I

Name _____

Roll No. _____ Year 20____20____

Exam Seat No. _____

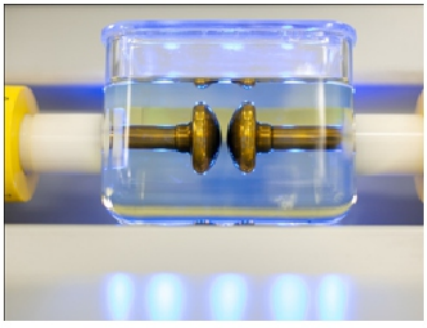
ELECTRICAL GROUP | SEMESTER - VI | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

MAINTENANCE OF ELECTRICAL EQUIPMENT

(XXXXX)



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

A Practical Manual for

Maintenance of Electrical Equipment

(22625)

Semester– (VI)

(EE, EP, EU)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)

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4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai -400051.

(Printed on November 2019)

Maharashtra State
Board of Technical Education
Certificate

This is to certify that Mr./Ms……Roll No……..…. of Sixth Semester of Diploma in ……..……. of Institute ……... (Code……..) has attained predefined practical outcomes (PROs) satisfactorily in course **Maintenance of Electrical Equipment (22625)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……

Date:…..... Exam Seat No. ……....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

The electrical diploma holder has to work in industry as technical person in middle level management. He has to work as production, maintenance, testing engineer in various industries like power generation, transmission, distribution, traction etc. and has to deal with different electrical measurement. While performing above task he has to measure different electrical and electronic parameters with testing, therefore he/she must require the skills for these measurements and broad idea of different meters and equipments.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs and PSO are expected to be achieved through the practicals of the course, Maintenance of Electrical Equipment.

PO 1. **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Electrical engineering problems.

PO 2. **Discipline knowledge:** Apply Electrical engineering knowledge to solve broad-based electrical engineering related problems.

PO 3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electrical engineering problems.

PO 4. **Engineering tools:** Apply relevant Electrical technologies and tools with an understanding of the limitations.

PO 5. **The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in the field of Electrical engineering.

PO 6. **Environment and sustainability:** Apply Electrical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO 7. **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Electrical engineering.

PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. **Communication:** Communicate effectively in oral and written form

PO 10. **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the Electrical engineering and allied industry.

Program Specific Outcomes (PSOs)

PSO 1. Electrical Equipment: Maintain various types of rotating and static electrical equipment.

PSO 2. Electric Power Systems: Maintain different types of electric power systems.

List of Industry Relevant Skills

The following industry relevant skills of the competency **'Maintain different electrical equipment following safe practices'.**

1. Follow safe practices to prevent accidents while using electrical equipment.
2. Prepare maintenance schedules for electrical equipment.
3. Maintain rotating electrical machines.
4. Maintain single phase and three phase transformers.
5. Maintain insulation systems of electrical equipment.

Practical- Course Outcome matrix

Course Outcomes (COs):-

a) Follow safe practices to prevent accidents while using electrical equipment.
b) Prepare maintenance schedules for electrical equipment.
c) Maintain rotating electrical machines.
d) Maintain single phase and three phase transformers.
e) Maintain insulation systems of electrical equipment.

Sr. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Perform the no load test, measure winding resistance for a single phase induction motor and determine its performance.	√	-	√	-	-
2.	Perform no load and blocked rotor test on three phase induction motor to determine the equivalent circuit.	√	-	√	-	-
3.	For the motor tested in practical at S. no. 2 plot the circle diagram and judge its performance.	√	-	√	-	_
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]	√	-	√	-	-
5.	Perform open circuit voltage ratio test on the three phase slip ring induction motor.	√	-	√	-	-
6.	Perform the phasing out and polarity tests on the three phase transformer.	√	-	-	√	-
7.	Perform the open circuit and short circuit tests on the single phase transformer and determine its performance (regulation and efficiency).	√	-	-	√	-
8.	Perform the open circuit and short circuit tests on the three phase transformer and determine its performance (regulation and efficiency)	√	-	-	√	-
9.	Perform back to back test on two identical single phase transformers and determine their efficiencies and regulations.	√	-	-	√	-
10.	Prepare the maintenance schedule & trouble shooting chart for the single phase induction motor.	√	√	-	-	√
11.	Prepare the maintenance schedule & trouble shooting chart for the three phase induction motor.	√	√	-	-	√
12.	Prepare maintenance schedule & trouble shooting chart for 3ph Transformers.	√	√	-	√	√
13.	Conduct the dielectric strength test on transformer oil (sample 1).	√	-	-	√	√

14.	Conduct the dielectric strength test on transformer oil (sample 2).	√	-	-	√	√
15.	HV test on three phase induction motor.	√	-	√	-	√
16.	HV test on single phase induction motor.	√	-	√	-	√

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.
5. **Select the proper range of meters referring to the machine/s specifications/ratings.**

Content Page

List of Practicals and Progressive Assessment Sheet

Sr. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks (25)	Dated sign. of teacher	Remarks (if any)
1*	Perform the no load test, measure winding resistance for a single phase induction motor and determine its performance.	1					
2*	Perform no load and blocked rotor test on three phase induction motor to determine the equivalent circuit.	8					
3*	For the motor tested in practical at S. no. 2 plot the circle diagram and judge its performance.	17					
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].	26					
5*	Perform open circuit voltage ratio test on the three phase slip ring induction motor.	35					
6*	Perform the phasing out and polarity tests on the three phase transformer.	41					
7#	Perform the open circuit and short circuit tests on the single phase transformer and determine its performance (regulation and efficiency).	49					
8#	Perform the open circuit and short circuit tests on the three phase transformer and determine its performance (regulation and efficiency).	57					

Sr. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks (25)	Dated sign. of teacher	Remarks (if any)
9*	Perform back to back test on two identical single phase transformers and determine their efficiencies and regulations	64					
10^	Prepare the maintenance schedule & trouble shooting chart for the single phase induction motor.	71					
11^	Prepare the maintenance schedule & trouble shooting chart for the three phase induction motor.	80					
12*	Prepare maintenance schedule & trouble shooting chart for 3ph Transformers.	87					
13 &	Conduct the dielectric strength test on transformer oil (sample 1).	94					
14 &	Conduct the dielectric strength test on transformer oil (sample 2).	100					
15 %	HV test on three phase induction motor.	106					
16 %	HV test on Single phase induction motor.	112					
Total					.		

Legend: - #: any one to be performed, &: any one to be performed, %: any one to be Performed, ^: any one to be performed, *: Compulsory

Note: - A Judicial Mix of minimum 12 or more practicals need to be performed, out of which practical marked as * are compulsory.

Note: To be transferred to relevant proforma of CIAAN-2017

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

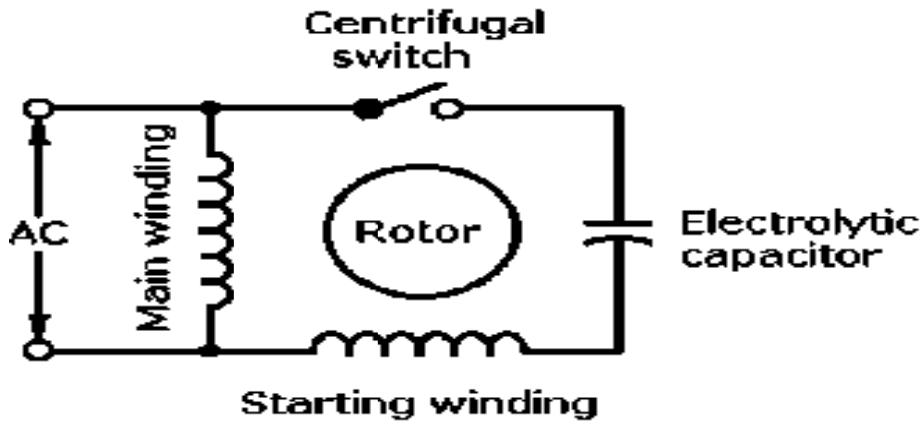
- Maintain rotating electrical machines.

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.

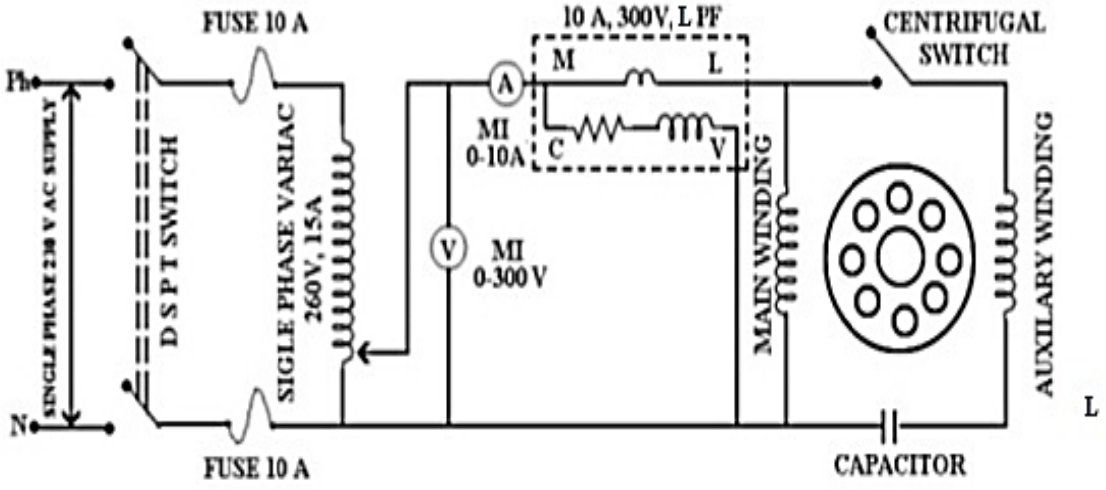


No Load Test:

It is a type of routine test performed on single phase induction motor.

It is performed to find core loss or iron loss, friction and windage losses, magnetizing current and no load power factor of single phase induction motor.

VII Circuit diagram:



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Single Phase Capacitor Start Cage Type Induction Motor	1Hp , 230V, 50Hz,	01	
2.	Single Phase Autotransformer	Range- 0-270V, 15 A,	01	

	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.					
2.					

3.					
4.					
5.					
6.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

A) Measurement Of Winding Resistance

Sr. No.	Winding	Resistance(in ohm)	Identification
1.	1		Main/Starting
2.	2		Main/Starting

B) No Load Test

Sr. No	V_0 (Volts)	I_0 (Ampere)	W_0 (Watts)	N (rpm)
1				

Calculations:

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

$Z_0 = \frac{V_0}{I_0} =$…….. Ω

$X_0 = Z_0 \sin \emptyset_0 =$ …… Ω

XV Results:

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XVI. Interpretation of results

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XVII. Conclusion

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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)

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XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. https://www.youtube.com/watch?v=qYqAudBmyXY
4. IS 7572-1974: Guide for testing single phase AC and universal electric motors

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. ……..
2. …….
3. …….

