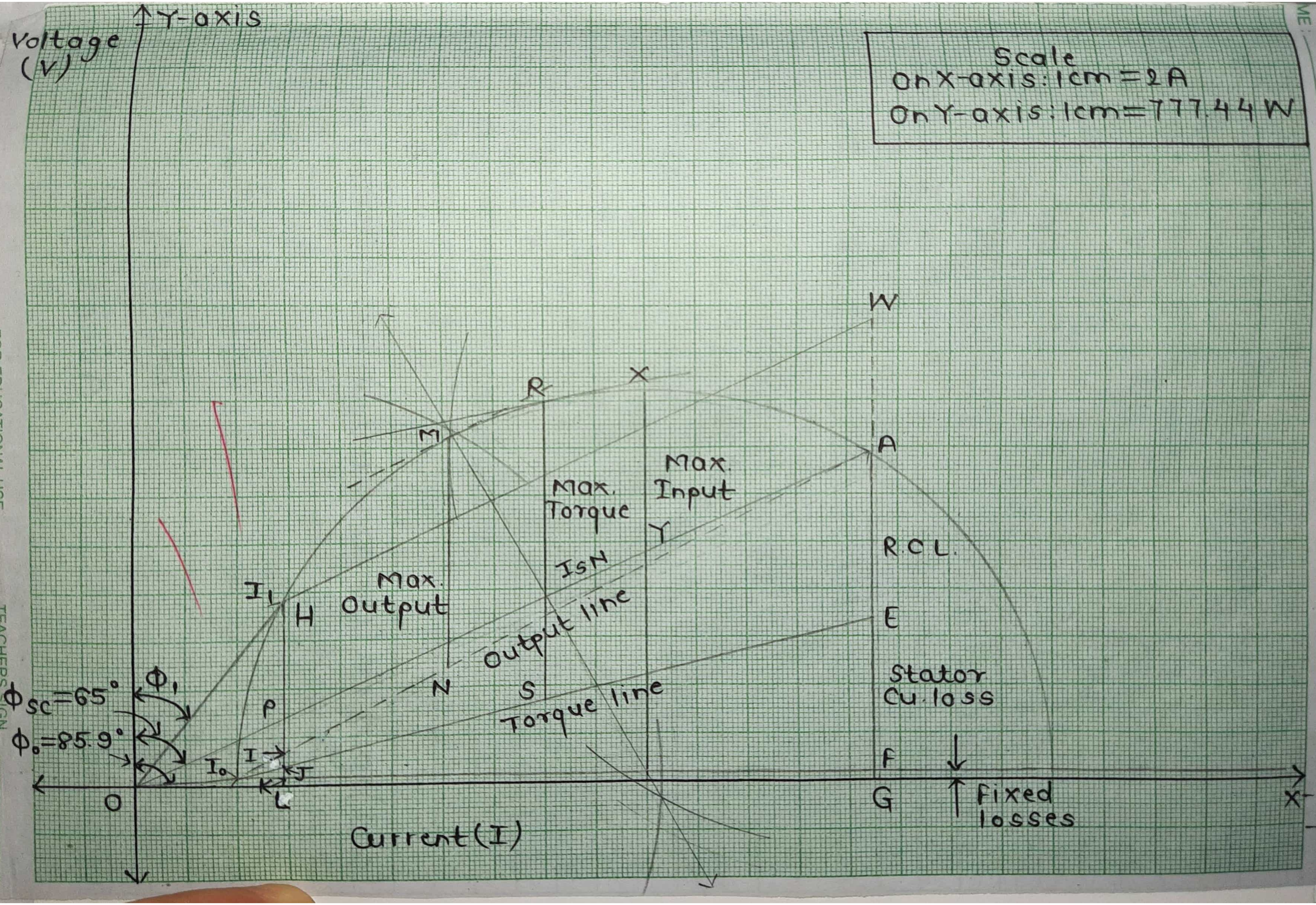
(B) Blocked rotor test – (i) Made the connections as per circuit diagram. Holded rotor with hand and gradually increased voltage till the rated current flows (ii) Noted the readings.

XIII Precautions followed

→ ① Ensured that auto-X'mer was at zero position initially.

② Gradually increased the voltage by 3ϕ Auto-X'mer till the rated current flows through the motor in block rotor test.

③ Proper range meter were selected


Voltage (V)
Y-axis
Scale
On X-axis: 1cm = 2A
On Y-axis: 1cm = 777.44 W
W
R
X
M
A
Max. Input
Max. Torque
Y
R.C.L.
I_{SN}
I_1
H
Max. Output
Output line
E
N
S
Stator Cu. loss
P
Torque line
$\phi_{sc} = 65°$
ϕ_1
$\phi_0 = 85.9°$
I_0
I
J
F
O
L
G
Fixed losses
X-axis
Current (I)

*Calculations →

- From no load test data,

$$W_0 = \sqrt{3}\, V_1 I_0 \cos\phi_0$$

$$\cos\phi_0 = \frac{W_0}{\sqrt{3}\, V_1 I_0}$$

$$= \frac{120}{\sqrt{3} \times 230 \times 4.3}$$

$$\cos\phi_0 = 0.07005$$

$$\phi_0 = \cos^{-1}(0.07005)$$

$$\therefore \phi_0 = 85.98^\circ$$

- From blocked rotor test data,

$$W_{sc} = \sqrt{3}\, V_{sc} I_{sc} \cos\phi_{sc}$$

$$\cos\phi_{sc} = \frac{W_{sc}}{\sqrt{3}\, V_{sc} I_{sc}}$$

$$= \frac{750}{\sqrt{3} \times 86 \times 12}$$

$$\cos\phi_{sc} = 0.4195$$

$$\phi_{sc} = \cos^{-1}(0.4195)$$

$$\phi_{sc} = 65.19^\circ$$

Short circuit current at normal voltage (I_{SN})

$$\frac{I_{SN}}{I_{SC}} = \frac{V_N}{V_{SC}}$$

$$\therefore I_{SN} = \left(\frac{V_N}{V_{SC}}\right) \times I_{SC}$$

$$= \left(\frac{230}{80}\right) \times 12$$

$$I_{SN} = 32.0930\,A$$

Date: / /20

Blocked rotor power at normal voltage (P_{SN})

$$P_{SN} = \left(\frac{V_N}{V_{SC}}\right)^2 \times P_{SC}$$

$$= \left(\frac{230}{86}\right)^2 \times 750$$

$$\therefore P_{SN} = 5364.38 \, W$$

From circle diagram,

$l(AG) = 6.9 \, cm$

$$\text{Power Scale} = \frac{P_{SN}}{l(AG)}$$

$$= \frac{5364.38}{6.9}$$

$$= 777.44 \, W$$

Output power (P_o) $= 3 \times H.P.$

$$= 3 \times 736$$

$$= 2206.05 \, W$$

$$l(AW)\text{ extended} = \frac{P_o}{\text{Power scale}}$$

$$= \frac{2206.05}{777.44}$$

$$= 2.8375 \, cm$$

$l(AW)$ extended is $2.8375 \, cm$

From circle diagram

$I_1 = l(OL) \times \text{current scale}$

$= 4.7 \times 2$

$= 9.4 A$

Power Factor $= \cos\phi$

$= \cos(37)$

$= 0.7986$ (lag)

% motor efficiency $= \frac{LP}{LK} \times 100$

$= \frac{2.9}{3.4} \times 100$

$= 0.8529 \times 100$

$= 85.29\%$

Rotor efficiency $= \frac{\text{Rotor output}}{\text{Rotor input}}$

$= \frac{LP}{LQ} \times 100$

$= 93.54\%$

Starting torque $T_{st} = l(AE) \times$ Power scale

$= 3.4 \times 777.446$

$= 2643.3164$ syn. watt

max. torque $(T_m) = 6.3 \times 777.44$

$= 4897.872 \ldots W$

Full load slip $= \frac{IJ}{HJ}$

$= \cancel{\frac{0.2}{3.5}}$

$= 0.0571$

Full load speed $(N) = N_s(1-S)$
$= 1500(1-0.0571)$
$= 1425$ RPM

max. output $= MN \times$ Power scale
$= 4.8 \times 777.44$
$= 3731.712 \ldots W$

Full load torque $= HJ \times$ Power scale
$= 3.4 \times 777.44$
$= 2643.296 \ldots N.m$

From circle diagram,

(i) motor Input $= XY \times$ Power Scale
$= 3.4 \times 777.44$
$= 2643.316 \ldots W$

(ii) Fixed loss $= l(LK) \times$ Power scale
$= 0.2 \times 777.44$
$= 155.488 \ldots W$

(iii) Stator Cu loss $= l(KJ) \times$ Power scale
$= 0.2 \times 777.44$
$= 155.488 \ldots W$

(iv) Rotor Cu. loss $= l(JI) \times$ Power scale
$= 0.3 \times 777.44$
$= 233.232 \ldots W$

(v) Total loss $= l(PL) \times$ Power Scale
$= 1.9 \times 777.44$
$= 1477.136 \ldots W$

(vi) Rotor Input ~~output~~ $= l(HP) \times$ Power Scale
$= 2.4 \times 777.44$
$= 1865.856 \ldots W$

XIV Observations and Calculations:

No Load Test

Motor input V_{rated} Volts	Motor current I_0 Amps	Motor No Load Power W_0 Watts (in W)
V_{rated}	I_0	
230	4.3	120

Blocked Rotor Test

Motor Voltage V_{SC} Volts	Motor current I_{rated} Amps	Motor blocked rotor Power W_{SC} Watts (in W)
V_{SC}	I_{rated}	
12	8.6	750

Measured voltage and current values are per phase values

Calculation:

- **Circle diagram calculations**

$\cos \phi_0 = \frac{W_0}{\sqrt{3}V_0 I_0} =$ 0.07005

$\cos \phi_{SC} = \frac{W_{SC}}{\sqrt{3}V_{SC} I_{SC}} =$ 0.4195

current scale I_{SCN} = 320.930

Assuming current scale 1 cm = 2A

- **Power scale calculation**

$W_{SCN} = W_{SC} \times (\frac{V_{rated}}{V_{SC}})^2 =$ 5364.38 W

Measured length of AQ = 6.9 cm, equate this AD with above calculated W_{SCN} and find the Power scale is 1 cm = 777.44 Watts

Rated o/p = 2206.05 W

- **FL Calculation**
  - Full load current = 4.7 cm = 4.7 cm × current scale = 9.4 Amp
  - Full load power factor = 0.7986 (lag)
  - Full load output = 2.9 cm = 2.9 cm × power scale = 2254.57 Watt
  - Full load Input = ~~2643.296 W~~ 12804.8941 W
  - Full load efficiency = 85.29 %

- Full load stator cu losses = 155.488W
- Fixed losses = 155.488W
- Full load rotor cu losses = 233.232W
- Full load Rotor Input = 1865.856W
- Full load slip = 0.0571
- Full load Torque = 2643.296 Torque ca
- Full load speed = 1425 RPm

➢ **Maximum Quantities calculation**

- Max Output = 3731.712W
- Max Input = —
- Max Torque = 4897.872W

➢ **Starting Torque calculation**

- Starting Torque = 2566.66 N.m

XV Results:

Motor FL efficiency = 85 %
Motor NL Torque = — Nm
Motor Max output = 5.2815 HP

XVI Interpretation of results

→ From result we can interpret that by using circle diagram we are able to calculate max full load input, full load output which is no possible in noload and block rotor test to find efficiency.

XVII Conclusion

→ By performing this practical we can conclude that circle diagram of an induction motor is useful to study performance of it as we can find slip, speed, copperloss, efficiency, starting torqule, max torque, etc parameters related to it.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Define circle diagram of Induction motor.
2) Describe step by step procedure for drawing Circle diagram.
3) Give advantages of Circle diagram
4) List out the testing of Induction motor as per IS.

Que. No. (2) Describe step by step procedure for drawing circle diagram.

Ans – Circle diagram of an induction motor can be drawn by using data obtained from no load, short circuit and stator resistance test.

Further procedure to draw circle diagram is as follows →

Step (I) Take reference phasor V as vertical Y-axis and current (I) on X-axis

Step (II) from no load test, calculate ϕ_0 and from blocked rotor test, calculate ϕ_{sc}.

$$\phi_0 = \cos^{-1}\left(\frac{W_0}{\sqrt{3}\,V_0 I_0}\right)$$

$$\phi_{sc} = \cos^{-1}\left(\frac{W_{sc}}{\sqrt{3}\,V_{sc} I_{sc}}\right)$$

& draw vector I_0 lagging V by ϕ_0 (OO')

Step (III) Draw horizontal unit O'D passing through point O' and parallel to X-axis

Step (IV) Calculate short circuit current with normal voltage applied

$$I_{SN} = I_{sc}\left(\frac{V_0}{V_{sc}}\right)$$

& draw I_{SN} at an angle ϕ_{sc} behind voltage vector (V) (OA)

Step (V) Join O'A called as output line

Step (VI) Draw perpendicular bisector of output line due to which point C' is obtained line O'D.

Date:

Step (VII) Taking point C as center drawn semi circle passing through point O' & A.

Step (VIII) Draw perpendicular from point A on axis line AG

Step (IX) Separate stator Cu loss and rotor Cu loss by bisecting line AG and obtained point E it.

Step (X) Join O' and E this is torque line

Step (XI) Calculate power scale.

Step (XII) Show full load point on circle diagr

Step (XIII) Calculate efficiency, torque, losses slip from circle diagram.

(Space for answers)

Que.No.(1) Define circle diagram of Induction motor.

Ans – A circle diagram is a graphical representation of the performance of an electrical machine. It is commonly used to illustrate the performance of transformer, synchronous motors and induction motors.

Hence, a circle diagram is graphical representation about parameters of motor such as power output, power factor, slip, speed, copper loss, efficiency, starting, etc.

Que.No.(3) Give advantages of circle diagram.

Ans – Easy, convenient and reasonably assurable method to determine several quantities like slip, torque, efficiency at any load, losses, power factor, etc.

Que.No.(4) List out the testing of induction motor as per IS.

Ans – Routine tests on 3ϕ induction motor –

(i) measurement of DC resistance
(ii) Measurement of insulation resistance
(iii) High voltage test
(iv) Reduced voltage running up test
(v) No load test
(vi) Locked rotor test
(vii) Measurement of slip

Type tests on 3 phase induction motor –

(i) Temp. rise test
(ii) Momentary overload test
(iii) Full load test
(iv) No load test

(v) Blocked rotor test

Experiment No. 4: Perform the brake load test on the three phase Induction motor to plot the following operating characteristics, [(1) torque versus speed, (2) current drawn versus output and (3) power factor versus output]

I Practical Significance

It is a type test conducted as per IS 325 on induction motor by actually loading, to understand performance parameters like speed, input stator current, power factor and efficiency.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment- Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices.'**

- Select various meters.
- Measure electrical quantities
- Connect machines as per relevant circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain rotating electrical machines.

V Practical Learning Outcome

- To perform Brake test on three phase induction motor.
- To study operating characteristics of 3 phase induction motor.

VI Minimum Theoretical Background

Brake test is suitable for small and medium capacity motors due to non- availability of large loading facility. Artificial loading arrangement is provided by Break-pulley and belt or rope. Motor can be tested gradually increasing the load by tightening the tension on the belt. The spring balance readings in kg on slack(S1) and tight (S2) side of the belt are noted and respective readings on input side of the motor such as current, voltage, power are noted. Speed is measured. From the observations the performance characteristics can be plotted. This test is also carried out for measurement of temperature rise of a motor.

Performance characteristics of three phase Induction motor.

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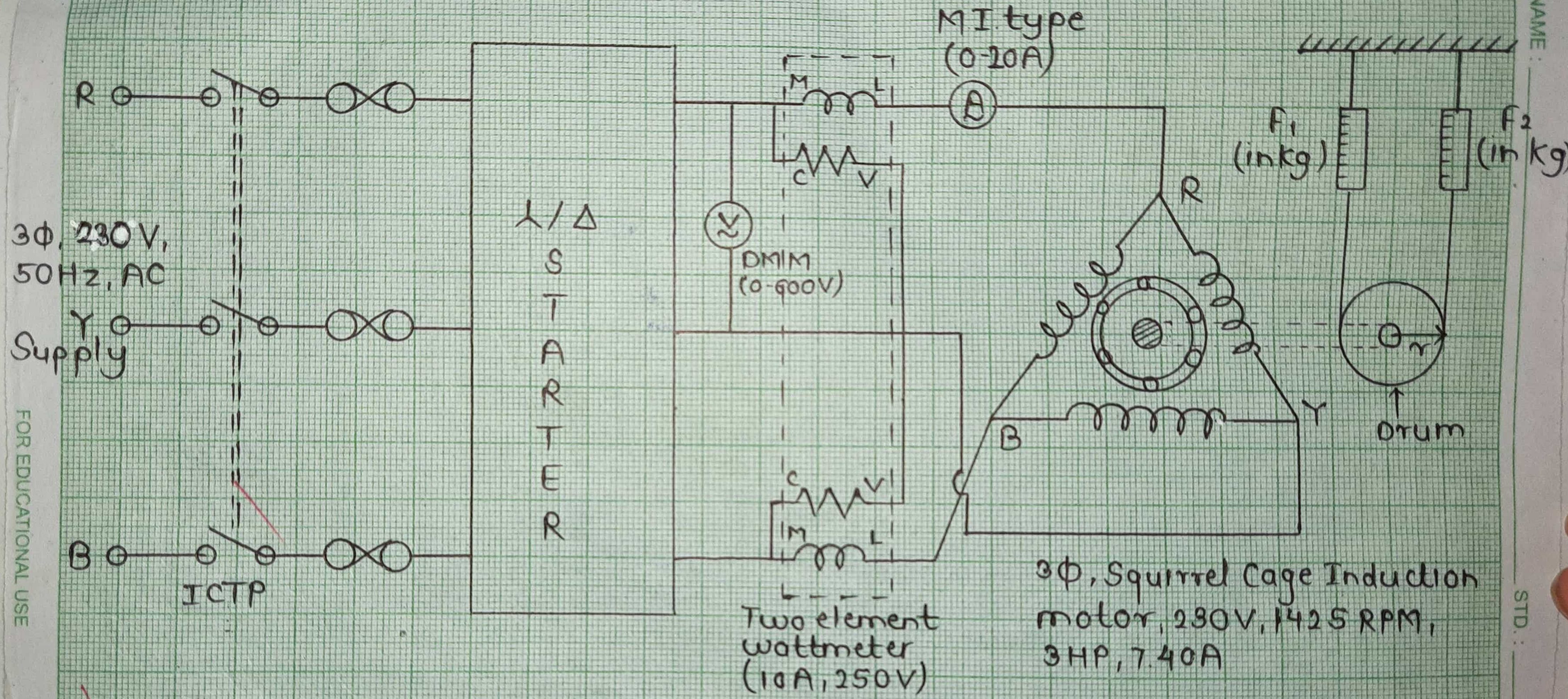


<u>Title</u> → Circuit diagram for performing break load test on the three phase induction motor.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification Make	Broad Specification Details	Quantity	Remark (If any)
1.	Power Supply	-	3ϕ, 230V, 50Hz, ~Supply	01	
2.	Starter	-	λ/Δ Starter	01	
3.	Wattmeter	Two element	(10A, 250V)	01	
4	DMM (mastech)	As voltmeter	(0-600V)	01	
5.	Induction motor	3ϕ, 230V, 3HP.	7.4A, 1425 RPM	01	
6	Break load	with	belt drive	01	
7.					
8					
9.					