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

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.

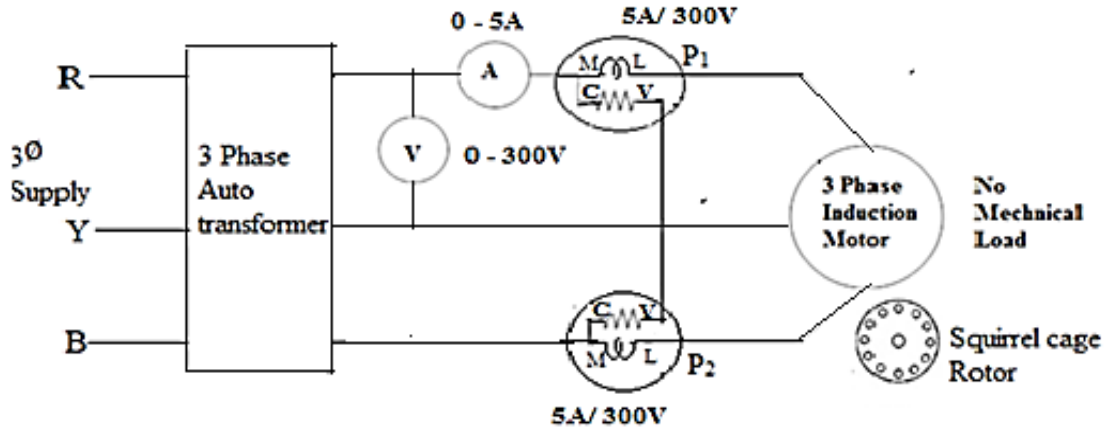
If the motor is run at rated voltage and frequency without any mechanical load, it will draw power necessary to supply the no load losses. The no load current will have two components. The active component and the magnetizing component, the former being very small as the no load losses are small. The 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.

Blocked Rotor Test

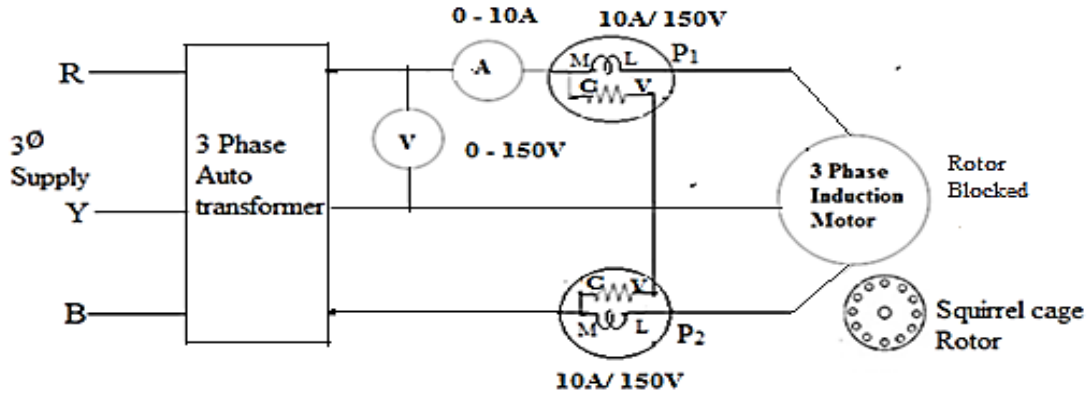
The stator is supplied with a low voltage of rated frequency just sufficient to circulate rated current through the stator with the rotor blocked and short circuited. The power input, current and the voltage applied are noted down. The power input during the blocked rotor test is wholly consumed in the stator and rotor copper losses. The core loss is low because the applied voltage is only a small percentage of the normal voltage. Again since the rotor is at stand still the mechanical losses are absent. Hence the blocked rotor input can be taken as approximately equal to the copper losses.

VII Circuit diagram:

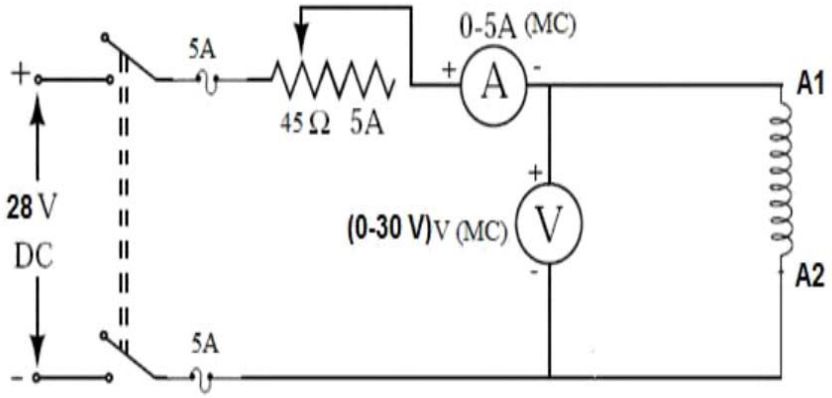
No load Test



Block Rotor Test



Measurement of Stator Resistance



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	AC Ammeter	Range- 0-5A and 0-10A	01 Each	
2.	DC Ammeter	Range- 0-5A	01	
3.	AC Voltmeter	Range- 0-300V and 0-150 V	01 Each	
4.	DC Voltmeter	Range- 0-30V	01	
5.	Wattmeter	Range- 300V, 10A	01	
6.	Tachometer	-	01	
7.	Induction Motor	3Hp/5HP, 415V, 50Hz, three phase squirrel cage	01	
8.	LPF Wattmeter	Range: 300V, 5A	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.
4) Ensure Autotransformer is at zero position at start.

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.					
2.					
3.					
4.					
5.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

Stator Resistance

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	W_1	W_2

Blocked Rotor Test

Motor Voltage V_{SC} Volts	Motor current I_{rated} Amps	Motor blocked rotor Power W_{SC} Watts	
V_{SC}	I_{rated}	W_1	W_2

Calculations:

Determination of Equivalent Circuit Parameters

From No Load Test

- Wattmeter reading W_0=……W
- Voltmeter reading V_0=…….V
- Ammeter reading I_0=…….A
- $\cos \emptyset_0 = \frac{W_0}{\sqrt{3}V_0 I_0}$ = ……..
- $\emptyset_0 = {}^{1}\cos^{-1} \emptyset_0$=……degree
- $\sin \emptyset_0$ =……
- R_0 per phase=$\frac{perphase\ no\ load\ voltage}{per\ phase\ no\ load\ current\ \times cos\emptyset_0}$ =……Ω
- X_0 per phase = $\frac{per\ phase\ no\ load\ voltage}{per\ phase\ no\ load\ current\ \times sin\emptyset_0}$ = ……Ω

From Blocked Rotor Test

- Wattmeter reading Wsc =……..W
- Voltmeter reading V_{SC}=…….V
- V/phase = V_{SC} /√3 =…….V
- Ammeter reading I_{SC}=……A
- cos Φ_{SC}=W_{SC} =$\frac{W_{SC}}{\sqrt{3}V_{SC}I_{SC}}$ = ……..

- Φ_{SC} =$\cos^{-1}$ Φ_{SC}=……degree
- Mean stator resistance R_{Smean}=……. Ω
- Total winding resistance and impedance as referred to the stator side R_{01} and Z_{01}(per phase)
- $\mathbf{Z_{01}} = \frac{\text{V/phase}}{\text{I/phase}}$…… Ω
- $R_{O1} = Z_{O1} \times \cos \Phi SC$……..Ω

- Total leakage reactance as referred to the stator side Xo1 =√(Z_{01}^2-R_{01}^2) =……Ω
- $R_{S(eff)}$=(1.2xR_{Smean})/2=……Ω
- Rotor resistance as referred to the stator side R'$_2$=R_{01}-$R_{S(eff)}$=……..Ω

- Electrical equivalent of the mechanical load $R_L = R'2 \left[\frac{1-S}{S}\right]$ =…… Ω

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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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. ……..
2. ……..
3. ……..

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

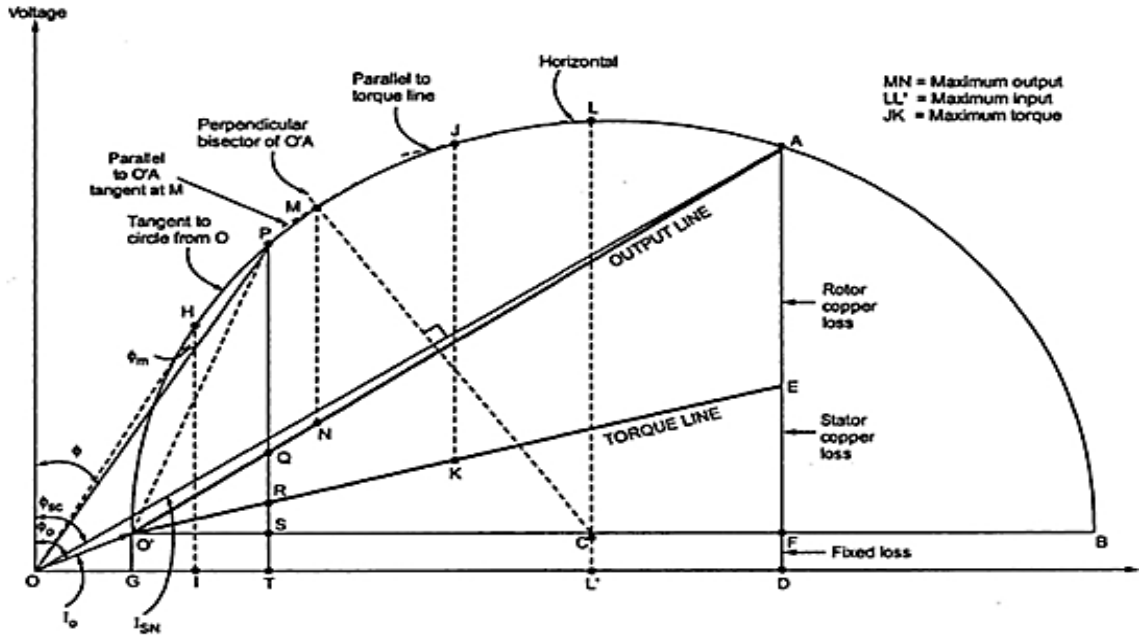
V Practical Learning Outcome

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

VI Minimum Theoretical Background

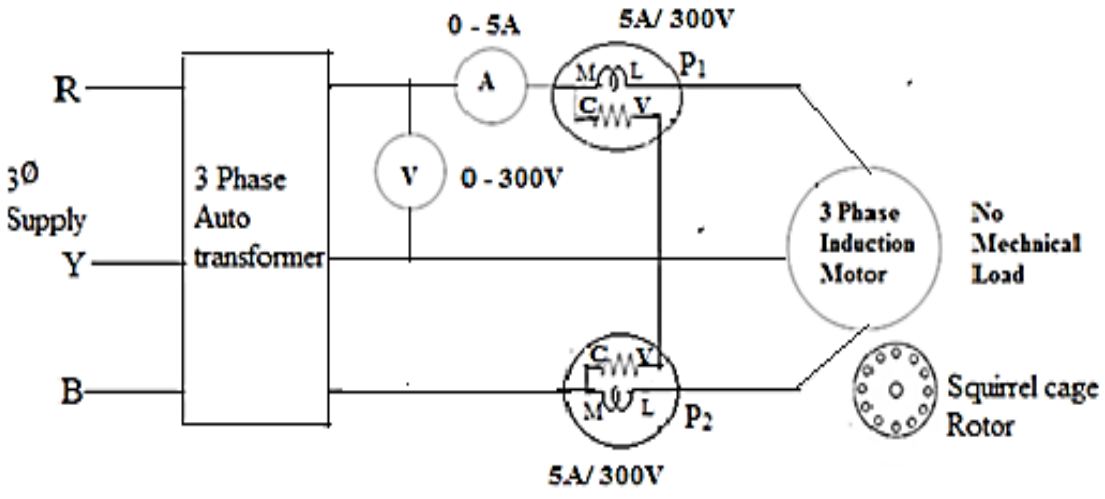
The circle diagram is the graphical representation of the performance of the electrical machine drawn in terms of the locus of the machines input voltage and current. Equivalent circuit for rotor of Induction motor is series R-L circuit with variable load resistance, so locus of rotor current for changing 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.

Circle diagram is locus of end of motor current vector when Induction motor is tested at various loads.

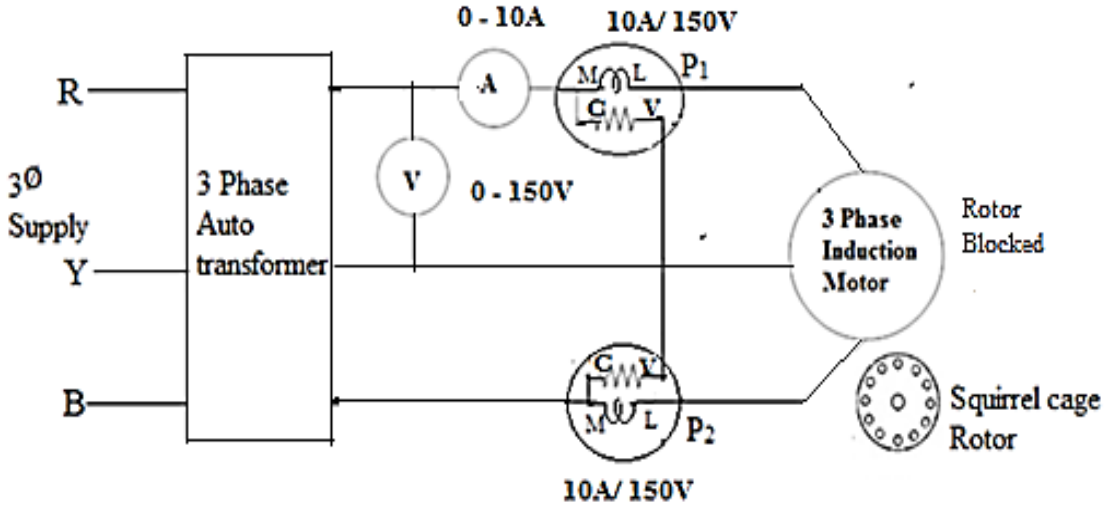


VII Circuit diagram:

No load Test



Blocked rotor Test



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1	AC Ammeter	Range- 0-5A and 0-10A	01 Each	
2	AC Voltmeter	Range- 0-500V	02	
3	Wattmeter	Range- 500V, 10A	01	
4	Tachometer	-	01	
5	Induction Motor	3Hp/5HP, 415V, 50Hz, three phase squirrel cage	01	
6	LPF Wattmeter	Range: 500V, 5A	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.
4. Ensure Autotransformer is at zero position at start.

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		
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2.					
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XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

No Load Test

Motor input V_{rated} Volts	Motor current I_0 Amps	Motor No Load Power W_0 Watts	
V_{rated}	I_0	W_1	W_2

Blocked Rotor Test

Motor Voltage V_{SC} Volts	Motor current I_{rated} Amps	Motor blocked rotor Power W_{SC} Watts	
V_{SC}	I_{rated}	W_1	W_2

Measured voltage and current values are per phase values

Calculation:

- **Circle diagram calculations**

  $\cos \emptyset_0 = \frac{W_0}{\sqrt{3}V_0 I_0}$ = ……..

  $\cos \emptyset_{SC} = \frac{W_{SC}}{\sqrt{3}V_{SC} I_{SC}}$ = …….

  current scale I_{SCN} = …….

  Assuming current scale 1 cm = ……

- **Power scale calculation**

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

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

  Rated o/p = …….

- **FL Calculation**
  - Full load current = …….. cm = …… cm × current scale

    = …….. Amp
  - Full load power factor = ……
  - Full load output = …….. cm = …… cm × power scale

    = ……. Watt
  - Full load Input = ……..
  - Full load efficiency = ……...

- Full load stator cu losses = ……
- Fixed losses = ……..
- Full load rotor cu losses = …….
- Full load Rotor Input = …….
- Full load slip = …….
- Full load Torque = ……...Torque ca
- Full load speed = ……..

➢ **Maximum Quantities calculation**

- Max Output = ……
- Max Input = ……..
- Max Torque = ……

➢ **Starting Torque calculation**

- Starting Torque = ……..

XV Results:

Motor FL efficiency = …… %
Motor NL Torque = …… Nm
Motor Max output = ……. HP

XVI Interpretation of results

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XVII Conclusion

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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.

(Space for answers)

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

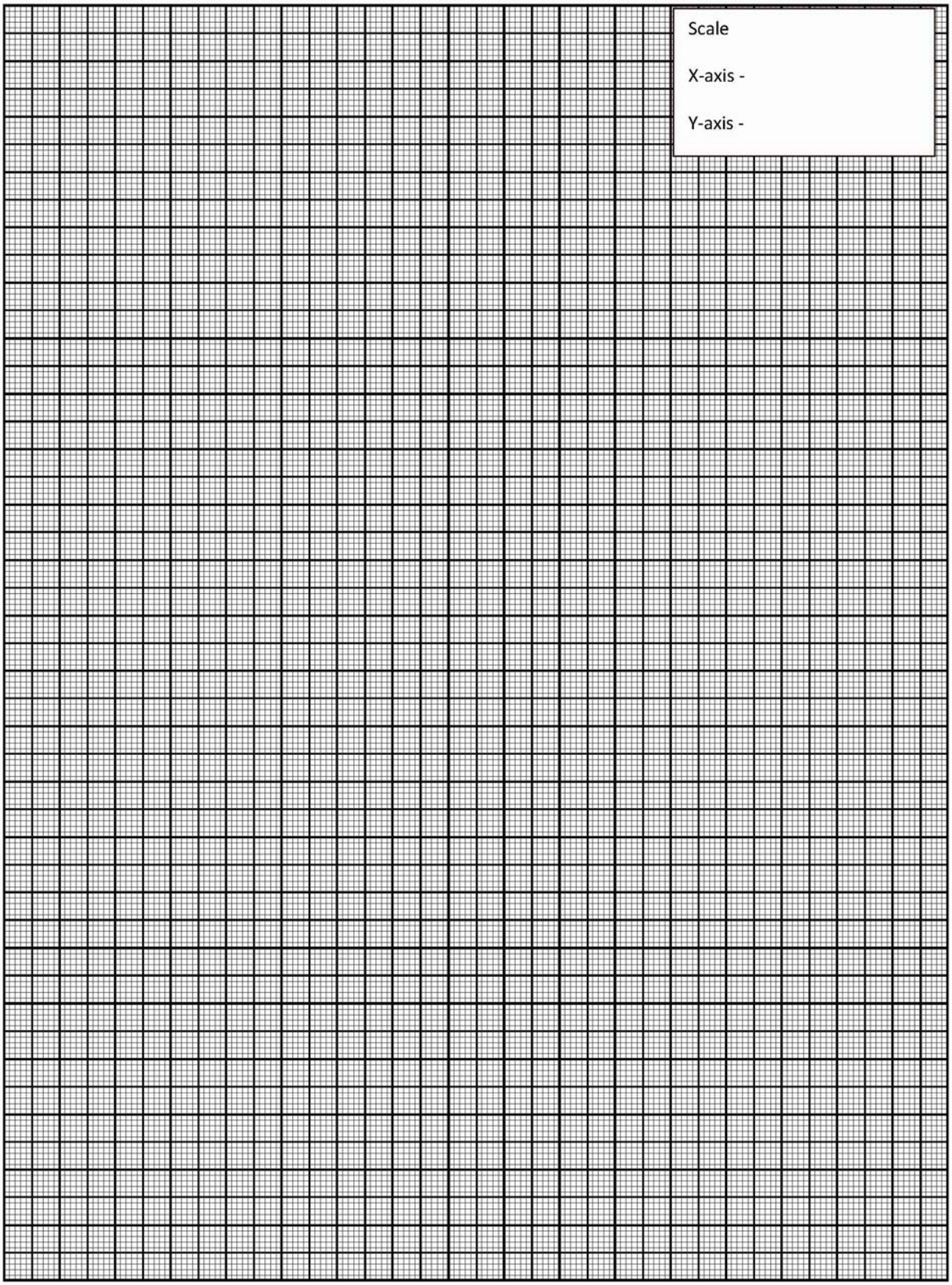
XX Assessment Scheme

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 (15 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. ……
2. ……
3. ……

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

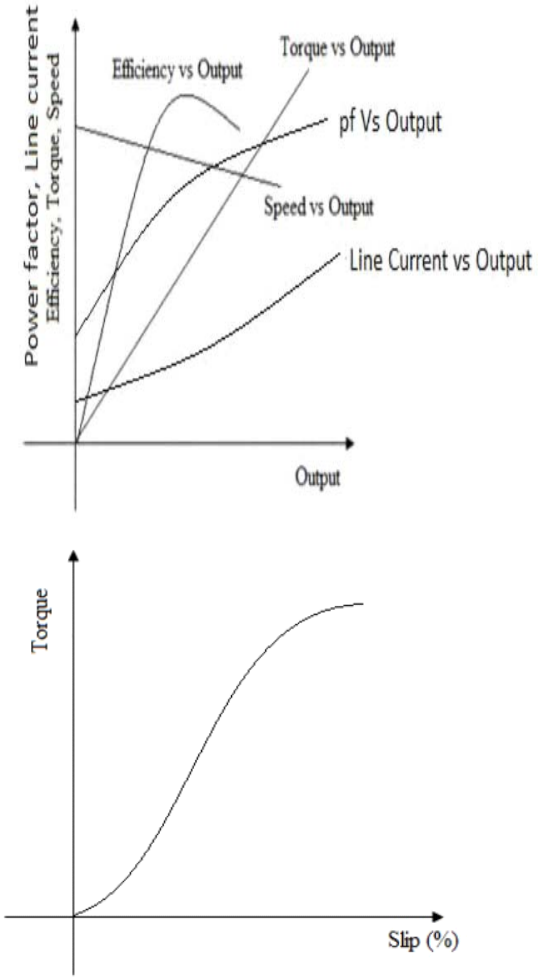
- Maintain rotating electrical machines.