XII Actual procedure followed

① Made connections as per circuit diagram
② Rotor was made very much free to rotate.
③ 3ϕ induction motor started using auto-X'mer.
④ Adjusted load till current was made to rated value of motor ⑤ Decreased load step by step and noted corresponding speed, load current, voltage, wattmeter readings

XIII Precautions followed

① All electrical connections were neat and tight.
② Made sure that main switch was in OFF position while making connections.
③ Started the motor with no load on it

XIV Observations and Calculations: [Written on extra sheet]

Sr. No	V_L(V)	I_L(A)	Input (W)	Load of brake drum in kg S1	Load of brake drum in kg S2	Speed(N) (rpm)	Torque (N-m)	Output (W)	% Slip	%	PF
1											
2											
3											
4											
5											
6											

Calculations:

Radius of Brake drum R=.0.08….m

Ns= Synchronous speed in rpm .1500…

N =Rotor speed in rpm ..1410…

S1&S2= Load of brake drum in kg .19 and 4 resp.

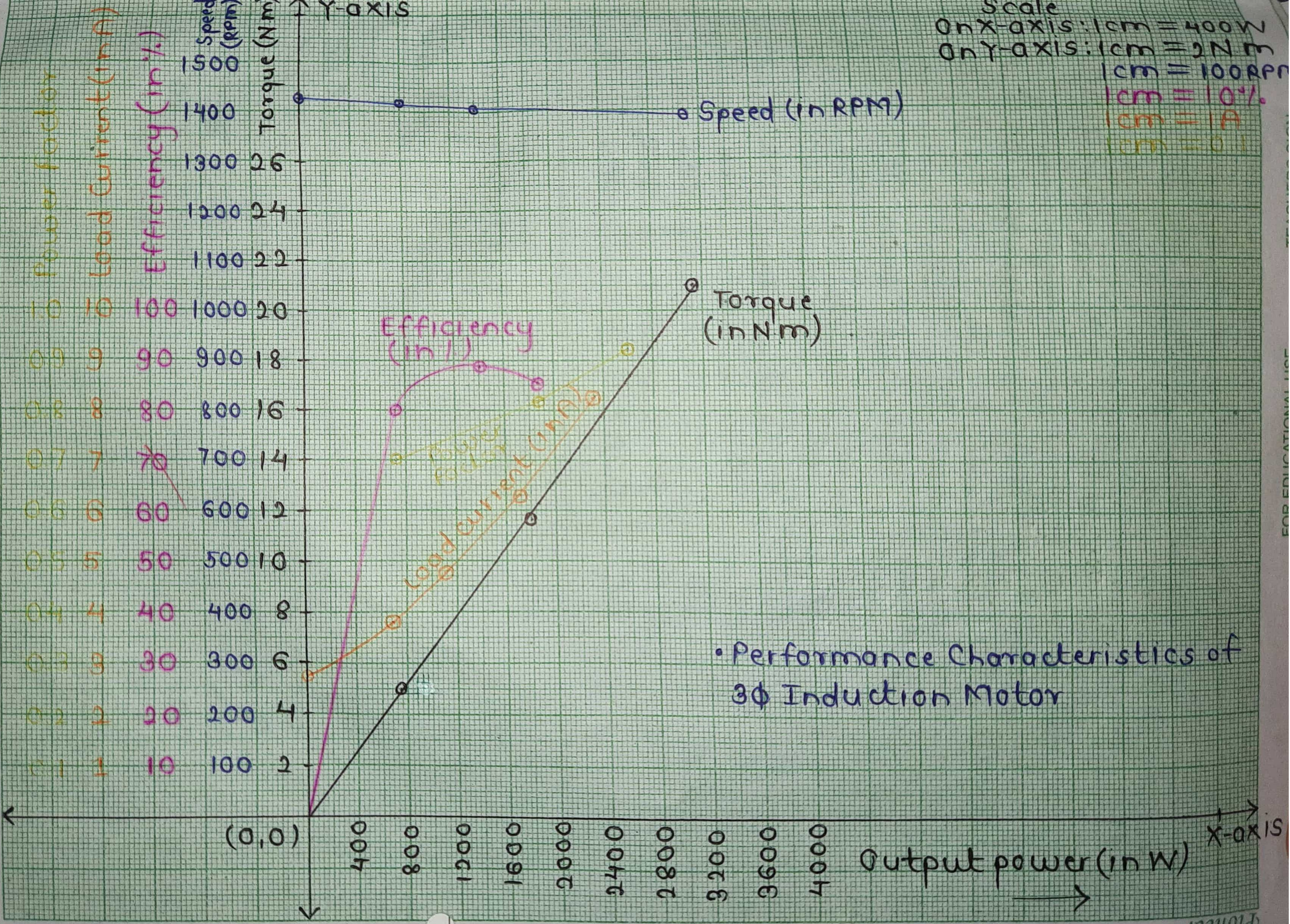
V_L=Line voltage in Volts .230.....

I_L= Line current in Amps ..6.14.....

- % slip= [(Ns-N)/Ns]*100=…6…..%
- Input Power (W) = (W_1+W_2)=.2000. Watts
- Torque (T) = 9.81*(S1-S2)*R =11.772… N-m
- Output Power = $\frac{2\pi NT}{60}$ =1734.89. watts
- % efficiency = [output/input]* 100=..86.74...%
- Power Factor (PF) = Input Power/ (√3$V_L$$I_L$) = 0.876

XV Results:

As load is increased on the 3ϕ induction motor, its speed gradually decreases on the other hand power factor increases. Torque also increases with increase in load current which increase due to increased load.



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Calculations and Observations →

Radius of pulley = 0.08m

Sr. No.	Voltage (in V)	Current (in A)	Input Power (in W)	F_1 (in kg)	F_2 (in kg)
1.	230	2.93	150	0	0
2.	230	3.80	900	9	2.5
3.	230	4.46	1300	13	3
4.	230	6.14	2000	19	4
5.	230	7.86	2750	25	5
6.	230	9.18	3300	27	5.2
7.	230	9.50	3400	29	6
8.	230	10.4	3500	35	7

Torque $(F_1-F_2)\times 9.81 \times 0.08$	Output power $= \frac{2\pi NT}{60}$	$\eta = \frac{O/P}{I/P} \times 100$	Speed (in RPM)
0	0	0	1425
5.1012	758.5529	84.57	1420
7.848	1162.804	89.45	1415
11.772	1734.89	86.74	1410
15.695	2308.48	83.94	1405
17.1085	2500.48	76.00	1400
18.0586	2638.07	77.59	1395
21.9744	3196.98	91.34	1390

Slip $\left(\frac{N_S - N}{N_S}\right)$	$P.F. = \frac{\text{Input power}}{\sqrt{3} V_L I_L}$
0.05	0.6498
0.0533	0.7681
0.0566	0.843
0.06	0.876
0.0633	0.921
0.0666	0.927
0.07	0.937
0.0733	0.947

XVI Interpretation of results

→ from result we can interpret that induction motor operates at max efficiency near full load. As power factor is also better than light load condition which increases losses taking place in motor.

XVII Conclusion

→ By performing this practical we acquire necessary skills to conduct actually loading of induction motor to understand parameters such as speed, input stator current, power factor, torque and efficiency.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the relation between torque and supply voltage in three phase induction motor.
2) Efficiency of induction motor increases with increase in load. Justify.
3) Power factor of induction motor is low at no load. Give reasons.
4) State the difference between load test of three phase induction motor and three phase transformer.

(Space for answers)

Que.No.(1) State the relation between torque and supply voltage in three phase induction motor.

Ans- The torque equation for 3ϕ Induction motor is given by,

$$T = \frac{kE_2^2 R_2}{R_2^2 + (S X_2)^2}$$

The torque of induction motor depends upon the magnitude of flux generated when the sinosoduial voltage is applied at the stator. The voltage is induced in stator winding and its magnitude depends upon the supply voltage.

The torque of the motor equals to square of the induced emf in the stator. The magnitude of induced emf in the stator is ~~app~~ equal to the magnitude of supply voltage.

$\boxed{T \propto V^2}$ (V→ Applied Voltage)

Que.No.(2) Efficiency of induction motor increases with increase in load Justify.

Ans→ The efficiency of the induction motor increases when the load increases because when motor load increases, its slip increases and rotor speed falls. Since, the rotor speed is slower, there is more relative motion. Also current through rotor is large and magnetic field also increases. So that torque also increases. ultimately motors are more efficient when load is increased on it.

Que.No.(3) Power factor of induction motor is low at no load Give reasons.

Ans→ An induction motor draws a large magnetizing current to produce the required flux in the air gap. Therefor, the induction motor takes a high no load current lagging the applied voltage by a large angle. Hence, the power factor of an induction motor on no load is low.

Que.No.(4) State the difference betn load test of three phase induction motor and 3ϕ transformer.

Ans→ In no load test of 3ϕ induction motor there is no mechanical load and on 3ϕ X'mer there is no electrical load. Besides the reluctance to the magnetic field is greater on account of presence of the air gap across which the stator power is transferred to the rotor in case of 3ϕ induction motor.

XIX References / Suggestions for Further Reading

1) www.electrical4u.com
2) www.electricaltechnology.org
3) IS 4029-2010: Guide for testing three phase induction motor

XX Assessment Scheme

	Performance indicators	Weightage
	Process related (15 Marks)	**60 %**
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
	Product related (10 Marks)	**40 %**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Bhavesh Gurav
2. Aadil Khatik
3. Rohan Joshi

Experiment No. 5 : To perform open circuit voltage ratio test on three phase slip ring induction motor

I Practical Significance

This test is a routine test which can be conducted as per IS 325 on Slip ring induction motor only. It is performed to know the open circuit voltage ratio of stator and rotor windings (slip ring induction motor).

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices.'**

- Select various meters.
- Measure electrical quantities.
- Connect circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain rotating electrical equipment.

V Practical Learning Outcome

- To perform open circuit voltage ratio/ turns ratio between phase winding.

VI Minimum Theoretical Background

This test is carried out to find the voltage ratio or turns ratio. Rated voltage is given to stator winding of slip ring induction motor and voltmeter is connected across slip rings. The voltage across slip ring= V_2 and it is the line voltage which should be divided by

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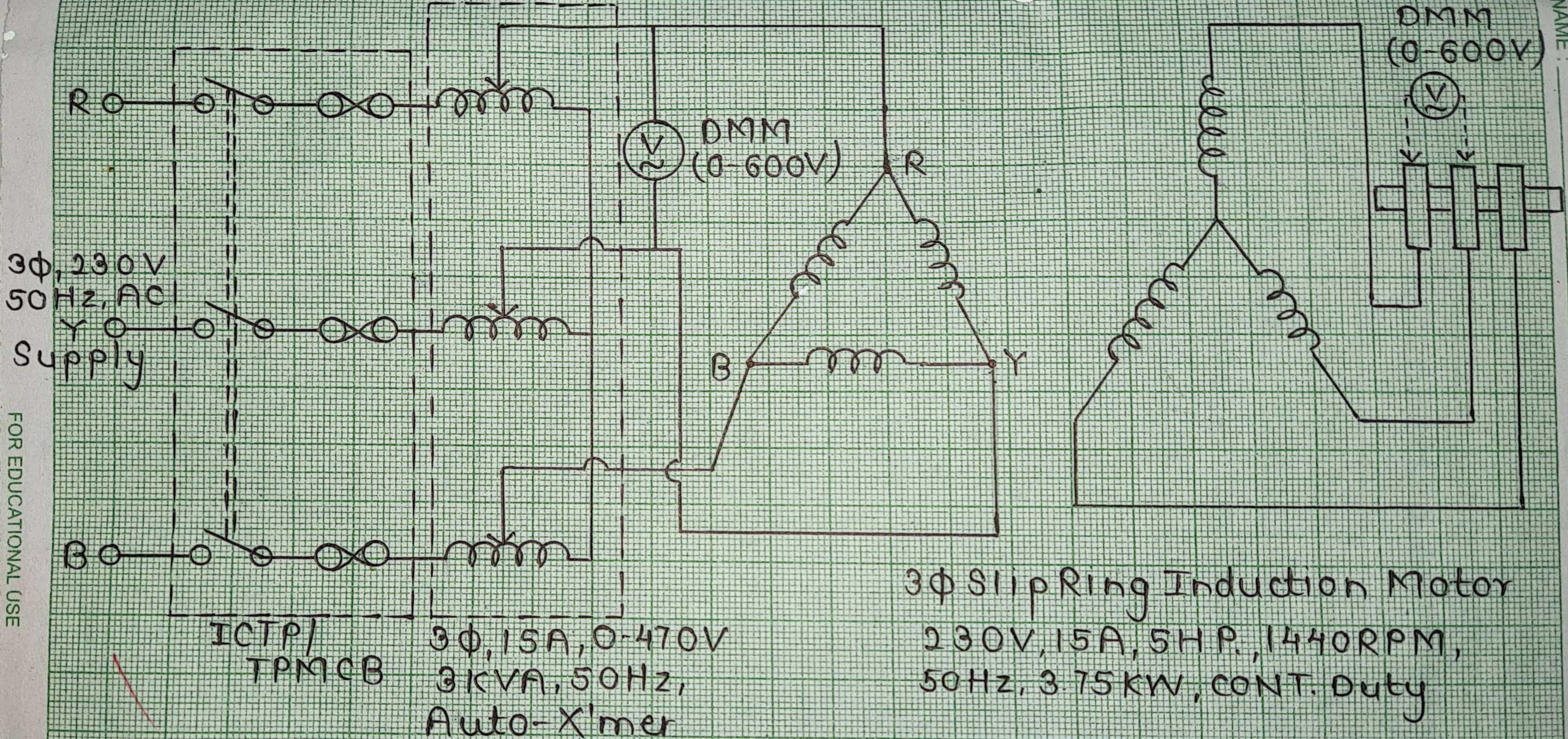


Title → Circuit digram to conduct open circuit voltage ratio test on 3ϕ Slip Ring Induction motor.

Date: / /20

* Observations and Calculations →

For 3ϕ, Δ-λ connected slipring Induction Motor

Sr. No.	Voltage across line Phase	Stator line Voltage (V_L) (in V)	Stator Phase Voltage (V_{ph}) (in V) (V_1)	Avg. Stator Phase Voltage (A)	Line Voltage across Slipring (V_L) (in V)	Phase Voltage across slipring $V_{ph}=\frac{V_L}{\sqrt{3}}$ (V_2)	Avg. Phase Voltage across Slipring (B)
1.	R-Y	104	104		138	79.67	
		145	145	167.75	194	112	127.88
		195	195		256	147.8	
		227	227		298	172.05	
2.	Y-B	105	105		138	79.67	
		149	149	170.5	194	112	127.59
		196	196		254	146.64	
		232	232		298	172.05	
3.	B-R	104	104		136	78.51	
		148	148	169	191	110.27	125.57
		195	195		249	143.76	
		229	229		294	169.74	

$$\text{Voltage ratio} = \frac{V_1}{V_2} \quad \ldots\ldots \left(\frac{A}{B}\right)$$

$$= \frac{\text{sum of avg. stator phase voltage}/3}{\text{Sum of avg. phase voltage across slipring}/3}$$

$$= \frac{(167.75+170.5+169)/3}{(127.88+127.59+125.57)/3}$$

$\therefore$ Voltage ratio $= 1.3312$

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Power supply	-	3Φ, 230V, 50Hz AC Supply	01	
2.	3Φ Auto-X'mer	-	3Φ, 0-470V, 50Hz, 3KVA	01	
3.	3Φ Slip Ring I.M.	-	230V, 3Φ, 5H.P., 15A, 1440 RPM, 50Hz	01	
4.	DMM	Mastech	As voltmeter (0-600V)	01	
5.	Connecting cables	-	PVC ($2.5mm^2$)	As per Req.	

XII Actual procedure followed

① Disconnected rotor resistance starter from the sliprings. ② Connected voltmeter across slip rings. ③ Gave rated voltage (V_1) to stator winding through auto-x'mer. ④ Measured voltage (V_2) across slip rings. Took different readings of V_2 across different slip rings and different position of rotor. Took avg. value.

XIII Precautions followed

① Disconnected the rotor resistance from slip ring properly.
② All connections were neat and tight.
③ Made sure that main switch was in OFF position while making connections.
④ Used wires of proper size for connections.

XIV Observations and Calculations: Written on extra sheet →

Sr. No.	Stator voltage	Rotor Voltage	Voltage Ratio
1	R-Y		
2	Y-B		
3	B-R		

Calculations:

Convert measured Stator and rotor voltages in phase values and find per phase voltage ratio

$$\text{Voltage Ratio} = \frac{\text{Average of primary or Stator voltage “}V_1\text{” per phase}}{\text{Average of secondary or rotor voltage “}V_2\text{” per phase}}$$

$$= \frac{\text{Average } V_1}{\text{Average } V_2}$$

$= 1.3312$

XV Results:

→ open circuit voltage ratio of stator and rotor winding (slip ring induction motor) is 1.3312. While calculating voltage ratio, took per phase values on both stator as well as rotor side.