V Practical Learning Outcome

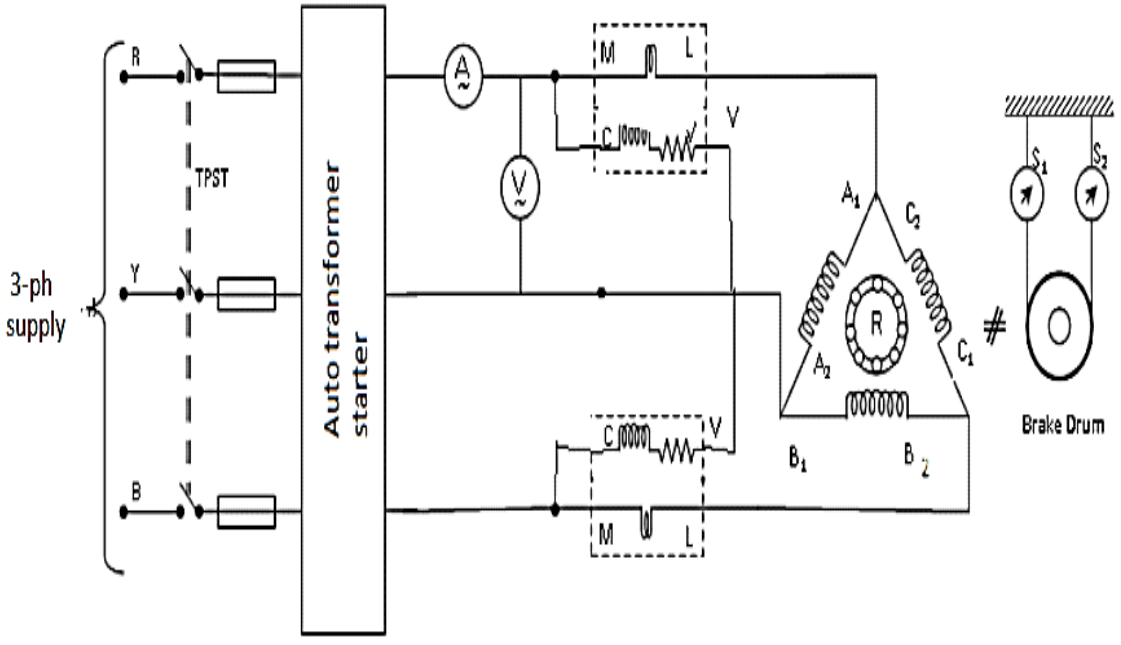
- To perform Brake test on three phase induction motor.
- To study operating characteristics of 3 phase induction motor.

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.



VII Circuit diagram:



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1	AC Ammeter	Range- 0 to 10A	01	
2	AC Voltmeter	Range- 0 to 500V	01	
3	Wattmeter	Range-(500V, 10A)	02	
4	Tachometer	-	01	
5	Induction Motor	3 HP/5Hp, 415V, 50Hz,1440 squirrel cage type		

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. There must be no load when starting the motor.

X Procedure

1) Connections are made as per circuit diagram.
2) The rotor was made very much free to rotate.
3) Pour some water inside the brake drum so as to cool the rotor belt.
4) 3-Φ induction motor started using autotransformer starter.
5) Adjusted the load till current was made to rated value of motor.
6) Decrease the load step by step and note corresponding speed, load, current, voltage and wattmeter readings.
7) At certain load, wattmeter W_2 will show negative reading. Note down the line current at this point.
8) Interchange the connection of current coil of wattmeter W_2 which was reading negative after switching off supply.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
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4.					
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XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

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

Calculations:

Radius of Brake drum R=……m

Ns= Synchronous speed in rpm ……

N =Rotor speed in rpm ……

S1&S2= Load of brake drum in kg ……

V_L=Line voltage in Volts ……

I_L= Line current in Amps ……

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

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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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

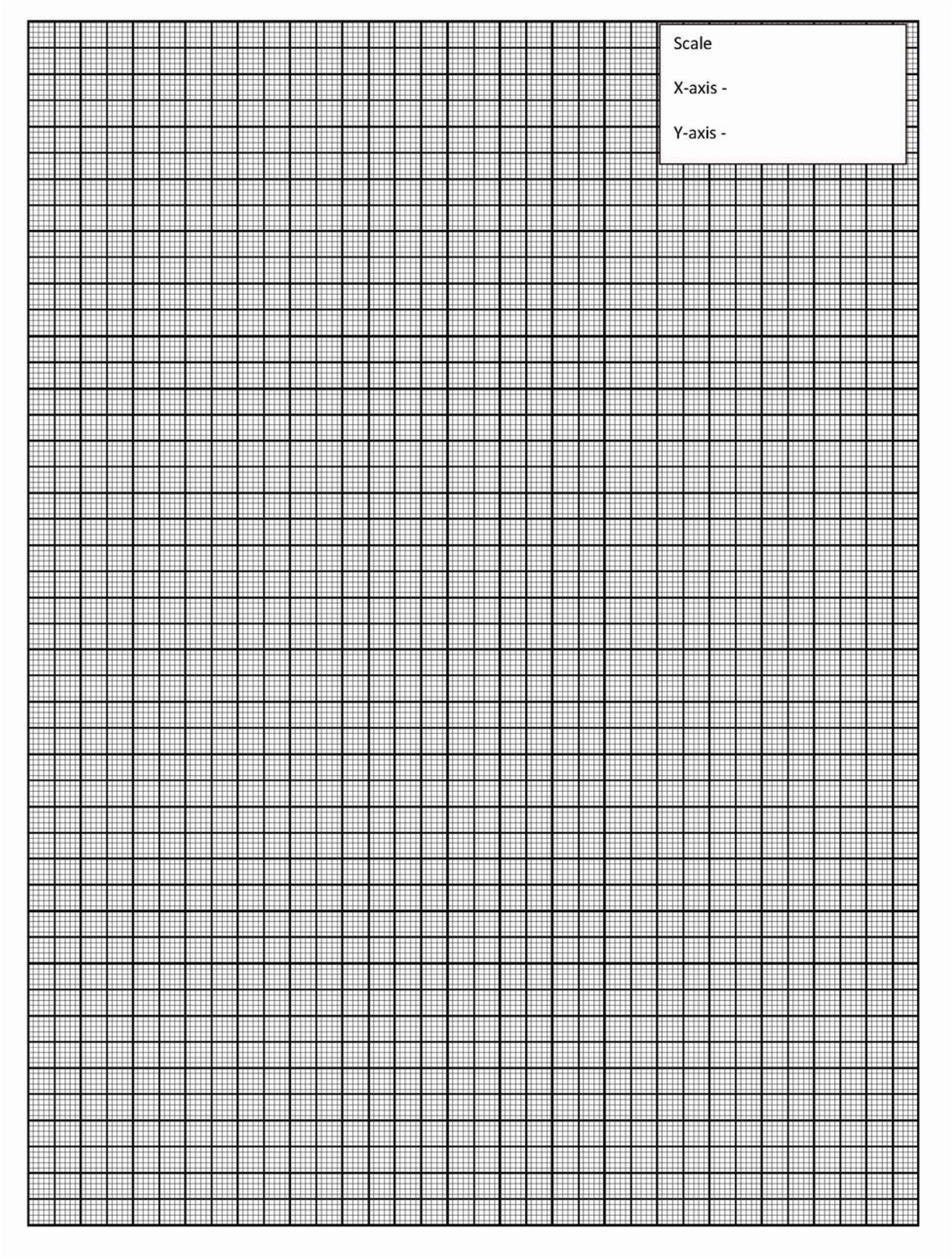
XX Assessment Scheme

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. ……..
2. ……..
3. ……..

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

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

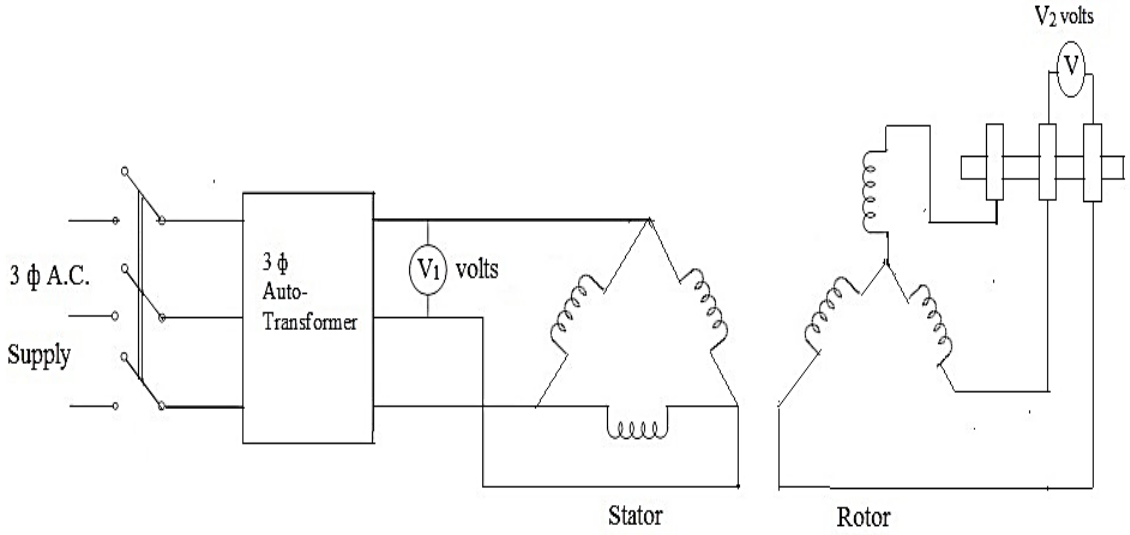
- To perform open circuit voltage ratio/ turns ratio between phase winding.

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

$\sqrt{3}$ to get V_{Ph}. The readings of V_2 are taken across different slip rings and in different positions of rotor. Average of these values is taken.