XVI Interpretation of results

→ from result we can interpret that this test can be used to find the voltage ratio or turns ratio. This test can only be performed on slip ring induction motor.

XVII Conclusion

→ By performing this practical we can conclude that this routine test performed as per IS 325 gives voltage ratio or turns ratio in slip ring induction motor. Necessary skills are developed to perform the given practical to find voltage ratio.

XVIII Practical related Questions

1) State the effect of larger air gap in an induction motor.
2) State the effect of change in position of rotor on voltage across slip rings.
3) State the effect on the working of slip ring motor if rotor circuit is open.

(Space for answers)

Que. No. (1) State the effect of larger air gap in an induction motor.

Ans → Effects of larger air gap in an induction motor are as follows →

(i) The permeability of the magnetic circuit rotor to stator will decrease

(ii) The magnetizing inductance of the motor thus decreases.

(iii) The magnetizing current will increase. This will cause a poorer power factor at all loads.

(iv) The magnetic flux in the air gap

will decrease and leakage fluxes will increase. This will cause a reduction in the maximum available torque.

Que. No. (2) State the effect of change in position of rotor on voltage across slip rings.

Ans →

Que. No. (3) State the effect on the working of slip ring motor if rotor circuit is open.

Ans → Same voltage will be induced in the rotor, but rotor current will remain zero because rotor is open circuited.

As there is no rotor current there will not be any torque developed and hence no rotation of rotor. Stator current will be small fraction of the rated motor current. Hence, it will not harm the motor.

Experiment No. 06 : Perform the phasing out and polarity tests on the three phase transformer.

I Practical Significance

Phasing out test is a type test carried out on transformer as per IS 2026 (Part-IV) to identify the primary and secondary winding terminals belonging to the same phase of a three phase transformer.

Polarity test is must for transformers when parallel operation is done. Because while doing parallel operation, if you connect terminals of opposite polarity, it will result in a dead short - circuit. So, to connect the same polarity windings together both in primary and secondary, polarity test is done.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

The practical is expected to help the student to attain the following industry identified Competency: '**Maintain different electrical equipment following safe practices**'.

- Select various meters
- Measure electrical quantities.
- Connect Circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain single phase and three phase transformers.

V Practical Learning Outcome

- Perform the phasing out and polarity tests on the three phase transformer

VI Minimum Theoretical Background

Phasing out Test

Phasing out is required only in case of three phase transformer to identify primary and secondary winding terminals belonging to the same phase. A small direct current is circulated in one of the primary winding and a galvanometer is connected across one of the secondary winding and remaining primary and secondary windings are short-circuited. A momentary noticeable deflection in the galvanometer on making and breaking of primary current confirms that this secondary winding corresponds to the primary chosen. The test is repeated for other windings.

Terminal marking:

It is the marking of corresponding terminals of H.V. and L.V. sides of a single phase and three phase transformer. High voltage terminals are always marked with upper

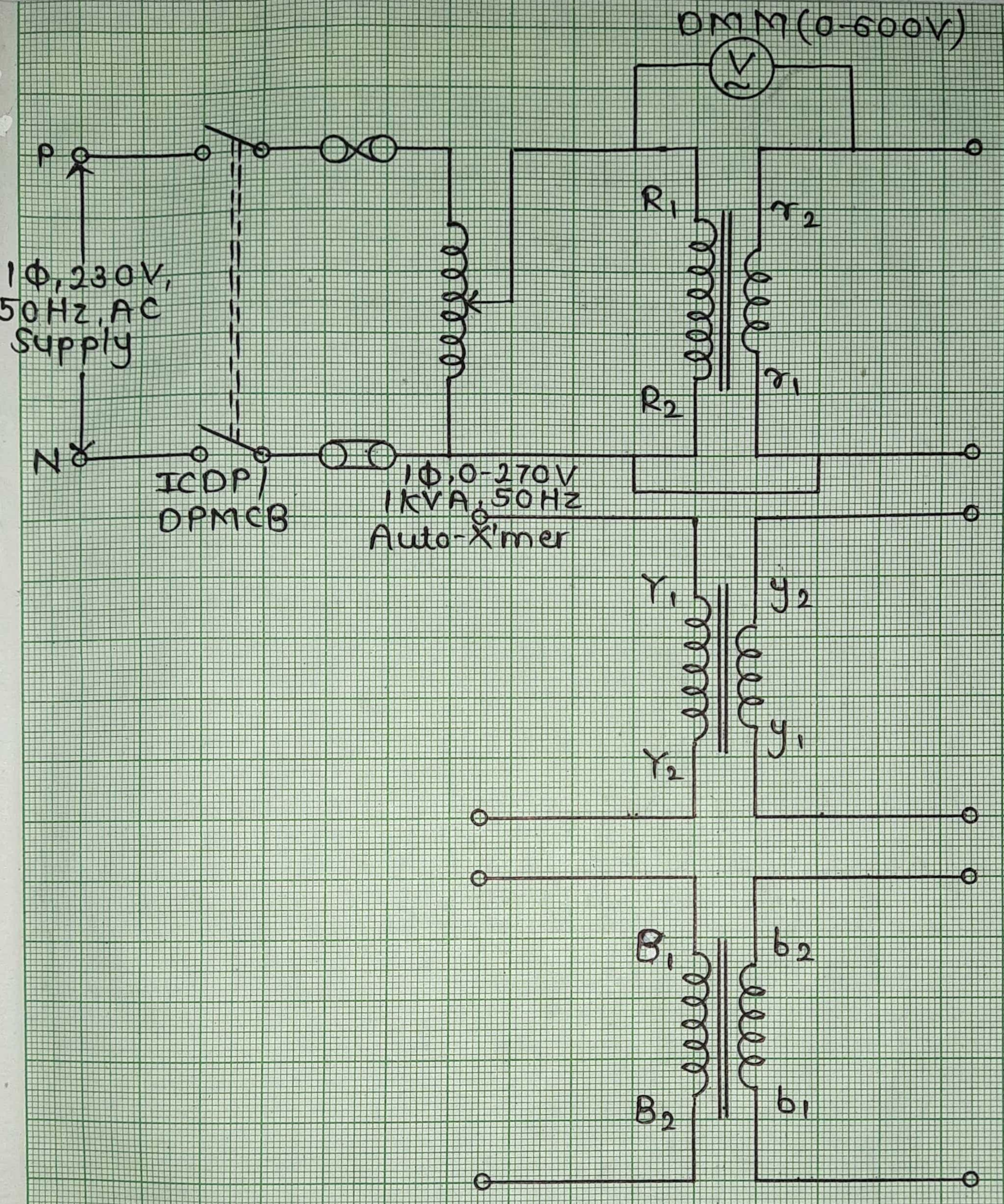
3. Connect Galvanometer across one of the secondary windings and short all the other windings.
4. Press the key "K" and observe Galvanometer deflection carefully.
5. Connect the Galvanometer to other secondary winding and repeat the procedure.
6. The secondary winding across which maximum deflection occurs, corresponds to primary winding to which D.C. supply is connected.
7. Repeat the same procedure steps 2-5 for other primary windings and identify their respective secondary windings.

B) Polarity Test

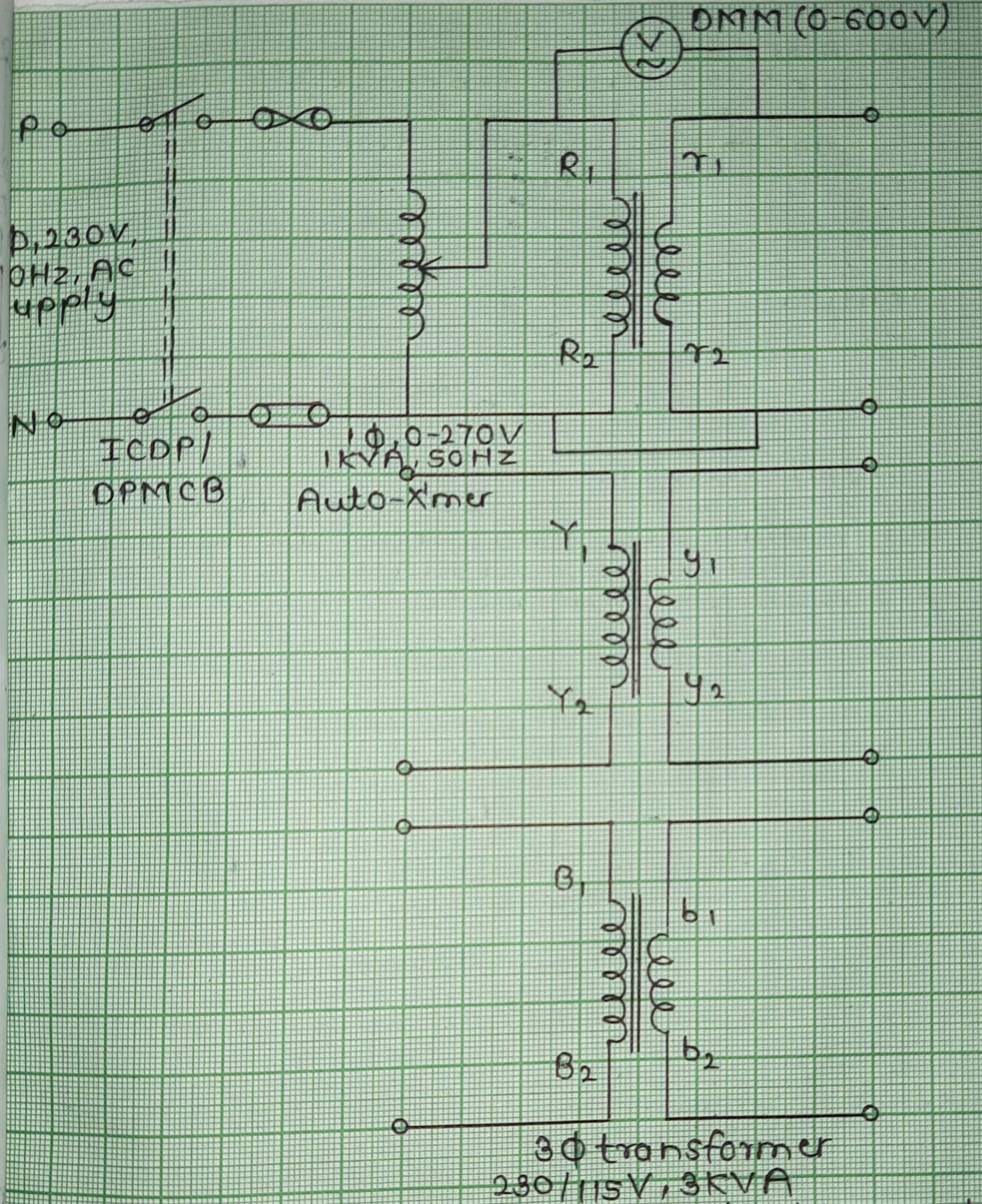
1. Make the connections as per circuit diagram.
2. Primary terminals are marked A_1 and A_2.
3. Short A_2 and a_2 by low resistance wire.
4. Keep terminals B_1, B_2, C_1, C_2 remains open.
5. Apply suitable voltage across primary.
6. Measure primary voltage E_1,secondary voltage E_2 and voltmeter reading
7. If voltmeter reading is equal to difference of primary voltageE_1 and secondary voltage E_2, then the connected (shorted) terminals are of same polarity.
8. If voltmeter reading is equal to sum of primary voltage E_1 and secondary voltage E_2 then the connected terminals are of opposite polarity.
9. Switch OFF the supply.
10. Repeat the same procedure for other phases of the transformer.

XI Resources used (with major specifications)

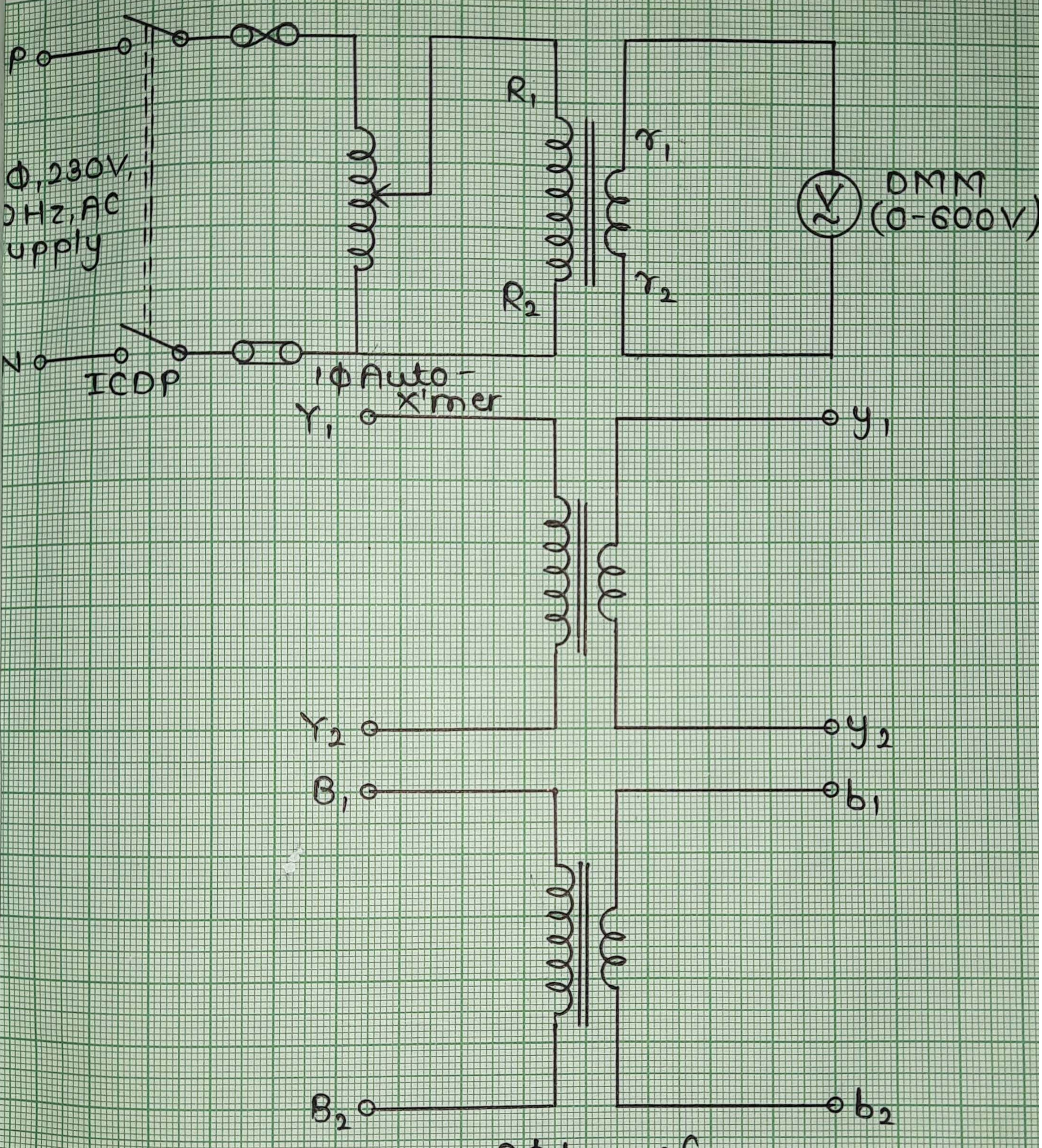
Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Power Supply	-	1ϕ, 230V, 50Hz AC Supply	01	
2.	Auto-X'mer	-	1ϕ, 0-270V, 1KVA	01	
3	DMM	-	As voltmeter (0-600V)	01	
4.	1ϕ transformer	1ϕ, 230/115V, 1KVA, λ/λ		01	
5.	Connecting cables	PVC(2.5mm²)		As per Req.	



Title → Circuit diagram for conducting polarity test of 3Φ transformer (Additive polarity)



Title → Circuit diagram for conducting polarity test of 3φ transformer. (Subtractive Polarity)



Title → Circuit diagram for conducting Phasing out test on 3Φ transformer.

(B) Reading of Polarity test →

Sr. No.	Name of Phase	E_1 (in V)	E_2 (in V)	Measured Voltage (in V)	Calculated Voltage $V=E_1-E_2$ or $V=E_1+E_2$	Type of Polarity
1.	R-Phase	120	63	56	57	Subtractive
2.	R-Phase	120	63	186	183	Additive
3.	Y-Phase	121	61	58	60	Subtractive
4.	Y-Phase	122	61	185	183	Additive
5.	B-Phase	122	61	59	61	Subtractive
6.	B-Phase	123	61	186	184	Additive

XII Actual procedure followed

→ (A) Phasing Out test - (i) Made connections as per circuit diagram (ii) Applied voltage to primary winding of one phase through Auto-X'mer keeping other open (iii) Measured reading across each secondary winding and noted the readings

(B) Polarity test - (i) Made connections as per circuit diagram (ii) Noted down the readings.

XIII Precautions followed

→ (1) made sure that main switch was in OFF position while making connections.

(2) All electrical connections were neat & tight.

(3) Followed all the safety practices.

(4) Used wires of proper size and insulation covering.

XIV Observations and Calculations:

a) Reading for Phasing Out Test

Sr. No.	D.C. supply given to primary winding	Reading of voltmeter ~~Deflection of Galvanometer~~ observed between secondary terminals.			Remarks (Corresponding Secondary)
		~~Deflection~~ Reading across first secondary (in V)	~~Deflection~~ Reading across second secondary (in V)	~~Deflection~~ Reading across third secondary (in V)	
1	P1	49	38	6	First
2	P2	22	47	24	Second
3	P3	6	41	52	Third

b) Reading for Polarity Test

Written on extra sheet →

Sr. No.	Name of phase	E_1 volt	E_2 volt	Measured Voltage (V)	Calculated Voltage V = (E1- E2) or ~~V = (E1 + E2)~~	Type of Polarity
1	R - Phase	103.3	53.3	47.4	50	Subtractive
2	Y- Phase	100.8	51.4	48.6	49.4	Subtractive
3	B - Phase	100.4	51	49.3	49.4	Subtractive

XV Results:

→ Voltmeter reading shows max value when it connected across the corresponding secondary for the polarity test the voltage difference betn primary and secondary is seen in the volltmeter reading.

XVI Interpretation of results

→ from result we can interpret that max value indicated in voltmeter in the corresponding winding is more due to more flux linking and induced emf for polarity test voltmeter shows subtractive polarity.

XVII Conclusion

→ By performing this test we can conclude that polarity test is carried out to check whether it is additive or subtractive Phasing out test is carried out to check/determine correspondi secondary of each phase.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw circuit diagram for phasing out test by considering Ac Supply voltage.
2. State the methods of terminal marking of transformer winding as per IS standards.
3. State which type of polarity is commonly used.

(Space for answers)

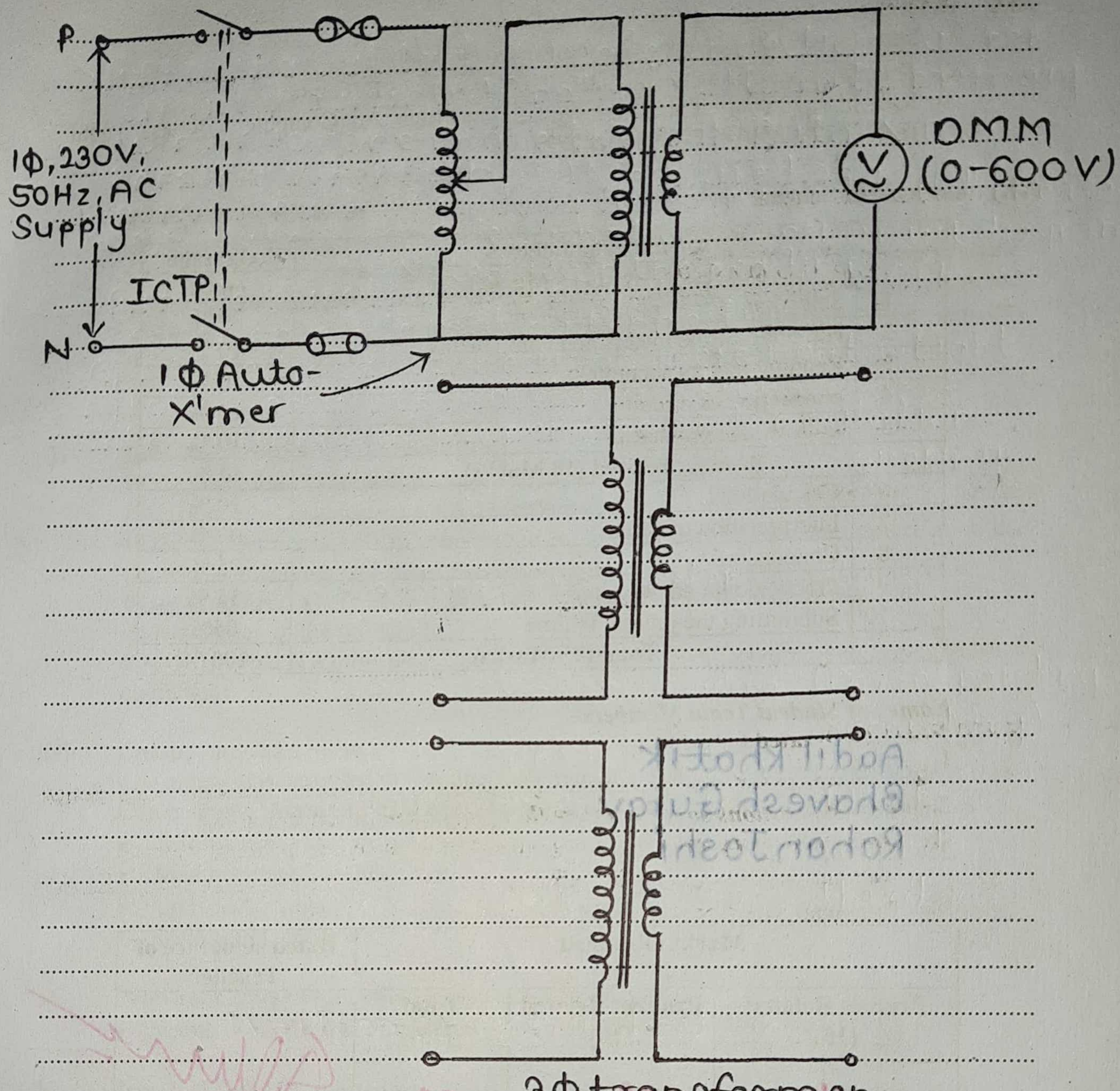
Que.No.(1) Draw circuit diagram for phasing out test by considering Ac Supply voltage

Ans →

→

Que.No.(3) State which type of polarity is commonly used

Ans → Subtractive type of polarity is commonly used.



3ϕ transformer

fig Circuit diagram of Phasing out test on 3ϕ X'mer

Que.No.(2) State the methods of terminal marking of transformer winding as per IS standards.

Ans→ According to IS standards polarity test is carried out for terminal marking of transformer winding. In this method Dot convention is used.

Experiment No. 7 : Perform the open circuit and short circuit tests on the single phase transformer and determine its performance (regulation and efficiency)

I Practical Significance

Pre-determining the regulation and efficiency of a transformer at any load condition (at any power factor) is of utmost importance in electrical power system or the relevant industry. Open circuit test and short circuit test are very economical and convenient methods to predetermine the regulation and efficiency of high capacity transformer as they are without actually loading of the transformer.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Electrical engineering problems.

PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

The practical is expected to help the student to attain the following industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters
- Measure electrical quantities.
- Connect Circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain single phase and three phase transformers

V Practical Learning Outcome

- Perform the open circuit and short circuit tests on the single phase transformer and determine its performance (regulation and efficiency).

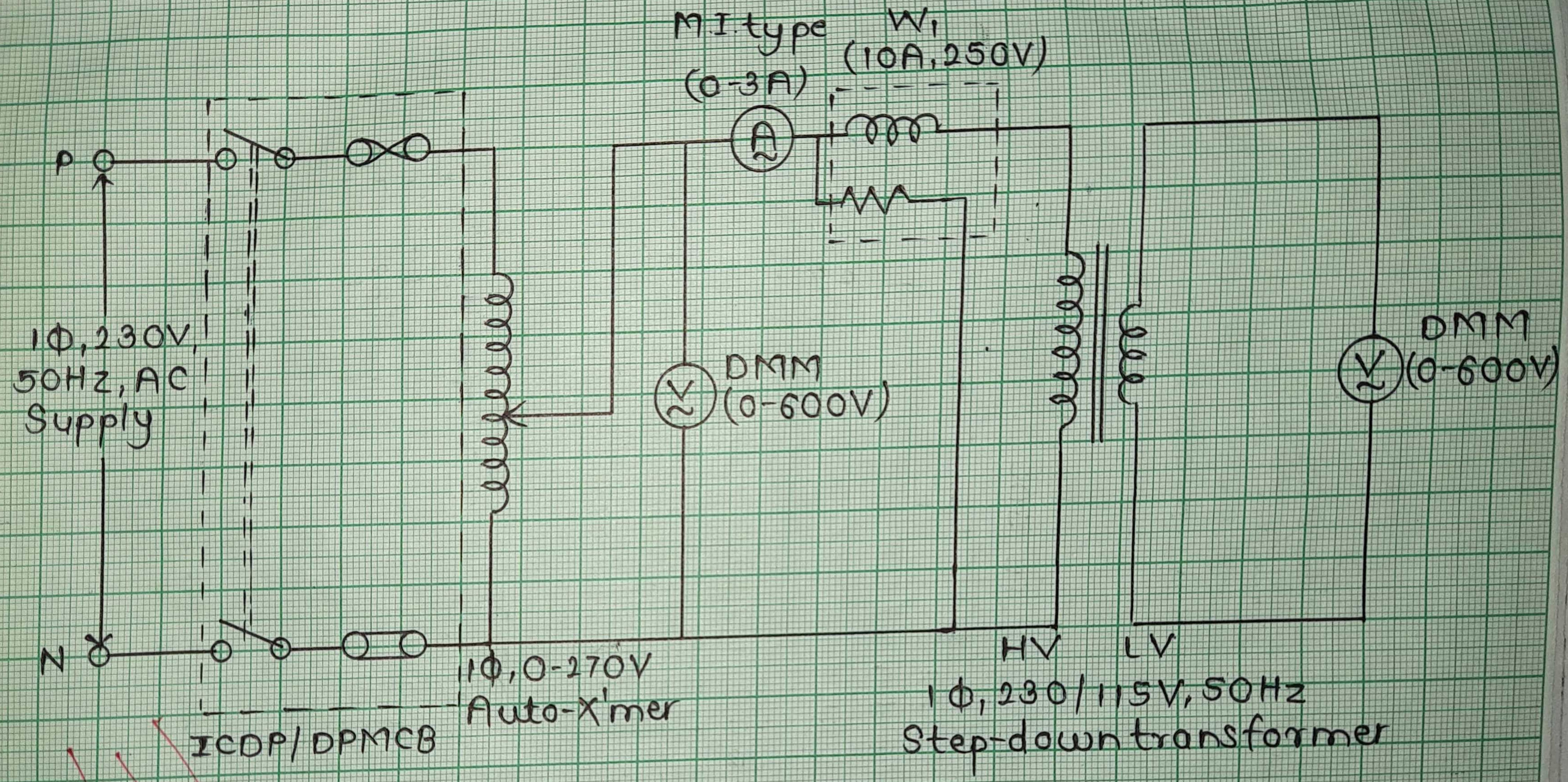
VI Minimum Theoretical Background

Open Circuit test (O.C. Test)

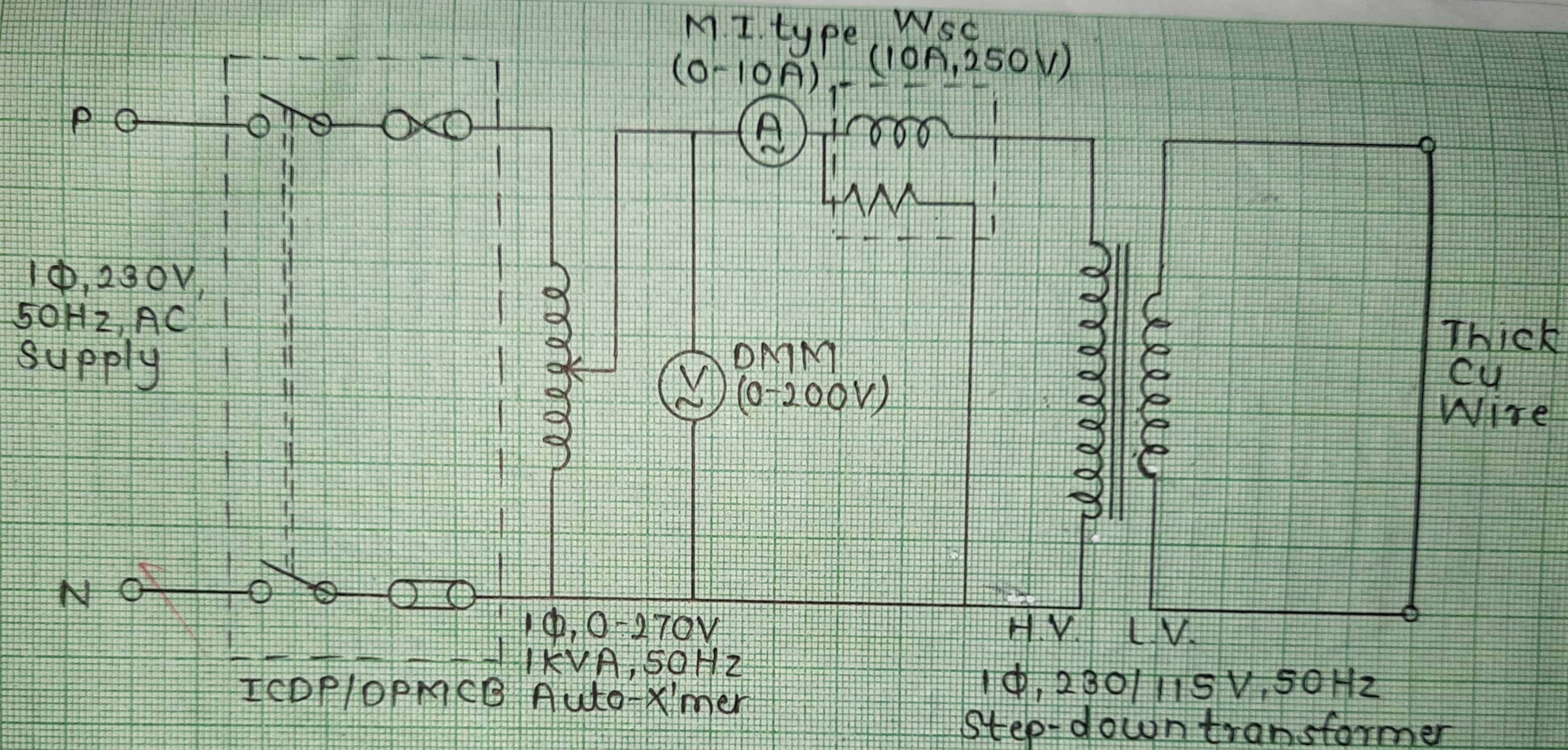
It is used to estimate iron losses, transformation ratio and parameters of magnetizing branch of equivalent circuit. It is determined by applying rated voltage to the low voltage winding and keeping the high voltage winding open.

Short Circuit test (S.C. Test)

It is to estimate copper losses and parameters of equivalent circuit of a transformer by applying low voltage to primary winding, just sufficient to circulate rated full load



<u>Title</u> → Circuit diagram to conduct open circuit test on 1Φ transformer.



Title → Circuit diagram to conduct short-circuit test on 1Φ transformer.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Power supply	-	1ϕ, 230V, 50Hz AC supply	01	
2.	Auto-X'mer	ME	1ϕ, 0-270V, 1KVA, 50Hz	01	
3.	Transfor-mer		1ϕ, 230/115V, 50Hz	01	
4.	DMM (mastech)		As voltmeter (0-600V)	01	
5.	Ammeter M.I. type	Supreme	(0-3A) (0-10A)	each 01	
6.	Wattmeter		(10A, 250V)	01	
7.	Connecting cables		PVC (2.5 mm^2)	As per Req.	

XII Actual procedure followed

A) O.C Test

① Made connections as per circuit diagram ② Set auto-X'mer on zero position & switched ON supply ③ Increased auto-X'mer voltage gradually till the rated voltage. ④ Noted down the readings in observation table ⑤ Brough auto-x'mer knob to min. and switched OFF the supply.

B) S.C Test

① Made connections as per circuit diagram ② Determined rated current from name plate data. ③ Switched on the supply and gradually increased the voltage through auto-X'mer till the rated current flows. ④ Noted down the readings in observation table ⑤ Brought auto-X'mer knob to min. and switched OFF the supply.

XIII Precautions followed

① Applied low voltage through auto-X'mer on the H.V. winding during S.C test ② Ensured that main switch was in OFF position while making connections. ③ Selected proper range measuring instruments.

* Calculations →

• For O.C. test –

$$W_0 = V_0 I_0 \cos\phi_0$$

$$\cos\phi_0 = \frac{W_0}{V_0 I_0}$$

$$= \frac{22}{230 \times 0.87}$$

$$\cos\phi_0 = 0.1099$$

$$\phi_0 = \cos^{-1}(0.1099)$$

$$\phi_0 = 83.68^\circ$$

$$\sin\phi_0 = \sin(83.68)$$

$$= 0.9939$$

$$I_w = I_0 \cos\phi_0$$

$$= 0.87 \times 0.1099$$

$$= 0.0956\ A$$

$$I_\mu = I_0 \sin\phi_0$$

$$= 0.87 \times 0.9939$$

$$= 0.8646\ A$$

$$R_0 = \frac{V_0}{I_w} = \frac{230}{0.0956} = 2405.8577\ \Omega$$

$$X_0 = \frac{V_0}{I_\mu} = \frac{230}{0.8646} = 266.0189\ \Omega$$

• For short circuit test -

$W_{sc} = I_{sc}^2 R_{01}$

$R_{01} = \dfrac{W_{sc}}{I_{sc}^2}$

$= \dfrac{94}{(4.34)^2}$

$= 4.9905 \Omega$

$Z_{01} = \dfrac{V_{sc}}{I_{sc}}$

$= \dfrac{24}{4.34}$

$= 5.5299 \Omega$

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

$= \sqrt{(5.5299)^2 - (4.9905)^2}$

$X_{01} = 2.3821 \Omega$

• Efficiency at full load

KVA rating : 1KVA

Power factor ($\cos\phi$) : 0.8 (lag)

Iron loss = 22W

Copper loss = 94W

• Efficiency at full load

$\% \eta = \dfrac{x \, kVA \times 10^3 \times \cos\phi}{x(kVA \times 10^3 \times \cos\phi) + W_i + W_{cu} x^2}$

$= \dfrac{1 \times 10^3 \times 0.8}{(1 \times 10^3 \times 0.8) + 22 + 94}$

$= 87.33\%$

Date: /

• Efficiency at 20% load

$$\eta = \frac{x \times KVA \times 10^3 \times \cos\phi}{x \times KVA \times 10^3 \times \cos\phi + W_i + x^2 W_{cu}}$$

$$= \frac{0.2 \times 1 \times 10^3 \times 0.8}{(0.2 \times 1 \times 10^3 \times 0.8) + 22 + (0.2^2 \times 94)}$$

$\eta = 86.13\%$

• Efficiency at 40% load

$$\eta = \frac{x \times KVA \times 10^3 \times \cos\phi}{(x \cdot KVA \times 10^3 \times \cos\phi) + W_i + x^2 W_{cu}}$$

$$= \frac{0.4 \times 1 \times 10^3 \times 0.8}{(0.4 \times 1 \times 10^3 \times 0.8) + 22 + (0.4^2 \times 94)}$$

$\eta = 89.52\%$

• Efficiency at 60% load

$$\eta = \frac{x \times KVA \times 10^3 \times \cos\phi}{(x \times KVA \times 10^3 \times \cos\phi) + W_i + x^2 W_{cu}}$$

$$= \frac{0.6 \times 1 \times 10^3 \times 0.8}{(0.6 \times 1 \times 10^3 \times 0.8) + 22 + (0.6^2 \times 94)}$$