VII Circuit diagram:



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1	Three phase Slip ring Induction Motor	3 HP/5 HP 1500RPM.415 V,	01	
2	Three Phase Autotransformer	Range- 0-415V, 15 A,	01	
3	Voltmeter	Range- 0 to 300V	02	

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

1) Disconnect the rotor resistance starter from the slip rings.
2) Connect voltmeter across slip rings.
3) Give rated voltage (V_1) to the stator winding though autotransformer.
4) Measure voltage (V_2) across slip rings. Take different readings of V_2 across different slip rings and different position of rotor. Take average value.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

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

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

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

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org

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. ……
2. ……
3. ……

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

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

case letters while low voltage terminals are marked with lower case letters. For a 3 phase transformer viewed from H.V. side, the arrangement of both sets of terminals shall be in alphabetical order from left to right. If neutral is provided, it should be on extreme left.

Types of polarity:

1. Additive polarity
2. Subtractive polarity

Polarity test: It is essential to know the relative polarity of primary and secondary terminals, at any instant for making correct connections, when the two transformers are to be connected in parallel to share the load on the system.

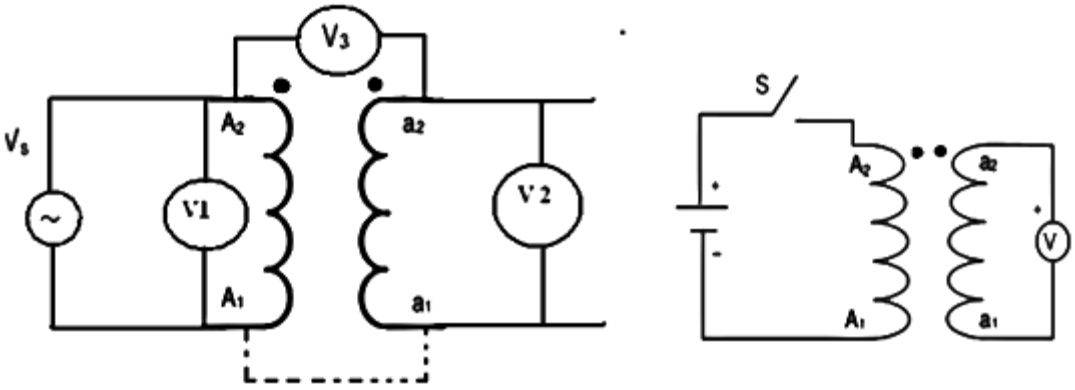

Fig a) A.C Test **Fig b) D.C Test**

Both A.C. and D.C methods can be used for detecting the polarities of the induced e.m.fs. The dot method is used to indicate the polarities. The transformer is connected to a low voltage A.C. source with the connection made as shown in the fig.(a). A supply voltage V_s is applied to the primary and the readings of the voltmeters V_1, V_2 and V_3 are noted.

- If V_3 readsV_1-V_2 then assumed dot locations are correct (for the connection shown). The beginning and end of the primary and secondary may then be marked by A_1-A_2 and a_1-a_2 respectively.
- If the voltage rises from A_1 to A_2 in the primary, at that instant it does so from a_1 to a_2 in the secondary.

Fig.(b) shows the D.C method of testing the polarity. When the switch S is closed if the pointer of voltmeter shows momentary deflection (kick) towards positive reading the assumed polarity is correct. If the pointer shows a kick towards negative side (below zero), the assumed polarity is wrong.

VII Circuit diagram:

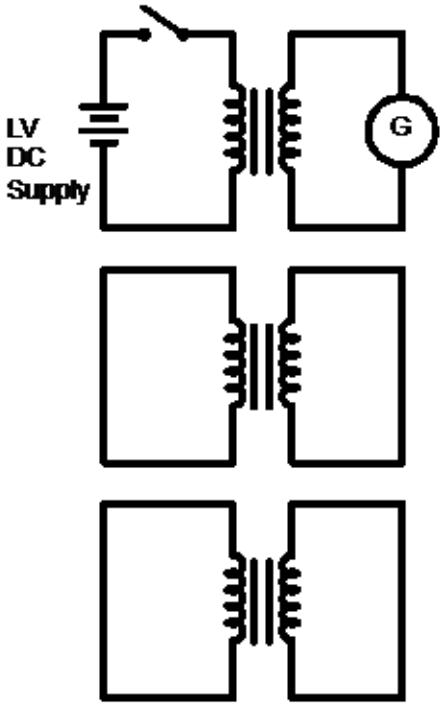

Fig A - Phasing Out Test

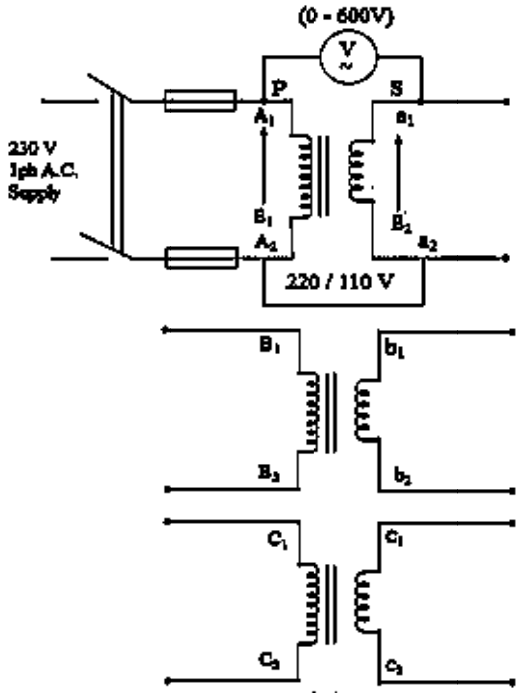

Fig B - Polarity test

Select the proper range of meters referring to the machine/s specifications/ratings

VIII Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Three phase transformer of suitable size	2 to3 KVA, 220V/110V	1 No.
2	Low Voltage D.C source	Up to 30V	1 No.
3	Galvanometer	30mA – 0 – 30mA	1 No.
4	AC Voltmeter	0-600 V	1 No.
5	Multimeter		1 No.

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.

X Procedure

A) Phasing Out Test

1. Make the connections as per circuit diagram.
2. Apply low voltage D.C. supply using a battery or DC power supply to primary winding.

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.					
2.					
3.					
4.					
5.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

a) Reading for Phasing Out Test

Sr. No.	D.C. supply given to primary winding	Deflection of Galvanometer observed between secondary terminals.			Remarks
		Deflection across first secondary	Deflection across second secondary	Deflection across third secondary	
1	P1				
2	P2				
3	P3				

b) Reading for Polarity Test

Sr. No.	Name of phase	E_1volt	E_2volt	Measured Voltage (V)	Calculated Voltage V = (E1- E2) or V = (E1 + E2)	Type of Polarity
1	R - Phase					
2	Y- Phase					
3	B - Phase					

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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XIX References / Suggestions for Further Reading

1) https://www.allinterview.com/showanswers/128205
2) Theory and performance of Electrical Machines - J.B. Gupta
3) Kataria & Sons Publishers of Engineering & Computer Books, Delhi. ISBN : 9789350142776,9350142775

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. …….
2. …….
3. …….

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

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

current or the required load current in the secondary winding, keeping low voltage winding short circuited.

Expression for % efficiency and regulation

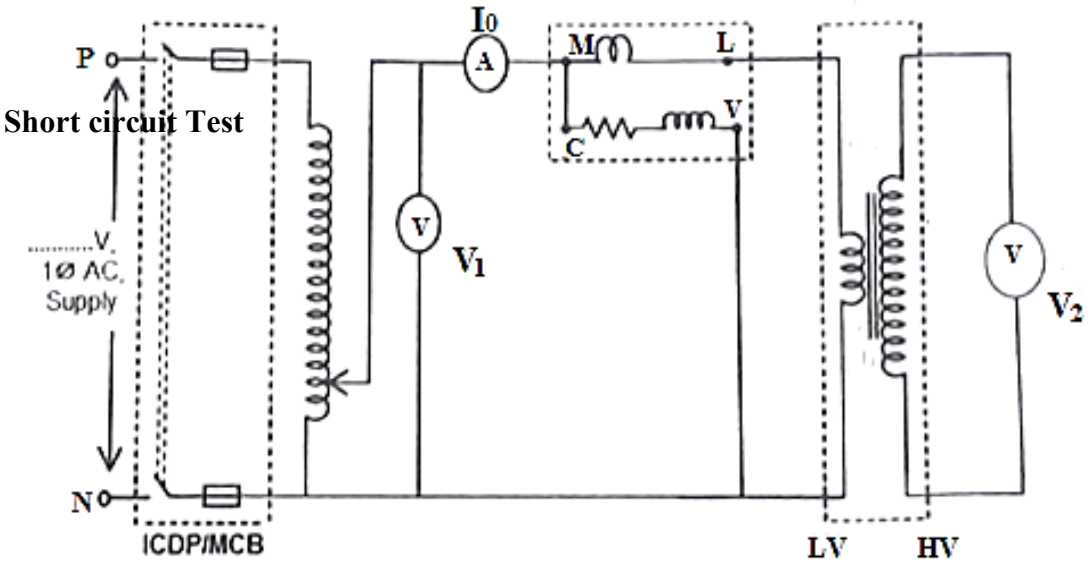
a) % Regulation at full load = $\frac{I_2R_{02}\cos\emptyset \pm I_2X_{02}\sin\emptyset}{V_2} \times 100$

% Regulation at any load = $\frac{x\, I_2R_{02}\cos\emptyset \pm x\, I_2X_{02}\sin\emptyset}{V_2} \times 100$

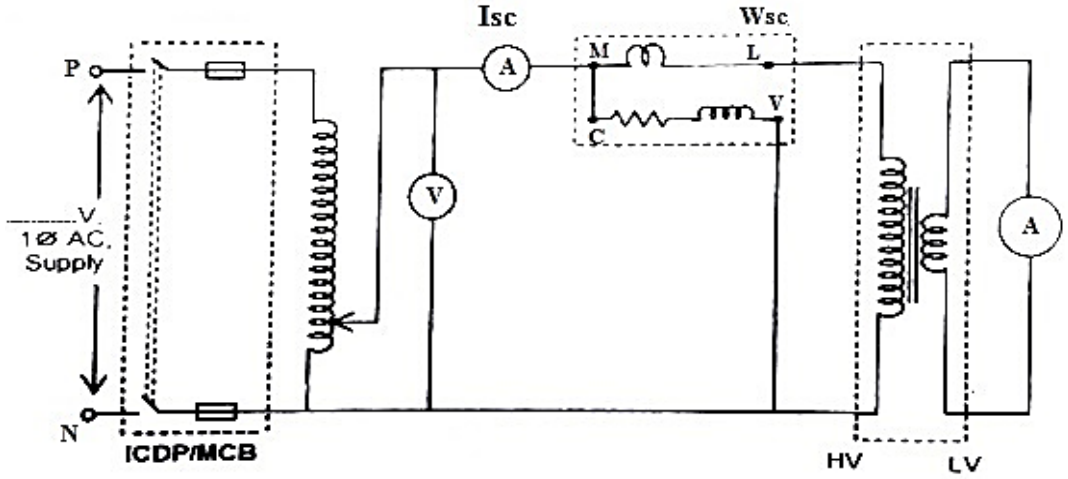
b) % Efficiency at any load = $\frac{x\,(\text{VA rating})\times\cos\emptyset}{x\,(\text{VA rating})\times\cos\emptyset + W_0 + x^2W_{SC}} \times 100$

VII Circuit diagram :

Open circuit test:



Short circuit Test



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Transformer	1 Phase, 500 VA to 1 KVA, 230 V/115V	1
2	Auto transformer	230 V, 1 Phase , 10 A	1
3	AC Voltmeter	0-75/ 150/ 300V MI Type	2
4	AC Ammeter	0-2.5- 5- 10 A MI Type	2
5	LPF Wattmeter	0-150/300/600 V, 1/2 A	1
6	Wattmeter	0-75/150/300 V, 5/10 A	1

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. Due care must be taken while taking reading in O.C test to avoid any accident as open terminals of HV winding are at high voltage.
5. It is extremely important to note that a low voltage is to be applied to the HV winding during SC test.