$\eta = 89.57\%$

• Efficiency at 80% load

$$\eta = \frac{x \times KVA \times 10^3 \times \cos\phi}{(x \times KVA \times 10^3 \times \cos\phi) + W_i + x^2 W_{cu}}$$

$$= \frac{0.8 \times 1 \times 10^3 \times 0.8}{(0.8 \times 1 \times 10^3 \times 0.8) + 22 + (0.8^2 \times 94)}$$

$\eta = 88.62\%$

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• Voltage Regulation Calculations →

• Voltage Regulation at full load

$$\text{Voltage Regulation} = \left[\frac{x \times I_{sc}(R_{01}\cos\phi + X_{01}\sin\phi)}{V_L}\right]$$

$$= \left[\frac{1\times 4.34(4.99\times 0.8 + 2.35\times 0.6)}{118}\right]\times 100$$

$$= 19.86\%$$

• Voltage Regulation at 80% load

$$\text{Voltage Regulation} = \left[\frac{0.8\times 4.34(4.99\times 0.8 + 2.35\times 0.6)}{118}\right]\times 100$$

$$= 15.89\%$$

• Voltage Regulation at 60% load

$$\text{Voltage Regulation} = \left[\frac{0.6\times 4.34(4.99\times 0.8 + 2.35\times 0.6)}{118}\right]\times 100$$

$$= 11.92\%$$

• Voltage Regulation at 40% load

$$\text{Voltage Regulation} = \left[\frac{0.4\times 4.34(4.99\times 0.8 + 2.35\times 0.6)}{118}\right]\times 100$$

$$= 7.94\%$$

Voltage Regulation at 20% load

$$\text{Voltage Regulation} = \left[\frac{0.2\times 4.34(4.99\times 0.8 + 2.35\times 0.6)}{118}\right]\times 100$$

$$= 3.97\%$$

XIV Observations and Calculations:

Open Circuit Test:

Sr. No.	Applied Voltage (V_1) or (V_0)Volts	No load current (I_0) Amp	No load Power (W_0) Watt	Secondary Voltage (V_2) Volts	Transformation Ratio K= $\frac{V_2}{V_1}$
1	230	0.87	22	118	0.5

Short Circuit Test:

Sr. No.	Voltage applied (V_{SC}) Volt	Current Circulated (I_{SC}) Amp	Short circuit power (W_{SC})
1	24	4.34	94

Calculations:

Total resistance referred to H.V side

$R_{02} = \frac{W_{SC}}{I_{SC}^2} =$ 4.9905 Ω

$X_{02} = \sqrt{(Z_{02}^2 - R_{02}^2)} =$ 2.3821 Ω

% Efficiency at full load

Full load at rated output of transformer in watts = kVA * 1000 * Power factor

$$\% \text{ Efficiency at full load} = \frac{x\,(\text{VA rating}) \times \cos\phi}{x\,(\text{VA rating}) \times \cos\phi + W_0 + x^2 W_{SC}} \times 100$$

= 87.33 %

% Efficiency at any load and given p. f $\cos\phi = 0.8$

$X = \frac{\text{actual load}}{\text{full load}} =$ 0.8

Then output power at actual load = x * (kVA)*1000* p. f = 640000 watts

Iron losses = $W_i = W_0 =$ 22

Copper losses = $W_{cu} = (x^2)\, W_{SC} =$ 60.16

Total losses = $W_i + W_{cu} =$ 82.16

% Efficiency = (output)/(Output + losses) *100

= 87.33 %

% Voltage regulation at full load of given p. f $\cos\phi = 0.8$

% Regulation at full load = $(I_2 R_{02} \cos\phi_0 \pm I_2 X_{02} \sin\phi_0)/V_2$

= 19.86 %

% Regulation at any(x) load = $(x\, I_2\, R_{02} \cos \phi_0 \;\pm x\, I_2\, X_{02} \sin \phi_0)/V_2$

'+' for lagging power factor $\left[\frac{0.8 \times 4.34\,(4.99 \times 0.8 + 2.35 \times 0.6)}{118}\right] \times 100$

'-' for leading power factor $= 15.89\%$

XV Results:

- At full load, unity power factor, the efficiency of the transformer is 89.6 %
- Voltage regulation of transformer is 19.86 %

XVI Interpretation of results

→ From result we can interpret that efficiency of transformer increases with increase in load, at a certain point it becomes max and after that it starts to decrease.

XVII Conclusion

→ By performing this practical we can conclude that open circuit and short circuit test data can be used to determine voltage regulation and efficiency at any load condition (at any p.f.).

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Compare direct and indirect testing method on the basis of time taken, power consumed, cost and accuracy of result.
2) State the need for low power factor wattmeter in O.C Test.
3) For which type of load, voltage regulation will be negative. Why?
4) The transformer efficiency is always higher than the efficiency of rotating machine-Justify.
5) Identify the winding kept open during the OC test. Justify your answer.

(Space for answers)

Que. No. (1) Compare direct and indirect testing method on the basis of time taken, power consumed, cost and accuracy of result.

and windage loss takes place. So, the transformer efficiency is always higher than the rotating machine.

Que.No.(5) Identify the winding kept open during O.C test. Justify your answer.

Ans → The O.C test is conducted on H.V. ~~test~~ side. Because, if we keep LV winding open then we need to supply very high voltage, it will be dangerous for the test. The H.V. side will have already less current in compare to L.V. side. The instruments will be unable to measure this low current. So, H.V. is kept open during O.C. test.

Ans –

Parameter	Direct Test	Indirect test
(i) Time taken	More	less
(ii) Power consumed	More	less
(iii) Cost	Expensive	Cheap
(iv) Accuracy of result	More Accurate	Less Accurate

Que. No. (2) State the need for low power factor wattmeter in O.C. test.

Ans – In open circuit test the secondary winding of transformer is kept open. As the secondary side is open the entire coil which is purely inductive in nature will draw lagging current to the applied voltage. So, to measure this power, low power factor wattmeter is required during O.C. test.

Que. No. (3) For which type of load, voltage regulation will be negative why?

Ans → For leading power factor load voltage regulation is negative. Capacitive load draws leading current which increases the leading angle. Increases which decreases cosine angle and increases sin angle so that the value of voltage regulation is –ve.

Que.No.(4) The transformer efficiency is always higher than efficiency of rotating machine Justify

Ans → Transformer has no air gap but in rotating machine it is available and generates more flux losses. Also armature generates back emf that does not happen in a transformer secondary. Also there is no rotating part in transformer so, no frictional

XIX References / Suggestions for Further Reading

1) http://www.electrical4u.com
2) http://www.electricaleasy.com/2014

XX Assessment Scheme

	Performance indicators	Weightage
	Process related (15 Marks)	**60 %**
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
	Product related (10 Marks)	**40 %**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. Bhavesh Gurav
2. Aadil Khatik

Experiment No. 08 : To perform open circuits and short circuit test on three phase transformer and determine its performance (efficiency and regulation).

I Practical Significance

Open circuit and short circuit test are conducted on three phase transformer as a routine test as per IS 2026 to assess the performance characteristics of three phase transformer without actually loading it.

Open circuits test is no load test performed to find R_0, X_0 of equivalent circuit of a transformer. Core loss of a transformer can be found with this test.

Short circuit test also called as load loss test is carried out to find impedance voltage; load losses of transformer with rated current on secondary side the input power represents total load loss. This is measured and adjusted to reference temp.

From results of both these tests we can find efficiency and regulation of transformer.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters.
- Measure electrical quantities.
- Connect circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain single phase and three phase transformers.

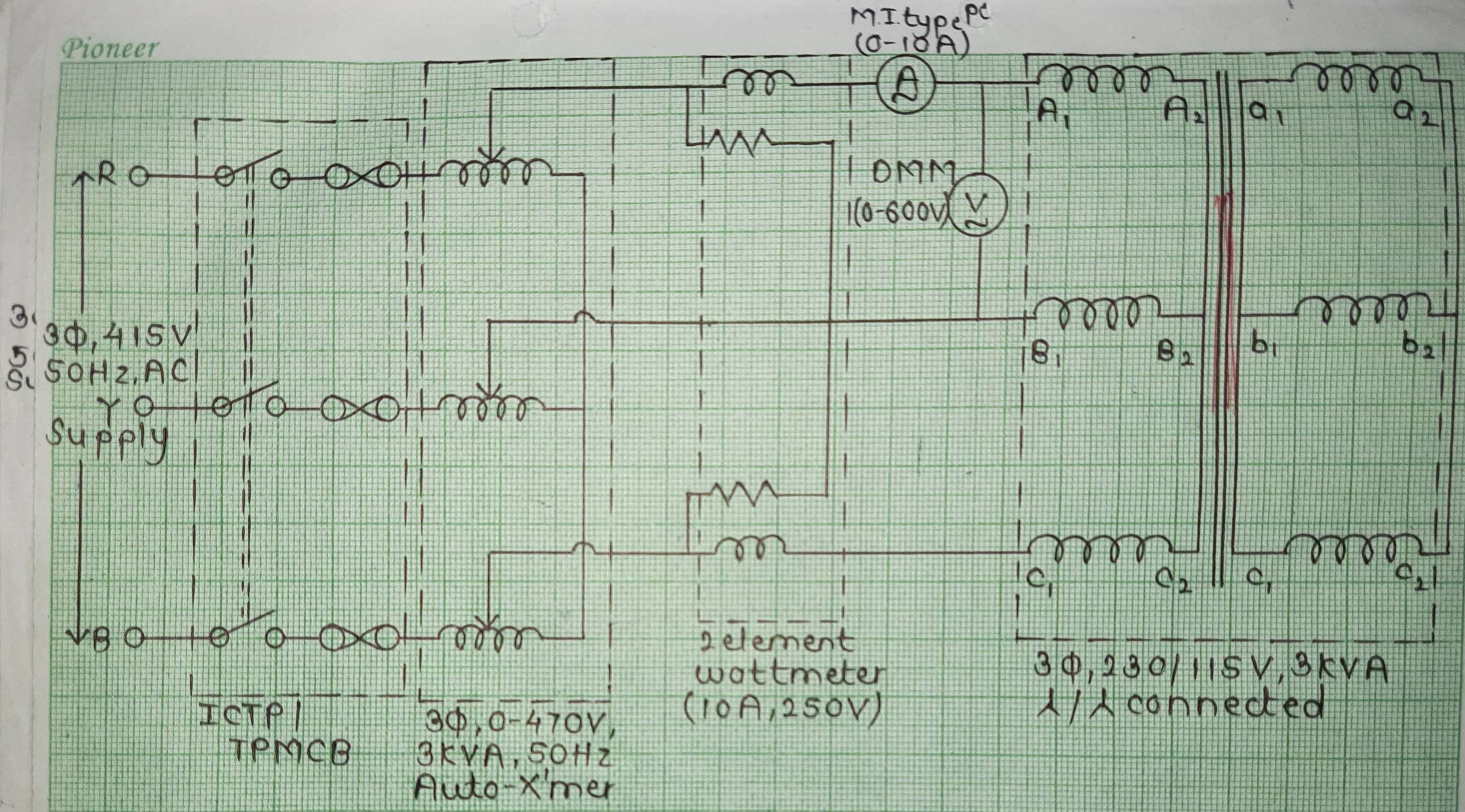
V Practical Learning Outcome

- Perform the open circuit and short circuit tests on the three phase transformer and determine its performance (regulation and efficiency).

VI Minimum Theoretical Background

In open circuit test carried out on a three phase transformer, generally L.V. winding is connected to supply and H.V.is left open because sometimes it may be difficult to manage H.V. voltage in laboratories. In industry for obtaining more accurate reading of core losses under such condition, a rectifier type voltmeter measuring average value of voltage but dial recording root-mean-square value and in addition voltmeter measuring root-mean-square voltage are used.

NAME : ______________________ STD. : __________ DIV.: __________ DATE : / /



Title → Circuit diagram to conduct short circuit test on 3Φ transformer.

IX Precautions to be followed

1. All electrical connections should be neat and tight.
2. Wires used for circuit connections have proper size and insulation cover.
3. Make sure that main switch is off position while making connections.
4. The transformer input current should not exceed its rated current.

X Procedure

Open Circuit Test

1. Make the connections as per circuit diagram.
2. Apply rated voltage to LV winding by increasing voltage of autotransformer.
3. Note down readings of instrument.

Short Circuit Test

1) Connect the circuit as per circuit diagram.
2) Short circuit LV side of three phase transformer by thick copper wire.
3) Apply voltage gradually till rated current flows.
4) Measure the readings of ammeter, voltmeter and wattmeter.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Power supply	3ϕ, 415V, 50Hz AC supply		01	
2.	3ϕ Auto-X'mer	3ϕ, 15A, 0-470V, 50/60Hz		01	
3.	Wattmeter	Two element (10A, 250V)		01	
4.	Ammeter	Supreme	M.I type (0-1A) (0-10A)	each 01	
5.	DMM	Mastech	As voltmeter (0-600V)	01	
6.	3ϕ transformer	3ϕ, 230/115V, 3kVA Δ/Δ connected		01	
7.	Connecting cables	PVC (2.5mm²)		As per Req.	

XII Actual procedure followed

(A) Open Circuit test – (i) Made connection as per circuit diagram (ii) Applied rated voltage to LV winding by increasing voltage of auto-X'mer (iii) Noted down readings.

(B) Short Circuit test – (i) Connected circuit as per circuit diagram (ii) Short circuited LV side of 3ϕ X'mer by thick copper wire (iii) Noted down readings.

XIII Precautions followed

1. All connections were ~~neat~~ neat and tight.
2. Made sure that main s/w was in OFF position while making connection.
3. Gradually increased voltage during short circuit till the rated current flows, the voltage should not be increased above it.
4. Followed all the safety practices.

XIV Observations and Calculations:

A) Open Circuit Test:

Sr. No.	No load current I_o AMP	V_0	W_1	W2	$W_O = W_{1+} W2$ (in W)
1.	0.4 A	230V	–	–	20W

Measured values of voltage and current are per phase values.

B) Short Circuit Test:

Sr. No.	Voltage applied (V_{SC})	Current circulated (I_{SC})	W_1	W_2	Short Circuit Power $W_{SC}=W_1+W_2$
1	124V	7.8A	–	–	350W

For calculation purpose convert the measured values of voltage and current in phase values if necessary.

Calculations: (all Voltage and Current values are phase values in formulas used in following calculations)

From Open Circuit Test

$cos\varphi_O = \frac{W_O}{3V_O I_O}$ = 0.1255

From Short Circuit Test

$Z_{01} = \frac{V\ sc}{Isc}$ = 9.1783Ω

$R_{01} = \frac{W_{SC}}{3I_{SC}^2}$ = 1.9175Ω

$X_{01} = \sqrt{(Z_{01})^2 - (R_{01})^2}$ = 8.9757Ω

P_{out} = 3 V_{ph} I_{ph} cosΦ = ...

P_{INPUT} = W_O+W_{SC}=......................

Written on extra sheet attached

% = $\frac{P_{OUT}}{P_{INPUT}}$ x 100=......................

$\%R = \frac{I_1 R_{O1} cos\varphi + I_1 X_{O1} sin\varphi}{V_1}$ x 100=......................

• Calculations →

• From open circuit test

$W_0 = \sqrt{3} V_0 I_0 \cos\phi_0$

$20 = \sqrt{3} \times 230 \times 0.4 \times \cos\phi_0$

$\therefore \cos\phi_0 = \dfrac{20}{\sqrt{3} \times 230 \times 0.4}$

$\therefore \cos\phi_0 = 0.1255$

$\phi_0 = 82.79°$

• From short circuit test

$Z_{01} = \dfrac{V_{sc}}{I_{sc}} = \dfrac{124/\sqrt{3}}{7.8}$

$= 9.1783\,\Omega$

$R_{01} = \dfrac{W_{sc}}{3 I^2_{sc}}$

$= \dfrac{350}{3 \times 7.8^2}$

$= 1.9175\,\Omega$

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

$= \sqrt{(9.1783)^2 - (1.9175)^2}$

$X_{01} = 8.9757\,\Omega$

• At full load →

Consider, power factor $(\cos\phi) = 0.8$ (lag)

$$\%\,\text{Efficiency} = \frac{x \times kVA \times 10^3 \times \cos\phi}{(x \times kVA \times 10^3 \times \cos\phi) + W_0 + x^2 W_{sc}}$$

$$= \frac{1 \times 3 \times 10^3 \times 0.8}{(1 \times 3 \times 10^3 \times 0.8) + 20 + (1^2 \times 350)}$$

$$\therefore \eta = 86.64\%$$

$$\%\,\text{Voltage Regulation} = \frac{(I_1 R_{01} \cos\phi) + (I_1 X_{01} \sin\phi)}{(V_1)} \times 100$$

$$= \frac{(7.8 \times 1.9175 \times 0.8) + (7.8 \times 8.9757 \times}{230}$$

$$= 23.46\%$$

XV Results:

→ From calculation of open circuit test, determined the Ro and X. equivalent circuit parameter of transformer Also from short circuit test calculated the impedance voltage value.

XVI. Interpretation of results

→ From result we can interpret that efficiency of transformer is high near its full load but voltage regulation increases with increase in load This happens because increase in load causes more voltage drop due to losses.

XVII. Conclusion

→ By performing this practical we acquire necessary skills to conduct O.C and S.C test on 3ϕ transformer to find out its efficiency and voltage regulation.

XVIII. Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State precaution to be taken while applying voltage to transformer winding.
2) State the reason why LV winding is short circuited in this test.
3) Define impedance voltage.
4) Copper loss is neglected in open circuit. Justify.
5) Draw no load phasor diagram of transformer.
6) State the reason for low value of input current during open circuit test.
7) State IS code for testing of transformers.

(Space for answers)

Que.No.(1) State precaution to be taken while applying voltage to transformer winding.

Ans → While applying voltage to transformer winding during the short circuit test voltage should be gradually increased till the rated current flows. If it is not done transformer winding may burn due to high current

Que.No.(2) State the reason why LV winding is short circuited in this test

Ans → LV winding is short circuited in this test because low range ~~meter~~ measuring instruments can be used if it is conducted on H.V. by short circuiting LV winding.