X Procedure

Open Circuit Test:

1. Make the connection as per the circuit diagram for O.C Test.
2. Set an auto transformer to zero position and switch ON the supply.
3. Increase the autotransformer output voltage gradually till rated voltage is reached.
4. Note down the readings of voltmeter, ammeter and wattmeter.
5. Bring the autotransformer knob to minimum position and switch OFF the supply.

Short Circuit test:

1. Note down the name plate rating and determine the rated currents for both the windings of given transformer
2. Make the connection as per the circuit diagram for O.C Test.
3. Set the auto transformer output to zero and switch ON the supply.
4. Increase the autotransformer output voltage very slowly and carefully till rated current
   flows through the windings.
5. Note down the readings of voltmeter, ammeter and wattmeter.
6. Bring the autotransformer knob to minimum position and switch OFF the supply.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					
3.					
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XII Actual procedure followed

A) O.C Test

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B) S.C Test

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XIII Precautions followed

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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= $\frac{V_2}{V_1}$

Short Circuit Test:

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

Calculations:

Total resistance referred to H.V side

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

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

% Efficiency at full load

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

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

= …… %

% Efficiency at any load and given p. f

$X = \frac{\text{actual load}}{\text{full load}}$ = ……..

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

Iron losses = $W_i = W_0$ = …….

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

Total losses = $W_i + W_{cu}$ = ……

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

% Voltage regulation at full load of given p. f

% Regulation at full load = $(I_2 R_{02}\cos\emptyset_0 \pm I_2 X_{02}\sin\emptyset_0)/V_2$

% Regulation at any(x) load = $(x\ I_2\ R_{02}\cos \emptyset_0 \ \pm x\ I_2\ X_{02}\sin \emptyset_0)/V_2$

'+' for lagging power factor

'-' for leading power factor

XV Results:

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

XVI Interpretation of results

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XVII Conclusion

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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)

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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. …….
2. …….
3. …….

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

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

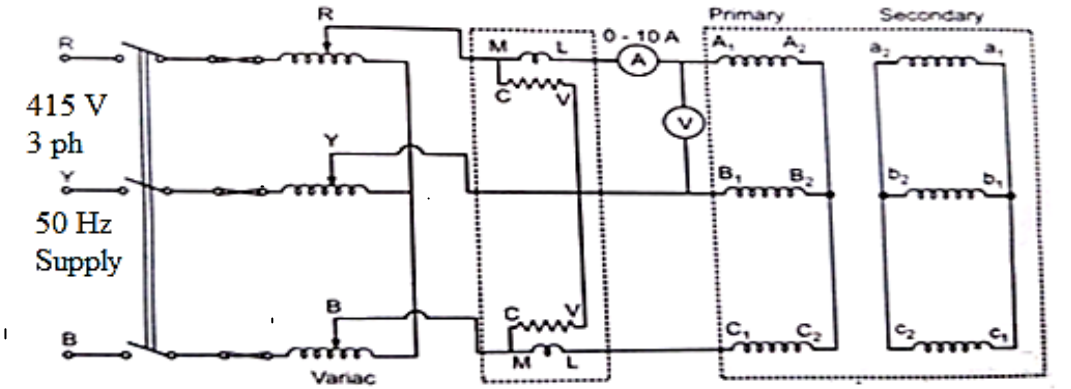
In open circuit test carried out on a three phase transformer, generally L.V. winding is connected to supply and H.V.is left open because sometimes it may be difficult to manage H.V. voltage in laboratories. In industry for obtaining more accurate reading of core losses under such condition, a rectifier 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.

In Short Circuit test, the equivalent impedance, the equivalent resistance and equivalent reactance of transformer referred to measuring side can be determined. If full load current is circulated through transformer winding full load copper loss is also determined. Generally HV winding is connected to variable voltage supply source and LV winding is short circuited. Reading of wattmeter indicates full load copper loss. The voltage applied under this condition is called impedance voltage.

VII Circuit Diagram: (Students Should draw diagram for Open Circuit Test)

Open Circuit Test

Short Circuit Test



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Three Phase Transformer	Range- 230V/115V, 3kVA, y-y type	01	
2.	Three Phase Autotransformer	Range- 415V, 30A	01	
3.	A.C.Ammeter	Range- 0 to 10A	01	
4.	A.C.Voltmeter	Range- 0 to 300V	01	
5.	Multimeter	-	01	
6.	Wattmeter	Range: 10A, 300V	02	

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.					
2.					
3.					
4.					
5.					
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XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

A) Open Circuit Test:

Sr. No.	No load current I_o AMP	V_0	W_1	W2	Wo= W_{1+} W2
1.					

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					

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

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

From Short Circuit Test

$Z_{O1} = \frac{V\,sc}{Isc}$ =.....

$R_{O1} = \frac{W_{SC}}{3I_{SC}^2}$ =.....

$X_{O1} = \sqrt{(Z_{O1})^2 - (R_{O1})^2}$ =.....

P_{out} = 3 V_{ph} I_{ph} cosΦ =.....

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

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

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

XV Results:

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XVI. Interpretation of results

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XVII. Conclusion

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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)

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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 %
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. …….
2. …….
3. …….

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

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

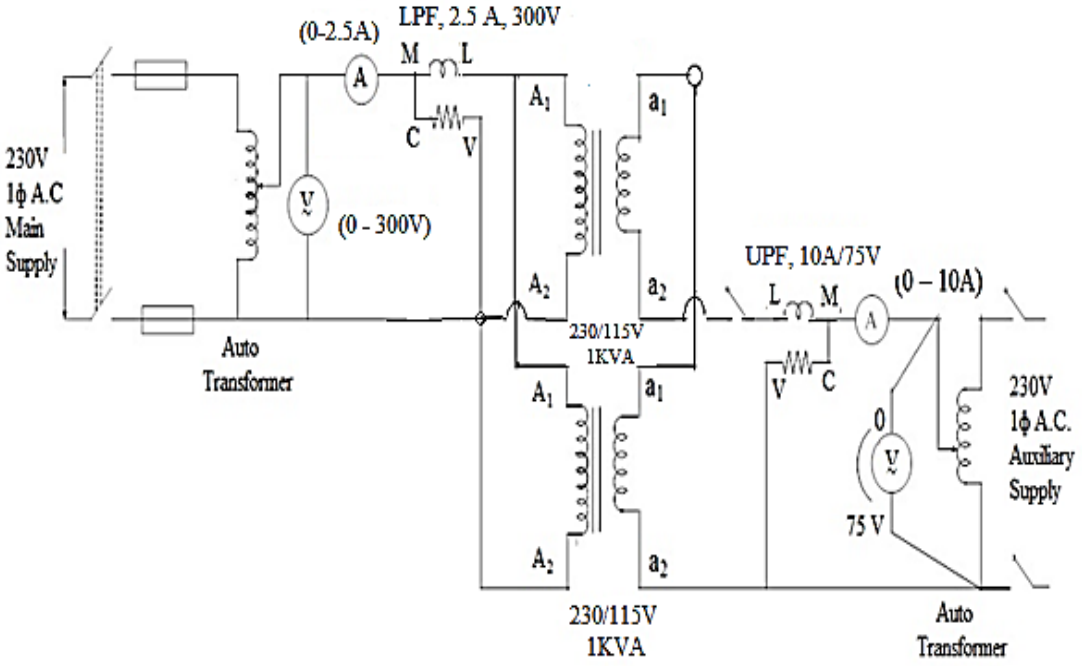
- Perform back to back test on two identical single phase transformers and determine their efficiencies and regulations.

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

their secondary currents are absent. An auto-transformer is connected in series with the two secondaries. A small voltage is injected in the secondary circuit from a separate ac source. It will circulate a current in the secondary side since the secondary's are in opposition, the secondary current will cause by transformer action primary side currents in opposite directions. Thus the total current in the primary local circuit of the windings is zero. The reading of wattmeter on primary is not affected and it will indicate only the iron losses of the two transformers. The auto-transformer is adjusted till the full load current flows in the secondary side of the transformer. At full load current the wattmeter on the secondary side indicates the full load copper losses of the two transformers as their winding resistances are in series.

VII Circuit diagram :



Select the proper range of meters referring to the machine/s specifications/ratings.

VIII Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Transformer	1 Phase, 1 KVA, 230 V/115V	2
2	Auto transformer	230 V, 1 Phase , 10 A	2
3	Voltmeter	0-300 V, 0-75 V	One each
4	Ammeter	0-10 A 0-2.5 A	One each
5	Wattmeter	LPF 2.5 A, 300 V UPF 10 A, 75 V	One each

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 auto transformer should be kept at zero output position initially.
5. Check the correctness of polarities of the two transformers by measuring voltage across switch.

X Procedure

1. Make the connections as shown in circuit diagram.
2. Initially keep switch‘s’ in open condition.
3. Switch ON the supply and check the correctness of polarities of the two transformers by measuring voltage across switch , if voltage gets zero then close switch ‘s’.
4. Note the reading of V_1, I_1 and W_1.
5. Now increase voltage of auxiliary transformer gradually so that full load current flows through secondary windings.
6. Note down V_2, $I_2$and W_2. While doing so, the values shown by V_1, I_1 and W_1 should not deviate from their earlier readings.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					

XII Actual procedure followed

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XIII Precautions followed

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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						

Calculation

Secondary no load voltage …… Volt

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

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

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

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

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

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

$$= \ldots\ldots\ldots\ldots\ldots\ldots * 100$$

$$= \ldots\ldots\ldots\ldots\ldots\ldots \%$$

XV Results:

- Total iron loss of the transformer is = …….. watts
- Total Full load Copper loss of the transformer is = …….. Watts
- The efficiency of each transformer is = …….. %
- Full load voltage regulation of each transformer is = ……..%

XVI Interpretation of results

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XVII Conclusion

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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. Justify
2) List out various tests to be conducted on transformer for finding out efficiency 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.

(Space for answers)

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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 %**

Names of Student Team Members

1. …….
2. …….
3. …….

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

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.

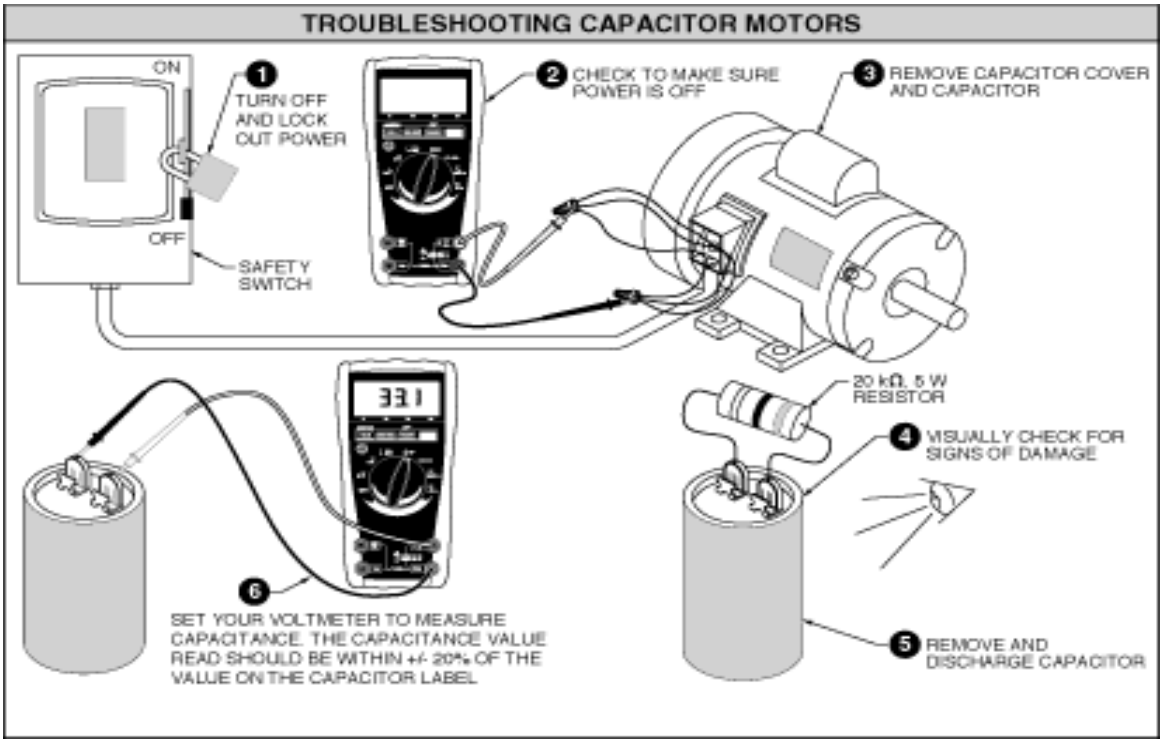
Trouble shooting chart:

Trouble shooting chart is essential for successful breakdown and preventive maintenance. In most of the industries trouble shooting charts are known as **"Repair Register"** and **"Card Index Form"**.

Troubleshooting process is as follows:

- Identify the problem
- Establish a theory of probable cause
- Test the theory to determine cause
- Establish a plan of action to resolve the problem and implement the solution.
- Verify full system functionality and if applicable implement preventive measures.
- Document findings, actions and outcomes.

VII Circuit Diagram:



VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Multimeter / Continuity Tester	-	01	
2.	Tachometer	-	01	
3.	Clip on meter	-	01	
4.	Test Lamp	-	01	
5.	Screw Driver	-	01	

6.	Hammer	-	01	
7.	Combination Plier	-	01	
8.	Spanner Set	-	01	
9.	Bearing Puller	-	01	
10.	Dial Test indicator	-	01	
11.	Feeler gauge	-	01	
12.	Megger	-	01	
13.	Test lamp	-	01	

IX Precautions to be followed

1. Make sure that supply is off and fuses are removed before carrying out maintenance work.
2. Use proper tools during maintenance work.
3. If replacement of part is required replace with proper rating / correct dimensions.

X Procedure

A) For maintenance Schedule:

1) Make a maintenance team of 4-5 students.
2) Plan the type of maintenance work to be carried out.
3) Select the single phase induction motor for the maintenance work.
4) Make sufficient space for the maintenance.
5) Before carrying out the maintenance work make sure that supply is OFF.
6) If breakdown maintenance is planned disconnect and remove the motor from the machine/job.
7) Follow the recommended steps for maintenance and prepare a report.

B) For Troubleshooting Chart:

1. Identify the trouble in single phase induction motor.
2. List out all possible reasons for occurrence of fault in respective trouble.
3. Establish a plan of action to resolve the problem and implement the solution.
4. Check the functionality of the motor.
5. Repeat above procedure for all troubles in single induction motor.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					

3.					
4.					
5.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and calculations:

i. For maintenance Schedule:

1) **Name of industry / plant/ shop: ……..**
2) **Name plate details of the motor:**

3) **Type of maintenance (Routine / Preventive / Breakdown): ……**
4) **Nature of maintenance planned (daily/ weekly/ yearly): …….....**
5) **List the activities carried out during maintenance:**

6) **Mention name of the part replaced (if any)**

ii. For Troubleshooting Chart:

Sr. No.	Trouble	Possible Fault (s)	Remedies/Solution
1	Motor does not start		
2	Motor runs too hot		
3	Speed varies		
4	Motor runs slow		
5	Excessive speed of motor		

6	Motor body gives shock		
7	Noisy running		

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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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%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….

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

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

financial loss. Aim of maintenance engineer should be to minimize the downtime of the machine. Troubleshooting chart is very helpful during breakdown maintenance.

VII Circuit Diagram:

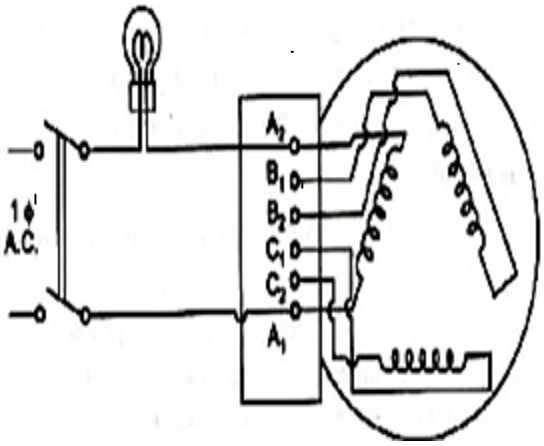

Fig: Open Circuit Faults

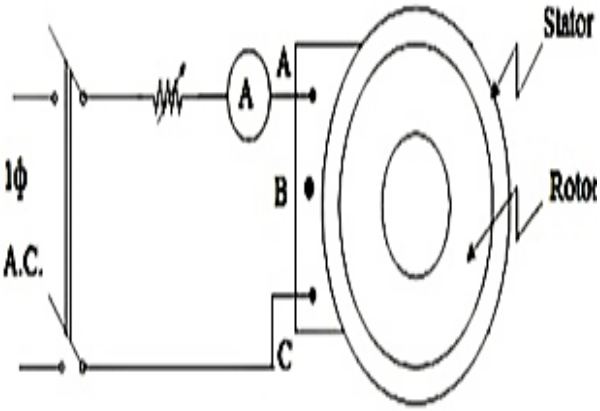

Fig: Broken Rotor Bar

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Multimeter / Continuity Tester	-	01	
2.	Tachometer	-	01	
3.	Clip on meter	-	01	
4.	Test Lamp	-	01	
5.	Screw Driver	-	01	
6.	Hammer	-	01	
7.	Combination Plier	-	01	
8.	Spanner Set	-	01	

IX Precautions to be followed

1. Make sure that supply is off and fuses are removed before carrying out maintenance work.
2. Use proper tools during maintenance work.
3. If replacement of part is required replace with proper rating / correct dimensions.

X Procedure

Students can visit workshop / machine laboratory of a industry/college to observe the maintenance activities carried out there.

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.					
2.					
3.					
4.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and calculations:

A) Maintenance schedule:

Name plate details of the motor:

Type of maintenance (Routine / Preventive / Breakdown):

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List the activities carried out during maintenance.

Mention name of the part replaced (if any)

B) Troubleshooting chart of three phase induction motor.

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:

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XVI Interpretation of results

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XVII Conclusion

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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)

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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%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

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

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.

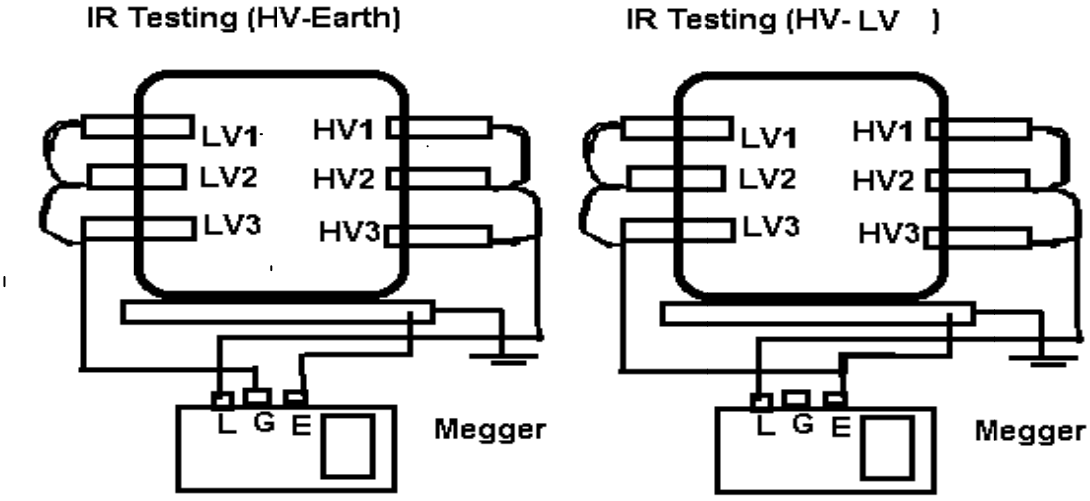
V Practical Learning Outcome

- 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.

VII Circuit Diagram:



VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Multimeter	-	01	
2.	Megger	2000 MΩ, 1000V DC or 500 V.	01	
3.	Spanner set	-	01	

IX Precautions to be followed

1. Make sure that supply is off and fuses are removed before carrying out maintenance work.
2. Use proper tools during maintenance work.
3. If replacement of part is required replace with proper rating / correct dimensions.