Que.No.(3) Define impedance voltage

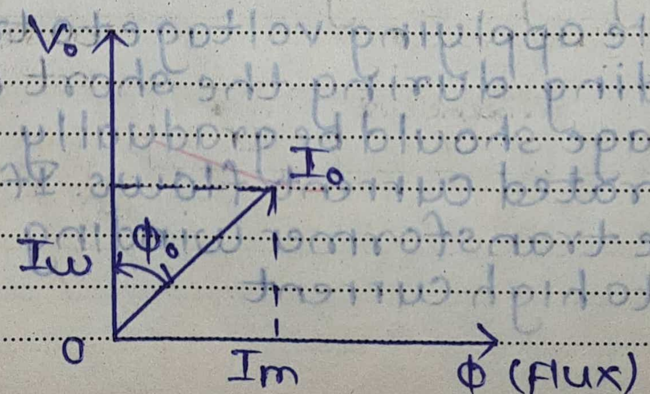
Ans → When transformer secondary is shorted and we starts applying voltage on primary side, the value of voltage applied to primary which is enough to flow the rated current in the secondary winding is called impedance voltage.

Que.No.(4) Copper loss is neglected in open circuit Justify

Ans → During open circuit test, the no load current which is only a fraction of full load current flows and as secondary is open circuited variable copper loss which depends on rated current are less so, they are neglected.

Que.No.(5) Draw no load phasor diagram of transformer

Ans →



Date: / /20

Que.No.(7) State the reason for low value of input current during open circuit test.

Ans → During open circuit test, secondary is kept open and hence there is no flow of load current in secondary. Here load component of current is zero hence it only makes magnetizing current which is of order 5 to 6% rated current. Therefor, value of input current during open circuit test is low.

		10 %
6	Calculation	05 %
7	Interpretation of result	05 %
8	Conclusions	15 %
9	Practical related questions	05%
10	Submitting the journal in time	100 %
	Total (25 Marks)	

Que.No.(6) State IS code for testing of transformer.

Ans→ IS 2026 is used for testing of transformer.

XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. https://www.youtube.com/watch?v=WOrZe2XtMgY
4. IS 2026 (Part II)-2010: Power transformers: Part 2 Temperature rise

XX Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		60 %
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
Product related (10 Marks)		40 %
6	Calculation	10 %

Experiment No. 9 : Back to Back test on two identical single phase Transformers

I Practical Significance

Sumpner's test or back to back test on transformers is another method for determining transformer efficiency, voltage regulation and heating under loaded conditions. Short circuit and open circuit tests on transformer can give us parameters of equivalent circuit of transformer, but they cannot help us in finding the heating information. Unlike O.C. and S.C. tests, actual loading is simulated in Sumpner's test. Thus the Sumpner's test gives more accurate results of regulation and efficiency than O.C. and S.C. tests.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Electrical engineering problems.

PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

The practical is expected to help the student to attain the following industry identified Competency: '**Maintain different electrical equipment following safe practices'.**

- Select various meters
- Measure electrical quantities.
- Connect Circuits.
- Follow safe practices.

IV Relevant Course Outcomes

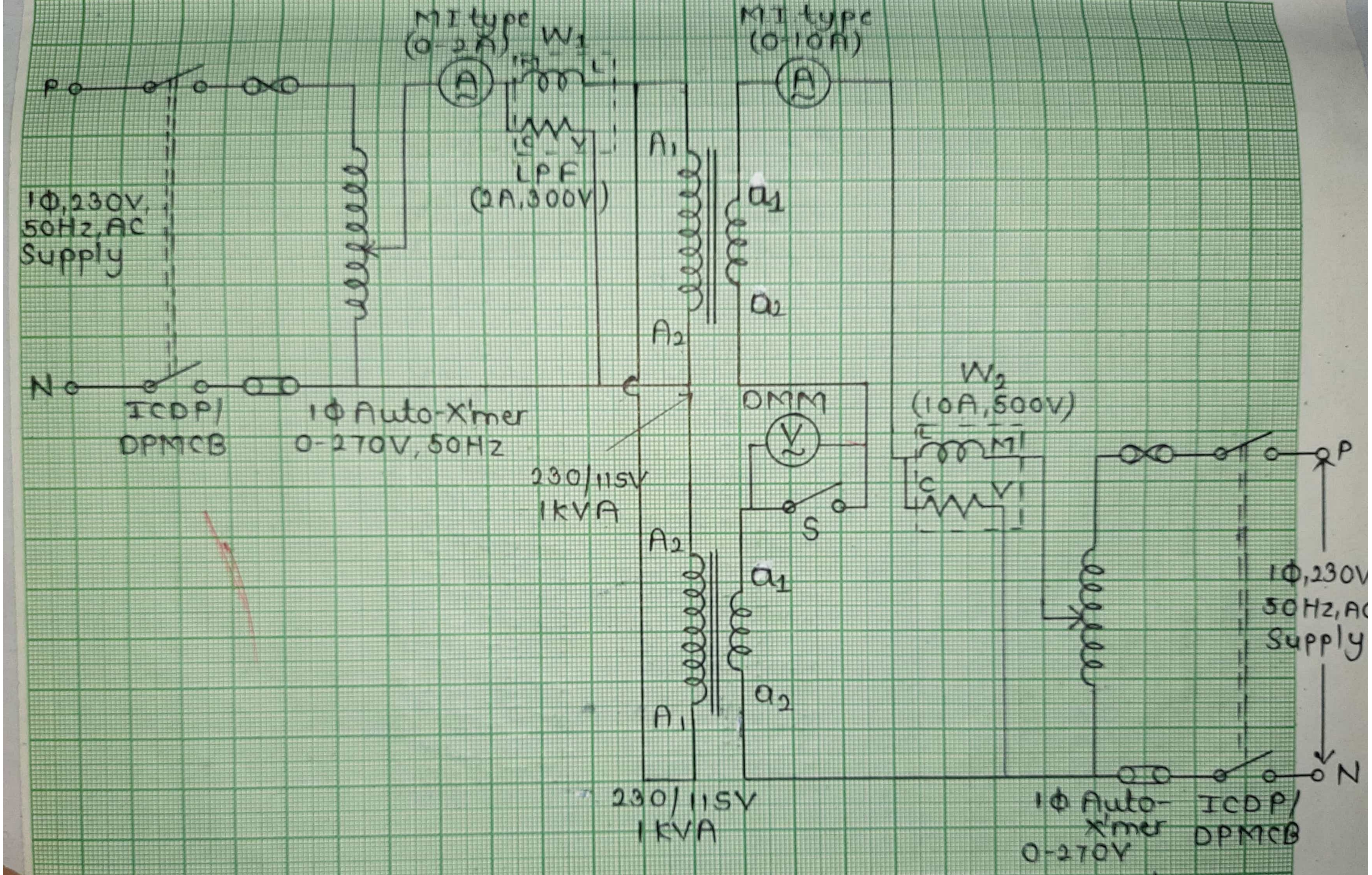
- Maintain single phase and three phase transformers.

V Practical Learning Outcome

- Perform back to back test on two identical single phase transformers and determine their efficiencies and regulations.

VI Minimum Theoretical Background

Back to back test is a method to find out transformer efficiency, voltage regulation and temperature rise under loaded conditions. This test is also called as Sumpner's test. It is regenerative test and hence economical and very useful. This test can be employed only when two identical transformers are available. Back to back test, the two primary windings of the identical transformers are connected in parallel across the supply and the two secondaries are connected in series with their polarities in opposition. Wattmeter, voltmeter and ammeter are connected at primary side and at secondary side. If primaries are energized then the voltage across the two secondaries will be zero since the emfs in them will cancel each other due to being in phase opposition. The power input to the two transformers at no-load is indicated by the wattmeter on the primary side. This power is, equal-to the iron losses of the two transformers as



Title → Circuit diagram for back to back test on two identical single phase transformer.

XII Actual procedure followed

① Made connections as per circuit diagram
② Initially kept s/w open ③ Switched on supply and checked polarity of two x'mer by measuring voltage across switch, got zero reading and closed the s/w. ④ Noted down reading of V_1, I_1, W_1 ⑤ Now increased voltage of auxiliary x'mer gradually so that full load current flows through secondary winding.

XIII Precautions followed

① All electrical connections were neat and tight

② Made sure that main switch in off position while making connections.

③ Checked the correctness of polarities of the two transformers by measuring voltage across switch.

XIV Observations and Calculations:

Sr. No.	Primary Side			Secondary Side		
	Primary Voltage (V_1)	Primary Current (I_1)	Primary Power (W_1)	Secondary Voltage (V_2)	Secondary Current (I_2)	Secondary Power (W_2)
1	230	0.6	25	26	8.6	220

Calculation

Secondary no load voltage ...115............ Volt

Iron loss per transformer $W_i = W_1/2 =$ ..12.5... Watts

Copper loss per transformer $W_{cu} = W_2/2 =$ ..110.... Watts

$$\% \text{ Efficiency} = \frac{\text{Output Power}}{\text{Output Power + Losses}} * 100$$

$$\% \text{ Efficiency} = \frac{\text{kVA} * \text{COS } \emptyset * 10^3}{\text{KVA} * \text{COS } \emptyset * 10^3 + \text{Iron loss} + \text{Copper Loss}} * 100$$

$\eta = 86.72\%$

$$\text{Regulation of each transformer} = \frac{\text{Voltage drop}}{\text{Secondary No load Voltage}} * 100$$

Regulation of each transformer = $\dfrac{\frac{V_2}{2}}{\text{Secondary No load Voltage}} * 100$

$= \dfrac{26/2}{115} * 100$

$= 11.3\ \%$

XV Results:

- Total iron loss of the transformer is = 12.5 watts
- Total Full load Copper loss of the transformer is = 115 Watts
- The efficiency of each transformer is = 86.72 %
- Full load voltage regulation of each transformer is = 11.3 %

XVI Interpretation of results

→ From result we can interpret that in back to back test we can calculate total iron loss and total copper loss at the same time which is not possible in ~~No load test (blocked~~ O.C and S.C test as each one measure ~~either~~ iron loss and copper loss separately

XVII Conclusion

→ By performing this practical we can conclude that back to back test can be used to determine iron loss, copper loss, efficiency and voltage regulation of 1ϕ transformer at the same time. It is more efficient than O.C and S.C test to measure iron loss and copper loss in X'mer.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) The magnitude of the regulation of transformer should be high or low. Ju
2) List out various tests to be conducted on transformer for finding out effic and regulation.
3) State condition to be satisfied for back to back connection?
4) State advantages and limitations of Back to Back test.
5) State the steps to temperature rise is measured by back to back test.

* Calculations →

KVA rating = 1 KVA
Power factor ($\cos\phi$) = 0.8
Secondary no load voltage = 115V

Iron loss per transformer (W_i) $= \frac{W_1}{2}$

$= \frac{25}{2}$

$= 12.5W$

Copper loss per transformer (W_{cu}) $= \frac{W_2}{2}$

$= \frac{220}{2}$

$= 110W$

% Efficiency $= \left[\frac{KVA \times \cos\phi \times 10^3}{(KVA \times \cos\phi \times 10^3) + W_i + W}\right] \times 100$

$= \frac{1 \times 10^3 \times 0.8}{(1 \times 10^3 \times 0.8) + 12.5 + 110}$

$= 86.72\%$

% Voltage Regulation $= \left[\frac{V_2/2}{\text{Secondary no load voltage}}\right] \times 100$

$= \left[\frac{26/2}{115}\right] \times 100$

$= 30$%

(Space for answers)

Que.No.(1) The magnitude of the regulation of transformer should be high or low Justify.

Ans- The magnitude of the regulation of transformer should be low Because if the transformer is fully loaded i.e load is connected to the secondary terminals, voltage drop takes place across it which is not desirable as power loss takes place. In order to obtain better performance of transformer, regulation should be low (i.e. voltage drop should also be low).

Que.No.(2) List out various tests to be conducted on transformer for finding out efficiency and regulation.

Ans- Test to be conducted on transformer for finding out efficiency and regulation →

(i) Direct loading test
(ii) Open circuit test and short circuit test
(iii) Back to back test.

Que.No.(3) State condition to be satisfied for back to back connection.

Ans → For back to back connections the two primary windings of the identical transformers are connected in parallel across the supply and the two secondaries are connected in series with their polarities in opposition.

Que.No.(4) State advantages ~~and~~ limitations of back to back test.

Ans → Advantages of back to back test →

1. The power regulated to carry out test is small
2. The voltage regulation and efficiency of both transformers can be calculated.
3. Temperature rise test can be calculated simultaneou

• Limitations →

1. Only limitation is that two identical transformers are required and In practical it is difficult to find two identical X'mer
2. Not economical due to two X'mer required

XIX References / Suggestions for Further Reading

1. https://www.electricaleasy.com/2014/04/sumpners-or-back-to-back-test-on-transformer.html
2. http://www.yourelectrichome.com/2011/07/sumpners-test-back-to-back-test.html
3. IS 2026 (Part –II) -2010: Power Transformers Part 2

XX Assessment Scheme

	Performance indicators	Weightage
	Process related (15 Marks)	**60 %**
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
	Product related (10 Marks)	**40 %**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Experiment No. 10 : Prepare the maintenance schedule & trouble shooting chart for the single phase induction motor.

I Practical Significance

Maintenance is a process which includes regular / periodical checking, testing and replacing defective parts. A good and rigid maintenance practice helps to keep the machines in efficient conditions keeping down time to minimum.

Single phase induction motors are widely used in low power applications. Therefore it is necessary to learn different faults occurring in single phase induction motor and give solution or remedies to eliminate the fault so that motor operates properly.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the
results to solve broad-based electrical engineering problems.

PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Identify the problems in single phase induction motor
- Identify possible faults and Rectify the faults in single phase induction motor
- Follow safe practices.

IV Relevant Course Outcomes

- Prepare maintenance schedule for electrical equipment.
- Maintain rotating electrical machines.

V Practical Learning Outcome

- Prepare the maintenance schedule & trouble shooting chart for the single phase induction motor.

VI Minimum Theoretical Background

Maintenance:

Maintenance is classified as routine maintenance preventive maintenance and breakdown maintenance. A rigid system of inspection and preventive maintenance will ensure long life, trouble free operation and low maintenance cost. The main aim of maintenance is to maintain insulation in good condition. Maintenance of induction motor is carried out as per IS 900-1992.

3.	Test lamp	—	—	01	
4.	Megger	—	—	01	
5.	1φ Induction motor	1φ, 230V, 50Hz, 1H.P. capacitor Start I.M. 1φ Induction		01	

XII Actual procedure followed

(1) Selected the motor for the maintenance work (2) Carried out maintenance work and prepared a report on it (3) Prepared trouble shooting chart for various troubles, their possible reasons and respective remedies for them.

XIII Precautions followed

(1) Made sure that supply was off and fuses were removed before carrying out maintenance work (2) Used proper tools for maintenance work (3) Followed ethical safety practices during the course of practical.

XIV Observations and calculations:

i. For maintenance Schedule:

1) **Name of industry / plant/ shop:** Electrical Machine Lab G.P.J.

2) **Name plate details of the motor:**

1φ, 230V, 50Hz, 1 H.P. Capacitor start Induction Run motor

3) **Type of maintenance (Routine / ~~Preventive~~ / ~~Breakdown~~):** Routine

4) **Nature of maintenance planned (~~daily~~/ weekly/ ~~yearly~~):** Weekly

5) **List the activities carried out during maintenance:**

(i) Checked physical condition of motor

(ii) Checked cooling arrangement of motor

(iii) Checked lubricating system.

(iv) Checked passage of ventilation for cooling system.

(v) Checked motor for vibrations, noise and coupling.

Date: / /20

✱ TROUBLE SHOOTING CHART OF SINGLE PHASE INDUCTION MOTOR ✱

Sr. No.	Troubles	Possible Fault	Remedies
1.	Motor does not start	(i) Power supply or line trouble	(i) Check the source of power, fuses, control, etc.
		(ii) Overload at start	(ii) Avoide overloa-ding at start
		(iii) Loose contact	(iii) Rectify the fault
		(iv) Open circuit in supply cable	(iv) Rectify the fault.
		(v) Open capacitor	(v) Change capacitor
2.	Motor runs too hot	(i) Over/Under voltage	Apply rated voltage & frequency
		(ii) Over/Under frequency	
		(iii) Overload	(iii) Avoid overloading
		(iv) Worn bearings	(iv) Replace bearings
3.	Speed varies	(i) Changing I/P voltage	(i) Apply rated voltage
		(ii) Loose connec-tions	(ii) Rectify the cause.

4.	Motor runs slow	(i) Low voltage (ii) Low frequency (iii) Broken rotor bar or loose rotor	Apply rated voltage & freque (iii) Rectify the cause.
5.	Excessive speed of motor	(i) More than rated voltage is applied (ii) Load is too less	(i) Apply rated voltage (ii) Apply load on motor
6.	Motor body gives shock	(i) Insulation failure due to high current than rated value (ii) Insulation damage due to mechanical injury	Rectify the fault
7.	Noisy Running	(i) Mis-alignment (ii) Bearings not properly fit (iii) Incorrect levelling (iv) Cooling fan is touching stationary parts (v) Loose foundation bolts (vi) Warn out bearings	(i) Rectify the caus (ii) Fit the bearings properly (iii) Rectify the cause (iv) Rectify the cause (v) Tight the foundation bolts (vi) Replace bearings

6	Motor body gives shock		
7	Noisy running		

XV **Results:**

According to observation in routine maintenance we can say that motor is in proper condition. If any fault would incure in future maintenance work it could be rectified with the help of trouble shooting chart.

XVI **Interpretation of results**

From result we can interpret that to check the condition of motor, maintenance work should be carried at fixed regular interval if any abnormality is found then that trouble should be removed with the help of troubleshooting chart.

XVII **Conclusion**

By performing this practical we can conclude that maintenance schedule and trouble shooting chart play a vital role in maintaining proper functioning of motor and its life span.

XVIII **Practical related Questions**

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the use of following tools in maintenance of electrical equipment:
   a. Feeler Gauge
   b. Growler
   c. Bearing Puller
2) State the procedure for checking of wire gauge.
3) State the function of spirit level.
4) List out tools used in each industry for repair and maintenance work.
5) State the effect of capacitor in single phase induction motor having higher value than required value.
6) List out the major causes of induction motor starts to fails.

7) Give the importance of the trouble shooting chart in induction motor.
8) Draw the diagram of measurement of winding resistance and insulation resistance of the induction motor

(Space for answers)

Que.No.(1) State the use of the following tools in maintenance of electrical equipment

Ans→ (i) Feeler Gauge: feeler guage is used to check the air gap of motor after dismantaling and reassembly

(ii) Growler: It is used for finding shorted turns of armature coil or stator / rotor winding.

(iii) Bearing Puller: It is used for withdrawing bearings, sprockets, gears, etc.

Que.No.(2) State the procedure for checking of wire gauge

Ans→ Stranded wire gauges should me measured by calculating the equivalent cross sectional copper area. First, measure the bare diameter of a single strand and locate the circular mils value in the row that matches your measurement. Second, multiply the circular mils by the number of strands in the cable.

Que.No.(3) State the function of Spirit level

Ans → Spirit level is used to check the level of horizontal surface

Que.No.(4) List out tools used in each industry for repair and maintenance work

Ans → Tools used in industry for repair and maintenance work are as follows →

(i) Bearing Puller
(ii) Filler Gauges
(iii) Dial Indicator
(iv) Spirit Level
(v) Megger
(vi) Earth Tester
(vii) Multimeter
(viii) Growler
(ix) Spanners
(x) Screw Drivers
(xi) Test lamp

Que.No.(5) State the effect of capacitor in single phase induction motor having higher value than required value

Ans → If capacitor of higher value than required value is used in single phase induction motor, it increases the capacitance which further increase winding current and rise in voltage will cause the winding to fail by burning / insulation failure / capacitor puncture. Conclusion is that while marginal increase in capacitor value may be tolerated but higher increase will damage the winding.

Que.No.(6) List out the major cause of induction motor fails to start.

Ans → Causes of induction motor fails to start are as follows →

Que. No. (7) Give the importance of the trouble shooting chart in induction motor.

Ans → Importance of trouble shooting chart in Induction Motor →

Troubleshooting chart provides an idea about the cause for the trouble and suggest a relevant action plan. It serves as a guideline for the maintenance personel while carrying out the maintenance of induction motor.

Que. No. (8) Explain setup for winding resistance and insulation resistance of the induction motor.

Ans → (A) Winding resistance -

Generally the resistance will be measured by voltmeter-ammeter method, by connecting D.C. supply. Incase of split-phase motors both winding resistances i.e. starting and running are measured separately and checked with the designed value.

(B) Insulation resistance -

Insulation resistance betn running winding and frame (earth), starting winding (disconnecting capacitor) and frame (earth) and betn starting and running winding is measured, suitably after the temperature rise test with the help of a megger developing 500 V D.C.

(i) Terminal voltage too low
(ii) Defective starting mechanism
(iii) Open circuit in supply cable
(iv) Loose contact
(v) Open in auxiliary or main winding
(vi) Open capacitor
(vii) Shorted capacitor
(viii) Bearing is seized (Frozon), etc.

XIX. References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. IS 900-1992: Code of practice for installation and maintenance of induction motors (first revision)
4. www.bis.org.in
5. www.standardbis.in

XX Assessment Scheme

	Performance indicators	Weightage
	Process related (15 Marks)	**60 %**
1	Selection of meters and components	20 %
2	Handling of the meters and components	10 %
3	Reading meters accurately	10 %
4	connection of circuits	10 %
5	Follow safe practices	10 %
	Product related (10 Marks)	**40 %**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%

Experiment No. 11: Prepare the maintenance schedule & trouble shooting chart for the three phase induction motor.

I Practical Significance

Maintenance is a process which includes regular / periodical checking, testing and replacing defective parts. A good and rigid maintenance practice helps to keep the machines in efficient conditions keeping down time to minimum.

Troubleshooting chart is essential for successful breakdown and preventive maintenance. Troubleshooting is the process of identifying and rectifying the fault. Troubleshooting chart may be prepared before occurrence of fault or by keeping history of faults that have already occurred.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Identify the problems in three phase induction motor
- Identify possible faults and Rectify the faults in three phase induction motor
- Follow safe practices.

IV Relevant Course Outcomes

- Prepare maintenance schedule for electrical equipment.
- Maintain rotating electrical machines.

V Practical Learning Outcome

- Prepare the maintenance schedule & trouble shooting chart for the three phase induction motor.

VI Minimum Theoretical Background

Maintenance is classified as routine maintenance, preventive maintenance and breakdown maintenance. A rigid system of inspection and preventive maintenance will ensure long life, trouble free operation and low maintenance cost. The main aim of maintenance is to maintain insulation in good condition. Maintenance of induction motor is carried out as per IS 900-1992.

Every industry must maintain a troubleshooting chart or repair maintenance chart. This chart should contain record of maintenance activities either in the form of card or register. Troubleshooting chart helps in locating the fault and rectifying the faults in a machine is under breakdown it will affect production of the industry which may cause

Visit any electrical industry and collect information on troubleshooting charts. Prepare troubleshooting charts of three phase induction motor. Collect information on troubleshooting charts from the internet.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.	Multimeter	Mastech	—	01	
2.	Tacometer	—	Digital	01	
3.	Megger	—	500 V D.C.	01	
4.	3ϕ Induction Motor	HI-FINE MOTOR	3 H.P. 440V 2.2 kW, 50Hz 1440 RPM	01	

XII Actual procedure followed

① Selected the 3ϕ Induction motor for the maintenance work ② Carried out maintenance work and prepared a report on it ③ Prepared trouble shooting chart for various troubles, their possible causes and respective remedies for them.

XIII Precautions followed

① Made sure that supply was OFF and fuses were removed before carrying out maintenance work ② Used proper tools for maintenance work ③ Followed ethical safety practices during the course of practical.

XIV Observations and calculations:

A) Maintenance schedule:

Name plate details of the motor: HI-FINE MOTOR 3 H.P. 1440 RPM, 440 V, 2.2 kW, 50 Hz, 3ϕ, 4.5 A, Induction motor.

Type of maintenance (Routine / Preventive / Breakdown):

Routine Maintenance

Date: / /20

TROUBLE SHOOTING CHART OF THREE PHASE INDUCTION MOTOR

Sr. No.	Troubles	Possible Faults	Remedies
1.	Motor does not start	(i) Blown fuse (ii) Overload at start (iii) loose contact (iv) Open circuit in supply cable (v) Terminal voltage too low (vi) Bearing is seized (Frozen)	(i) Replace with new (ii) Reduce load on motor (iii) Rectify the cause (iv) Rectify the cause. (v) Apply rated voltage. (vi) Rectify the cause.
2.	Motor runs hot	(i) Overload (ii) Clogged ventilation ducts (iii) low or high voltage (iv) One phase open (v) Weared bearings (vi) Uneven air gap	(i) Reduce load (ii) Clean ventilation ducts. (iii) Apply rated voltage (iv) Rectify the cause (v) Replace bearings (vi) Rectify the cause.

3.	Motor runs slow	(i) Low voltage/ frequency (ii) Overload (iii) Single Phasing (iv) Improper conn-ection of motor leads to supply line (v) Shorted stator coils	(i) Apply rated frequency/volta (ii) Reduce load on motor (iii) Rectify the cause (iv) Use proper connections (v) Rectify the cause
4.	Motor Vibrates	(i) Loose iron core (ii) Mis-alignment (iii) Due to bent shaft (Run out) (iv) Warn out bearings (v) Incorrect levelling (vi) Loose foundati-on bolts.	(i) Tight the iron c (ii) Rectify the cau (iii) Replace the shaft (iv) Replace beari (v) Rectify the cause (vi) Tight the foundation bolt
5.	Motor hums (a) During start up (b) When running	(i) Unequal phase resistance (ii) Open circuit (iii) Interturn S.C. on motor (iv) S.C. betn turn to turn	Rectify the cause

6.	Thermal overload protection operates while motor is running	(i) Over/Under voltage (ii) Unbalance voltage (iii) Over/Under frequency (iv) Ventilation fan is not working (v) Overload (vi) Worn bearings (vii) Single phasing	Apply balanced rated voltage (iii) Apply rated frequency (iv) Rectify the fault (v) Reduce load (vi) Replace bearings (vii) Rectify the cause.

List the activities carried out during maintenance.

(i) Checked the physical condition of machine.
(ii) Checked the accessories like starter, control equipments, etc.
(iii) Checked lubricating system.
(iv) Checked the motor earthing connection.
(v) Checked for vibrations, noise and coupling.

Mention name of the part replaced (if any)

No part to be replaced

Tip → Machine should be cleaned to avoid accumulation of dirt and dust. Also it should be oiled regularly in order to avoid noisy operation.

B) Troubleshooting chart of three phase induction motor.

Written on extra sheet attached →

Sr. No.	Troubles	Possible Faults	Remedies
1.	Motor does not start		
2.	Motor runs hot		
3.	Motor runs slow		
4.	Motor vibrates		
5.	Motor hums a. During startup b. When running		
6.	Thermal overload protection operates while motor is running		

XV Results:

→ According to observations in routine maintenance, motor should be cleaned and oiled at regular intervals. If any other fault in machine is occured in future inspection it should be rectified with the help of trouble shooting chart.

XVI Interpretation of results

→ From the result we can interpret that to check the condition of 3ϕ Induction motor maintenance work should be carried out at fixed time intervals. It helps in detecting the fault in initial stage and stop from becoming a major one.

XVII Conclusion

→ By performing this practical we can conclude that maintenance schedule and trouble shooting chart play a vital role in maintaining functioning of motor and its life span.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the use of following tools in maintenance of electrical equipment:
   a. Bearing puller
   b. Dial indicator
   c. Spirit level
2. State the faults which may occur due to lack of maintenance.
3. State the effect of wrong brush pressure on life of slip rings.
4. List the activities carried out during yearly maintenance of three phase induction motor.

(Space for answers)

Que.No.(1) State the use of following tools in maintenance of electrical equipment

Ans → (a) Bearing puller: It is used for withdrawing bearings, sprockets, gears, etc.

(b) Dial indicator: It is used to check run-out of rotating parts (commutators, rotors, shafts)

(c) Spirit Level: It is used to check the level of horizontal surface

Que.No.(2) State the faults which may occur due to lack of maintenance.

Ans → faults which may occur due to lack

of maintenance are as followed →
1. Overheating of motor
2. Vibrations
3. Noise
4. Excessive sparking at brushes/slip rings
5. Motor hums during start up or running.
6. Bearing overheating
7. Thermal overload
8. Motor runs slow, etc.

Que. No. (3) State the effect of wrong brush pressure on life of slip rings.

Ans → If brush pressure is low, it will increase the electrical wear (sparking) on the other hand if brush pressure is high, friction increases which causes mechanical wear and tear.

Que. No. (4) List the activities carried out during yearly maintenance of three phase induction motor

Ans → Activities carried out during yearly maintenance of three phase induction motor → (As per IS 900-1992)
(i) Check bearing against worn-out.
(ii) Check the brushes against worn-out.
(iii) Check the slip ring against worn-out.
(iv) Check the condition of starting and protective equipment
(v) Check the condition of foundation.
(vi) Check the insulation resistance.
(vii) Check the earth resistance.

Experiment No. 12 : To prepare maintenance schedule and troubleshooting chart for three phase transformer.

I Practical Significance

Maintenance is a process which includes regular / periodical checking, testing and replacing defective parts. Regular maintenance increases the life of a machine. Troubleshooting chart helps locating the fault in a machine and rectifying it. It helps in reducing down time of machine.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Identify the problems in three phase transformer
- Identify possible faults and Rectify the faults in three phase transformer
- Follow safe practices.

IV Relevant Course Outcomes

- Prepare maintenance schedule of electrical equipment.
- Maintain single phase and three phase transformer.

V Practical Learning Outcome

- Prepare maintenance schedule and troubleshooting chart of three phase transformer.

VI Minimum Theoretical Background

Maintenance is classified as routine maintenance, preventive maintenance and breakdown maintenance. The main aim of maintenance is to maintain machine in a good running condition. Maintenance of three phase transformer is carried out as per IS 10028 (Part III)-1981. Troubleshooting chart is essential for successful breakdown and preventive maintenance. Troubleshooting chart may be prepared before occurrence of fault or by keeping record of history of faults that has already occurred.

2.	Megger	—	—	01	
3.	Spanner set			01	
4.	3ϕ transfor-mer	3ϕ, 250 KVA, 50Hz 11KV/415V		01	

XII Actual procedure followed

① Identified various troubles in 3ϕ transformer ② List outed their possible reasons for occurence of fault ③ Established a plan of action for the respective causes, to resolve the fault.

XIII Precautions followed

① Used proper tools for maintenance work
② Made sure that power supply was in OFF position while carrying out maintenance work
③ Followed all the safety practices.

XIV Observations and calculations:

A. Maintenance of a three phase transformer

- **Name of industry / workshop / plant:** G.P. Jalgaon 11KV/415V distribustion transformer.
- **Specifications of a transformer:** DWARKA INDUSTRIES 250 KVA, 50 HZ, 3ϕ, Oil Natural cooled, Dy11, HV current-13.12A, L.V. current - 332A
- **Type of maintenance plan (Routine/~~Preventive~~/~~Breakdown~~)** Routine
- **Nature of maintenance (~~Daily~~/ Weekly/ ~~Yearly~~)** Weekly
- **Write observations / activities carried out during maintenance work:**
  (i) Cleanliness in substation yard
  (ii) Checked colour of silica gel
  (iii) Checked physical condition of X'mer and earthing.
- **State the difficulties faced during maintenance**

- **Name the defective part / object (if any) observed during maintenance. State the actions taken.**

→ No defective part as transformer was in working state.

Written on extra sheet attached →

B. Troubleshooting chart of three phase transformer

Sr. No.	Troubles	Possible Faults	Remedies
1.	Overheating in a transformer		
2.	Transformer does not show output voltage		
3.	Short circuit (Internal/External)		
4.	Phase voltage is unequal		
5.	Oil leakage		
6.	Noise in a transformer		
7.	Vibration in a transformer		

Calculations:

XV Results:

→ Prepared a report based on the observations during the maintenance of 3ϕ transformer. Also prepared trouble shooting chart based on troubles which generally occur with possible causes and remedy on it.

* TROUBLE SHOOTING CHART OF THREE PHASE TRANSFORMER *

Sr. No.	Troubles	Possible faults	Remedies
1.	Overheating in transformer.	(i) Prolonged overloading (ii) Failure of cooling system (iii) Low oil level in transformer tank (iv) High ambient temp.	(i) Avoid overloading the transformer. (ii) Check cooling system (iii) Fill the required oil in X'mer tank. (iv) Rectify the cause
2.	Transformer does not show output voltage	(i) C.B. may trip (ii) Loose connection at bushings (iii) Connections may be open at bushings (iv) Failure of primary winding (v) Loose contact of tap changer	(i) Rectify the fault (ii) Check the connections. (iii) Check the connections. (iv) Rectify the cause (v) Check the connections to tap changer.

3.	Short circuit (Internal/ External)	(i) It may be due to insufficient clearance on overhead line	(i) Rectify the cause
		(ii) Accumulation of dust on insulator	(ii) Clear the du[st] and rectify the ca[use]
		(iii) Fault in tap changer	Rectify the cause
		(iv) loose connections, causing local overheating	Rectify the cause
		(v) Vibration on insulation resulting internal S.C.	Rectify the cause
4.	Phase voltage is unequal	(i) Primary input voltage is unequal	(i) Apply contact primary I/P volta[ge]
		(ii) Unbalance loading	(ii) Balance the loading
		(iii) Unsymmetrical fault	(iii) Rectify the cause.
5.	Oil leakage	(i) Insufficient tightness of mechanical parts	(i) Rectify the cause
6.	Noise in a transformer/Vibrations in	(i) Bad/loose foundation nut bolts	(i) Replace/tight the foundation nut bolts as per requirement.

XVI Interpretation of results

→ From result we can interpret that maintenance work at regular time interval give us an idea about the condition of machine. Trouble shooting chart play important role if we find any fault during this inspection of machine.

XVII Conclusion

→ By performing this practical we can conclude that regular maintenance is important for detecting defective parts or minor faults which may develop in major fault. It increase life of machine if any fault occur, trouble shooting chart helps in locating and rectifying it

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State how to reduce humming noise in a transformer.
2) State the situation under which silica gel is to be replaced.
3) State the function of diverter switch in on ~~load~~ tap changer.
4) State the function of transformer oil.
5) State the value of breakdown voltage of new transformer oil.
6) List activities to be carried out during annual maintenance of a transformer.

(Space for answers)

Que. No. (1) State how to reduce humming noise in a transformer

Ans → Ways to reduce humming noise in a transformer →

(i) Mounting the transformer on a solid plane
(ii) Avoiding installing transformers in corners, corridors and stairwells.
(iii) Choosing a low tarffic area for installation
(iv) Keeping the bolts enclosures tight.
(v) Using sound dampening materials.

Que.No.(2) State the situation under which silica gel is to be replaced.

Ans→ Silica gel should be replaced soon after it changes colour from blue to pink.

Que.No.(3) State the function of diverter switch in ON load tap changer.

Ans→ Tap changers typically use numerous tap selector switches which may not be switched under load, broken into even and odd banks and switch beth the banks with a heavy-duty diverter switch which can switch between them under load.

Que.No.(4) State the function of transformer oil.

Ans→ Transformer oil is used in oil filled electrical power transformer to insulate, stop arcing and corona discharge and to dissipate the heat of the transformer (i.e acts as a coolant)

Que.No.(5) State the value of breakdown voltage of new transformer oil.

Ans→ The value of breakdown voltage of new transformer oil is 71 KV.

Que. No. (6) List activities to be carried out during annual maintenance of a transformer.

Ans → Activities to be carried out during annual maintenance of a transformer →
(As per IS10028)

(i) Check oil in transformer against acidity, resistivity, sludge formation and tanδ.
(ii) Check oil filled bushings.
(iii) Check lubricating oil in gear box of driving mechanism.
(iv) Check surge diverter and air gap.
(v) All values should be checked for any leakage and for open/close operation.
(vi) All activities mention above after 6 months are to be done.