X Procedure

1. Identify the trouble in transformer.
2. List out all possible reasons for occurrence of fault in respective trouble.
3. Establish a plan of action to resolve the problem and implement the solution.
4. Check the functionality of the transformer.
5. Repeat above procedure for all troubles in transformer.
6. Student may visit substation in college premises or any industry to observe various maintenance and troubleshooting activities. Student may search on internet the report of maintenance and troubleshooting activities done by industry.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					

2.					
3.					
4.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and calculations:

A. Maintenance of a three phase transformer

- **Name of industry / workshop / plant:**

- **Specifications of a transformer:**

- **Type of maintenance plan (Routine/Preventive/Breakdown)_____**
- **Nature of maintenance (Daily/ Weekly/ Yearly)_____**

- **Write observations / activities carried out during maintenance work:**

- **State the difficulties faced during maintenance**

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

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:

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XVI Interpretation of results

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XVII Conclusion

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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)

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XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. IS 10028 (Part III)-1981- Code of practice for selection, installation and maintenance of transformer: Part 3 Maintenance
4. www.bis.org.in
5. www.standardbis.in
6. https://www.anelectricalengineer.com/power-transformer-troubleshooting

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. ……..
2. ……..
3. ……

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

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.

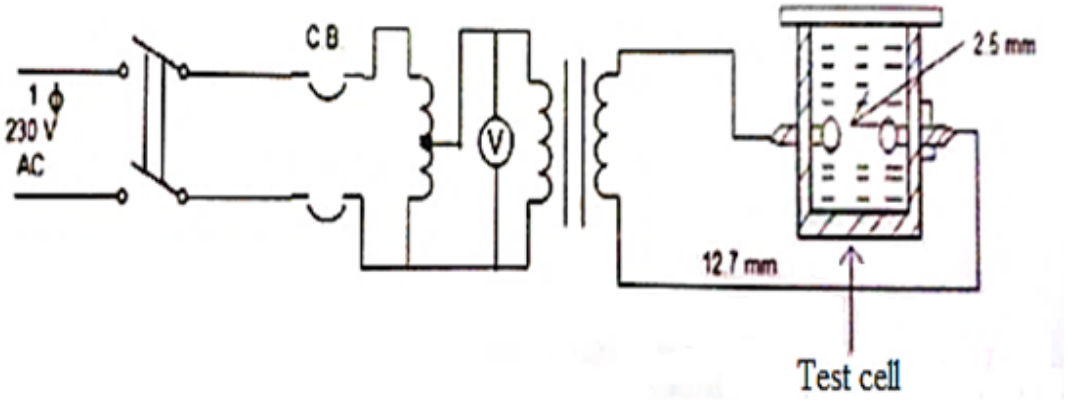
V Practical Learning Outcome

- 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.

VII Circuit diagram:



VIII Resources required

Sr No.	Name of Resource	Suggested Broad Specification	Quantity
1	Oil Test Kit	60 kV, Motorized Input supply – 230 Volt, 50 Hz	1

IX Precautions to be followed

1. Before using transformer oil breakdown voltage tester, the tester shell should be reliably grounded.
2. Check the distance between the electrodes
3. When collecting transformer oil and oil samples wipe the sampling valve and slowly
   open it. First flush the test cup 2-3 times and then take the oil sample.
4. When placing or removing the oil cup, it should be done under the condition of power off.
5 Transformer oil needs to be static in the cup 5 to 10min, to eliminate air bubbles.

X Procedure

1. Adjust the electrodes in the test cup for the required gap and lock them in the position with the help of locking nuts provided.
2. Fill $4/5^{th}$ of the cup with fresh oil tested and place the cup on the HV transformer bushing.
3. Close the top cover of the box. Door open lamp will switch OFF. Switch ON the unit mains ON and (H.T OFF) lamp will glow.
4. Press (H.T ON) push button, (H.T ON) lamp will glow and (H.T OFF) lamp will be OFF. The voltage will increase automatically and voltmeter will read the output voltage. In case of breakdown of the oil H.V will be disconnected, (H.T OFF) lamp will glow and (H.T ON) lamp will be switched OFF.
5. Note down the voltage reading at which breakdown has occurred, this reading will have to be taken within 30 seconds of breakdown.
6. Repeat the test sequence after the transformer oil test is completed.
   (Typically three repetitions depending on the standards)
7. Calculate the mean value of breakdown voltage.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

Sr. No.	Input Voltage	Breakdown Voltage in kV	Mean of breakdown voltage
1.			
2.			
3.			

XV Results:

- The breakdown strength of fresh transformer oil is = …….. kV

XVI Interpretation of results

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XVII Conclusion

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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.

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XIX References / Suggestions for Further Reading

1. https://www.electrical4u.com/transformer-insulating-oil-and-types-of-transformer-oil/
2. https://www.b2hv.com/oil-test.html

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. ……..
2. ……..
3. ……..

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

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.

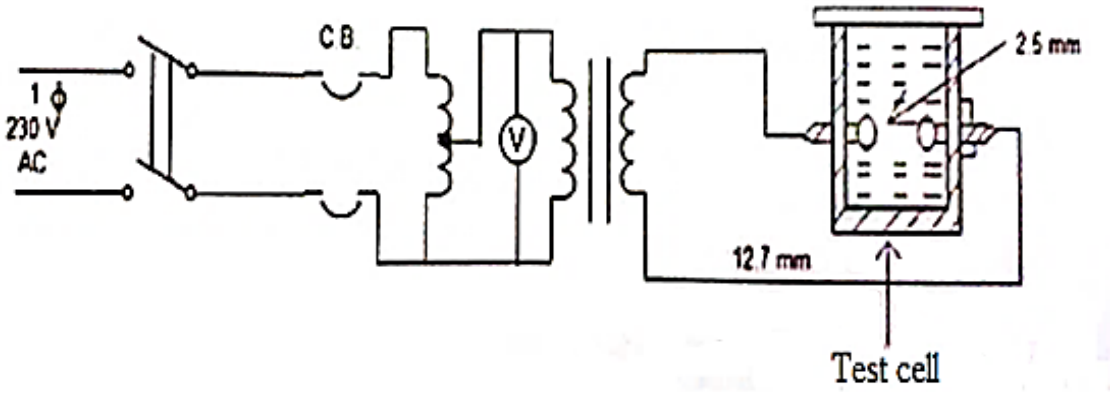
V Practical Learning Outcome

- 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.

VII Circuit diagram:



VIII Resources required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Oil Test Set	60 kV, Motorized Input supply – 230 Volt, 50 Hz	1

IX Precautions to be followed

1. Before using transformer oil breakdown voltage tester, the tester shell should be reliably grounded.
2. Check the distance between the electrodes
3. When collecting transformer oil and oil samples wipe the sampling valve and slowly
   open it. First flush the test cup 2-3 times and then take the oil sample.
4. When placing or removing the oil cup, it should be done under the condition of power off.
5. Transformer oil needs to be static in the cup 5 to 10min, to eliminate air bubbles.

X Procedure

1. Adjust the electrodes in the test cup for the required gap and lock them in the position with the help of locking nuts provided.
2. Fill $4/5^{th}$ of the cup with used oil tested and place the cup on the HV transformer bushing.
3. Close the top cover of the box. Door open lamp will switch OFF. Switch ON the unit mains ON and (H.T OFF) lamp will glow.
4. Press (H.T ON) push button, (H.T ON) lamp will glow and (H.T OFF) lamp will be OFF. The voltage will increase automatically and voltmeter will read the output voltage. In case of breakdown of the oil H.V will be disconnected, (H.T OFF) lamp will glow and (H.T ON) lamp will be switched OFF.
5. Note down the voltage reading at which breakdown has occurred, this reading will have to be taken within 30 seconds of breakdown.
6. Repeat the test sequence after the transformer oil test is completed.

a. (Typically three repetitions depending on the standards)

7. Calculate the mean value of breakdown voltage.

XI Resources used (with major specifications)

Sr. No.	Name of Resource	Broad Specification		Quantity	Remark (If any)
		Make	Details		
1.					
2.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and Calculations:

Sr. No.	Input Voltage	Breakdown Voltage in kV	Mean of breakdown voltage

XV Results:

- The breakdown strength of used transformer oil is = …….. kV

XVI Interpretation of results

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XVII Conclusion

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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)

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XIX References / Suggestions for Further Reading

1. https://www.electrical4u.com/transformer-insulating-oil-and-types-of-transformer-oil/
2. https://www.b2hv.com/oil-test.html

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……..

2……..

3……

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

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

VII Circuit Diagram: (Students should develop circuit diagram under the guidance of teacher)

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 equipment 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.					
2.					
3.					
4.					

XII Actual procedure followed

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XIII Precautions followed

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XIV Observations and calculations:

Test	Recommended test voltage (Min 2000V)	Observations (Yes/No)
High voltage test V-rated voltage V_{OC}- voltage between slip rings on open circuit. **(High voltage can be generated with the help of two or more transformers with their primaries in parallel and secondaries in series)**	Stator winding 1000+2V	Burning Smell…… Sparking…… Excessive heat…….. Any other…….. None of the above……..
	Rotor winding of slip ring motor 1000+2V_{OC}	

Calculations:

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

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XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. www.bis.org.in
4. www.standardbis.in

XX Assessment Scheme

Performance indicators		Weightage
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total	**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. ……..

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

Experiment No. 16: To perform HV test on single 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.

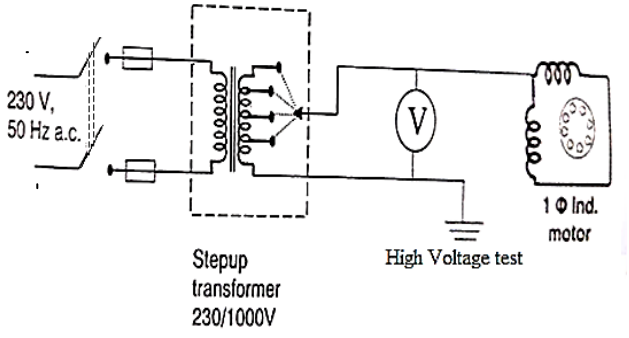
V Practical Learning Outcome

- Perform HV test on single phase induction motor.

VI Minimum Theoretical Background

High voltage test is a routine test which is conducted on each machine after manufacturing. This test is carried out to check withstand capability of insulation at high voltages. It gives idea about weakness of insulation, damaged insulation. 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.

VII Circuit Diagram:



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					
2					
3					
4					

XII Actual procedure followed

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XIII Precautions followed

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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…… Sparking…… Excessive heat…….. Any other…….. None of the above……..

Calculations:

XV Results:

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XVI Interpretation of results

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XVII Conclusion

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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)

XIX References / Suggestions for Further Reading

1. www.electrical4u.com
2. www.electricaltechnology.org
3. www.bis.org.in
4. www.standardbis.in

XX Assessment Scheme

Performance indicators		Weightage
Process related (60%)		**15 Marks**
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 (40%)		**10 Marks**
6	Calculation	10 %
7	Interpretation of result	05 %
8	Conclusions	05 %
9	Practical related questions	15 %
10	Submitting the journal in time	05%
	Total	**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….

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