Experiment No. 13 : Conduct the dielectric strength test on transformer oil

(Sample 1)

I Practical Significance

Transformer oil is used for insulation and cooling purpose in transformers and other electrical equipment, needs to be tested periodically to check its dielectric strength. This is because it tends to deteriorate over time because of the environmental condition.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.
PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.
PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.
PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

The practical is expected to help the student to attain the following industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters
- Measure electrical quantities.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain single phase and three phase transformers.
- Maintain insulation systems of electrical equipment.

V Practical Learning Outcome

- Conduct the dielectric strength test on transformer oil (sample 1).

VI Minimum Theoretical Background

Breakdown voltage of transformer oil is also known as the dielectric strength of transformer. Transformer oil, a type of insulating and cooling oil used in transformers and other electrical equipment, needs to be tested periodically to ensure that it is still fit for purpose. This is because it tends to deteriorate over time. Testing consists of measuring breakdown voltage and other physical and chemical properties of samples of the oil, either in a laboratory or using portable test equipment on site.
To assess the insulating property of dielectric transformer oil, a sample of the transformer oil is taken and its breakdown voltage is measured. The lower the resulting breakdown voltage, the poorer the quality of the transformer oil. The transformer oil is filled in the vessel of the testing device. Two standard-compliant test electrodes with a typical clearance of 2.5 mm are surrounded by the dielectric oil.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Oil Testing Kit	SUVIDHI INDUSTRIES	230VAC, 1KVA, O/P-0-80KV	01	
2.	Transformer Oil sample	-	Re-Filtered Oil Sample	As per Req.	

XII Actual procedure followed

① Filled the cup with test sample and placed the cup on HV transformer bushing. ② Closed the top cover of box. ③ Switched ON the unit mains ON ④ Pressed H.T. ON button, voltage increased automatically ⑤ Noted down the value at which breakdown occured. ⑥ Calculated mean value of B.D.V.

XIII Precautions followed

① Checked the distance betn the electrodes.
② While placing or removing oil sample, checked that power supply was OFF.
③ Check that transformer oil testing kit was grounded before using it

XIV Observations and Calculations:

Sr. No.	Input Voltage (in V)	Breakdown Voltage in kV	Mean of breakdown voltage (in kV)
1.	230	14	
2.	230	14	$\boxed{14}$
3.	230	14	

XV Results:

- The breakdown strength of ~~fresh~~ Re-Filtered transformer oil is = ...14............ kV

XVI Interpretation of results

From result we can interpret that as it is refiltered oil it does not have high breakdown voltage similar to fresh oil sample. It indicates poor breakdown strength

XVII Conclusion

→ By performing this practical we can conclude that, dielectric test gives us the value of breakdown voltage of transformer oil. This value should be high as much as possible because it indicates its suitability to work properly at high operating voltages.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the properties of transformer oil.
2) "Transformer oil should have high breakdown voltage". Justify
3) Define Dielectric Strength.
4) State the importance of the transformer oil.
5) Give value of distance which is to be maintained between two electrodes.

(Space for answers)

Que.No.(1) State the properties of transformer oil.

Ans → Properties of transformer oil →

① High dielectric strength
② Stable at high temperature
③ Excellent insulating property
④ Stability against oxidation
⑤ Thermal conductivity

Que.No.(2) "Transformer oil should have high breakdown voltage" Justify

Ans → The high breakdown voltage of transformer oil indicates that the presence of contaminants is lower. It is essential that contaminants value should be low in order to maintain the insulating property for proper function-ing of transformer. Therefor, transformer oil should have high breakdown voltage.

Que.No.(3) Define 'Dielectric Strength'

Ans → Dielectric strength is defined as the maximum voltage required to produce a dielectric breakdown through the material and is expressed as volts per unit thickness.

Que.No.(4) State the importance of transformer Oil.

Ans → Transformer oil are important for the running of transformer winding and are the dielectric substance that helps in maintaining their temperature. It provides the chemical stability to ensure long lasting service. Transformer oil are vital for the proper running and functioning of the transformer.

Que.No.(5) Give value of distance which is to be maintained betn two electrodes.

Ans → 2.5mm distance is to be maintained betn two electrodes (in some kit it is 4mm).

Experiment No. 14 : Conduct the dielectric strength test on transformer oil (Sample 2)

I Practical Significance

Transformer oil is used for insulation and cooling purpose in transformers and other electrical equipment, needs to be tested periodically to check its dielectric strength. This is because it tends to deteriorate over time because of the environmental condition.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad based electrical engineering related problems.
PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.
PO4: Engineering Tool: Apply relevant Electrical technologies and tools with an understanding of the limitations.
PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

The practical is expected to help the student to attain the following industry identified Competency: **'Maintain different electrical equipment following safe practices'.**

- Select various meters
- Measure electrical quantities.
- Follow safe practices.

IV Relevant Course Outcomes

- Maintain single phase and three phase transformers.
- Maintain insulation systems of electrical equipment.

V Practical Learning Outcome

- Conduct the dielectric strength test on transformer oil (sample 2).

VI Minimum Theoretical Background

Breakdown voltage of transformer oil is also known as the dielectric strength of transformer. Transformer oil, a type of insulating and cooling oil used in transformers and other electrical equipment, needs to be tested periodically to ensure that it is still fit for purpose. This is because it tends to deteriorate over time. Testing consists of measuring breakdown voltage and other physical and chemical properties of samples of the oil, either in a laboratory or using portable test equipment on site.
To assess the insulating property of dielectric transformer oil, a sample of the transformer oil is taken and its breakdown voltage is measured. The lower the resulting breakdown voltage, the poorer the quality of the transformer oil. The transformer oil is filled in the vessel of the testing device. Two standard-compliant test electrodes with a typical clearance of 2.5 mm are surrounded by the dielectric oil.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.	Oil Testing kit	SUVIDHI INDUSTRIES	230 VAC 1KVA O/P-0-80KV	01	
2.	Transformer Oil sample	Used transformer Oil sample		As per Req.	

XII Actual procedure followed

→ ① Filled the cup with test sample and placed the cup on the HV transformer bushing. ② Closed the top cover of box ③ switched ON the unit mains ON ④ Pressed H.T. ON button, voltage increased automatically ⑤ Noted down the value at which breakdown occured ⑥ Calculated mean value of B.D.V.

XIII Precautions followed

→ ① Checked the distance betn the electrodes.
② While placing or removing oil sample, checked that power supply was off.
③ Checked that transformer oil testing kit was grounded before using it.

XIV Observations and Calculations:

Sr. No.	Input Voltage (in V)	Breakdown Voltage in kV	Mean of breakdown voltage (in kV)
1.	230	19	
2.	230	18	$\boxed{18.3333}$
3.	230	18	

XV Results:

- The breakdown strength of used transformer oil is = 18.3333 kV

XVI Interpretation of results

→ From result we can interpret that breakdown strength of used transformer oil is less than fresh transformer oil. This happen due to presence of moisture and dirt-dust in used transformer oil.

XVII Conclusion

By performing this practical we can conclude that dielectric strength test gives us idea about breakdown voltage of transformer oil so we can interpret whether it can work properly in transformer tank

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the properties of transformer oil.
2) Transformer oil should have high breakdown voltage. Justify
3) Define Dielectric Strength.
4) State the importance of the transformer oil.
5) Give value of distance which is to be maintained between two electrodes.
6) Comment on the results obtained for fresh oil and used oil tests.

(Space for answers)

Que. No. (1) State the properties of transformer oil.

Ans → Properties of transformer oil →

1. High dielectric strength
2. Stable at high temperature
3. Excellent insulating property
4. Stability against oxidation
5. Thermal conductivity

Que. No. (2) Transformer oil should have high breakdown voltage Justify

Ans → The high breakdown voltage of transformer oil indicates that the presence of contaminants is lower It is essential that contiminants value should be low in order to maintain the insulating property for proper functioning of transformer Therefor, transformer oil should have high breakdown voltage.

Que.No.(3) Define 'Dielectric Strength'

Ans → Dielectric strength is defined as the maximum voltage required to produce a dielectric breakdown through the material and is expressed as volts per unit thickness

Que.No.(4) State the importance of transformer Oil

Ans → Transformer oil are important for the running of transformers winding and are the dielectric substance that helps in maintaining their temperature It provides the chemical stability to ensures long lasting service Transformer oil are vital for the proper running and functioning of the transformer

Que.No.(5) Give value of distance which is to be maintained betn two electrodes

Ans – 2.5mm distance is to be maintained betn two electrodes (in some kit it is 4mm)

Que.No.(6) Comment on the results obtained for fresh oil and used oil tests

Ans → Breakdown strength of fresh oil is much more as compared to used oil sample as used oil contain moisture and impurities which reduces its breakdown strength On the other hand fresh oil is free from moisture and impurities so its breakdown strength is more.

Experiment No. 15 : To perform HV test on three phase induction motor.

I Practical Significance

This is routine test performed on all the machines manufactured in an industry. This test is generally performed at manufacturer's premises. It is performed to check withstand capability of insulation against high voltage.

II Relevant Program Outcomes (POs)

PO2: Discipline knowledge: Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO3: Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based electrical engineering problems.

PO4: Engineering tools: Apply relevant Electrical technologies and tools with an understanding of the limitations.

PSO1: Electrical Equipment: Maintain various types of rotating and static electrical equipment.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Maintain different electrical equipment following safe practices.**

IV Relevant Course Outcomes

- Maintain insulation systems of electrical equipment.

V Practical Learning Outcome

- Perform HV test on three phase induction motor.

VI Minimum Theoretical Background

In this test specified voltage is applied between various windings and earth. This test should be carried out together with insulation resistance test at manufacturer's premises. This test is performed if the value of insulation resistance is greater than values specified in IS 4722 (30.2.2). The test is performed with alternating voltage of any convenient frequency between 40Hz and 60 Hz. The test voltage should be sine wave form as far as possible. Test is started by applying one third of test voltage and then voltage is increased to full test voltage in steps.

Recommended Test Voltage

Sr.No.	Part of Motor	Test Voltage
1.	Stator winding (Primary)	(1000V) + Twice rated voltage with minimum 2000V
2.	Rotor Winding (Secondary) not permanently short circuited	(1000V) + Twice open circuit standstill voltage measured between slip rings with rated voltage applied to stator winding

XVI Interpretation of results

→

XVII Conclusion

→

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) State the causes of failure of insulation of motor winding.
2) State the recommended value of insulation resistance for three phase induction motor with rated voltage 415V.
3) State the measures taken to improve the value of insulation resistance.

(Space for answers)

Que. No. (1) State the causes of failure of insulation of motor winding

Ans → Causes of failure of insulation of motor winding are as follows →

(i) Overheating of motor due to over loading

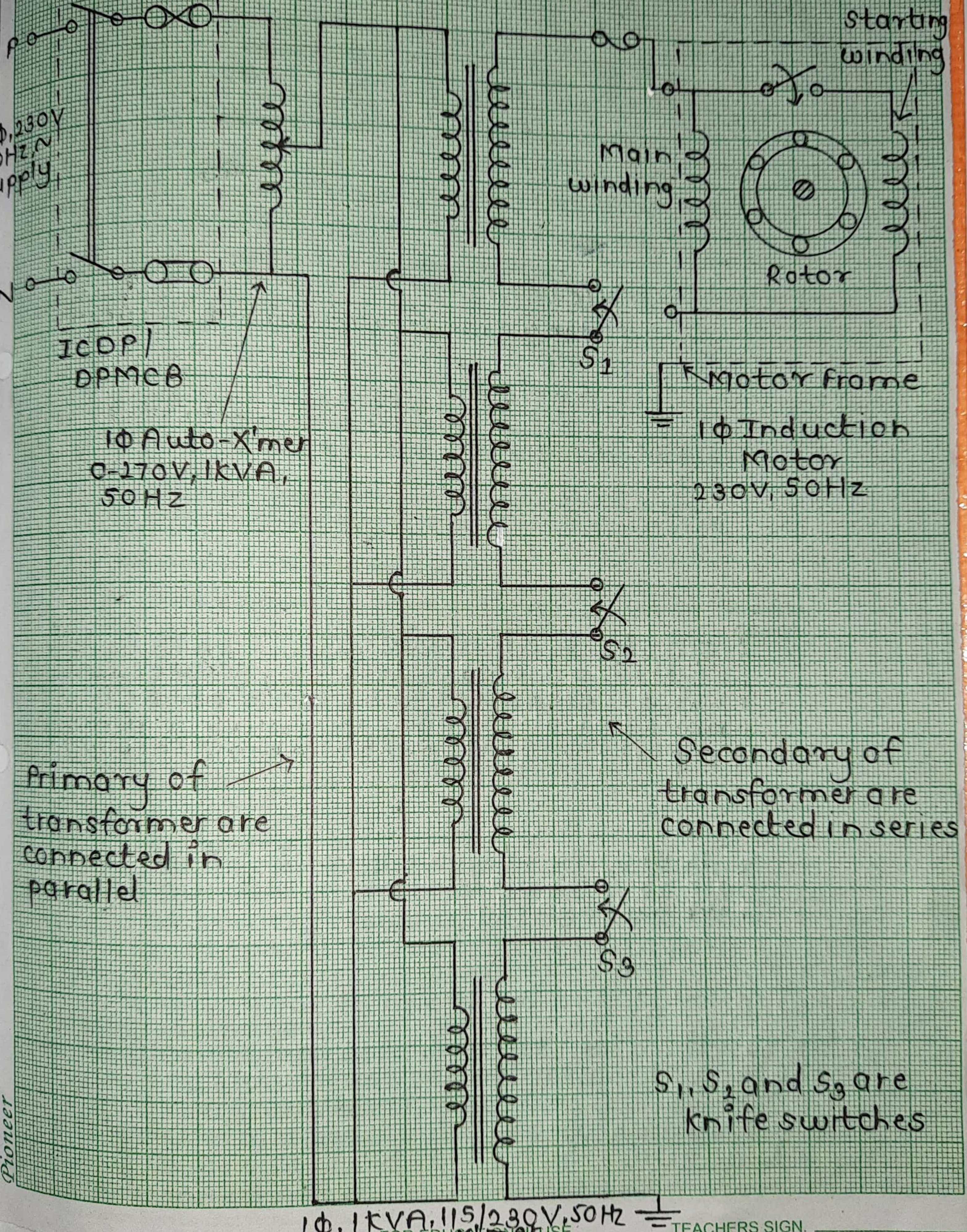
(ii) Corrosion
(iii) Physical damage
(iv) High magnitude current above rated value

Que. No. (2) State the recommended value of insulation resistance for three phase induction motor with rated voltage 415V

Ans →

NAME: Practical No.16 STD.: DIV.: MEE (22625)

* Title → Circuit diagram to conduct HV test on single phase induction motor.



Pioneer

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1	HV Tester	-	01	

IX. Precautions to be followed

1) Maintain the safe distance between practical set up and students as very high voltage is used in the experiment for testing.
2) Perform test in dry area only.
3) Perform the test under the guidance of teacher only.
4) Common ground connections should be solidly connected to both test set and motor under test.
5) Make use of safety equipments while performing the test.

X Procedure

1) Make the connections as per diagram.
2) Initially apply one third of test voltage at power frequency.
3) Increase the voltage in steps of 5% of test voltage with time interval of ten seconds.
4) Increase the voltage up to test value and maintain it for one minute.
5) Reduce the voltage suddenly to one third of test voltage and switch off.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1	Power Supply	–	230V, 50Hz, 1ϕ AC Supply	01	
2	Auto-X'mer	–	0-270V, 1KVA, 1ϕ 50Hz	01	
3	1ϕ X'mer	–	1ϕ, 115V/230V, 50Hz	04	
4	1ϕ Induction motor	–	1ϕ, 230V, 50Hz	01	
5	Knife switches	–	–	09	

XII Actual procedure followed

→ ① Made connections as per circuit diagram. ② Initially applied one third of test voltage at power frequency. ③ Increased the voltage in steps. ④ Increased the voltage up to test value and maintained it for one min. ⑤ Reduced the voltage to one third of test voltage & switched off.

XIII Precautions followed

→ ① Maintained safe distance betn practical set up and ourself as very high voltage is used in the experiment for testing.
② Performed practical under guidance of teacher.
③ Common ground connections were solidly connected to both test set and motor under test.

XIV Observations and calculations:

Test	Observations (Yes/No)
High voltage test Test voltage 1000V for a motor of 250V **(High voltage can be generated with the help of two or more transformers with their primaries in parallel and secondaries in series)**	Burning Smell……No Sparking………No Excessive heat……No Any other……No None of the above……Yes

Calculations: Due to unavailability of same KVA rating transformer, test is conducted on 500V with two X'mers (115V/230V) primary in parallel and secondary in series connection. Insulation resistance of motor is $\geq 1 M\Omega$

XV Results:

→ From observation we can say that, as no burning smell, sparking or excessive heat development was developed on applied test voltage, insulation of motor properly withstanded the high test voltage (i.e. 500V)

XVI Interpretation of results

→ From result we can interpret that insulation of motor is of good quality. It is not damaged or weakened so it can sustain high voltage stresses.

XVII Conclusion

→ By performing this practical we acquire necessary skills to perform HV test on 1ϕ Induction Motor to check withstand capability of insulation at high voltages. It gives idea about weakness or damage of insulation.

XVIII Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Name IS Code which specifies testing of single phase induction motor.
2) State the precautions to be taken while working on electrical installations.
3) State the construction of HV tester.

(Space for answers)

Que.No.(1) Name IS Code which specifies testing of single phase induction motor

Ans→ IS 7572-1974 specifies testing of single phase induction motor

Que.No.(2) State the precautions to be taken while working on electrical installations.

Ans→ Precautions to be taken while working on electrical installations→

1. Wear hand gloves, safety shoes, safety helmet ~~should be used~~ etc while working on live circuits.
2. Work permit should be taken if necessary.
3. Electrical installation should be well grounded.
4. Never use equipment with frayed cords, damaged insulation or broken plugs.
5. Always use insulated and ISI marked tools while working.
6. Avoid water at all time when working with electricity.

Que.No.(3) State the construction of HV Tester.

Ans → HV tester is designed and constructed to perform high voltage AC tests on electrical appratus and material in accordance with IEC 60 and IEC 270 test standards.

HV tester contains high voltage step-up transformer with tap changing arrangement on the secondary side. It also contain power switches which control the high voltage given to the equipment under test. Voltmeter is also connected to display the value of voltage applied during the test.