I

Name ______________________

Roll No. ______________ Year 20 ______ 20 ______

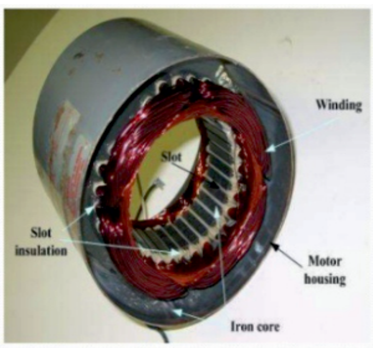
Exam Seat No. ______________________

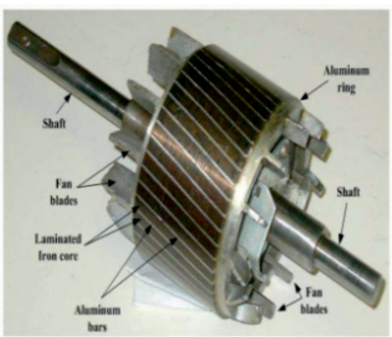
ELECTRICAL GROUP | SEMESTER - V | DIPLOMA IN ENGINEERING AND TECHNOLOGY

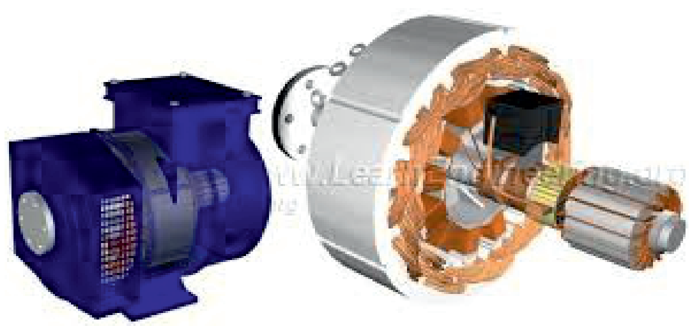
A LABORATORY MANUAL

FOR

INDUSTRIAL A C MACHINES (22523)







MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

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

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Practical Manual

for

Industrial A C Machines

(22523)

Semester – V

(EE, EP, EU)

Maharashtra State

Board of Technical Education, Mumbai

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

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001: 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on May,2019)

Maharashtra State
Board of Technical Education
Certificate

This is to certify that Mr./Ms………………………………….. Roll No……………………….of Fifth Semester of Diploma in ………………………………………………………….of Institute……………………………………………………….… ……….. (Code………………..) has attained predefined practical outcomes (PROs) satisfactorily in course **Industrial A.C. Machines (22523)** 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-base 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, Industrial A.C. Machine.

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 **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications'.**

1. Use the relevant three phase induction motor (IM) for different applications.
2. Use the relevant single phase induction motors in different applications.
3. Use the relevant three phase alternator for different load conditions.
4. Use suitable synchronous motors in different applications.
5. Use suitable Fractional HP motors for different applications.

Practical- Course Outcome matrix

Course Outcomes (COs):-

a. Use the relevant three phase Induction motor (IM) for different applications.
b. Use the relevant single phase Induction motor in different applications.
c. Use the relevant 3 phase alternator for different load condition.
d. Use suitable synchronous motors in different applications.
e. Use suitable Fractional HP motors for different applications..

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Identify the different parts (along with function and materials) for the given single phase and three phase induction motor.	√	√	-	-	√
2.	Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL, star-delta, auto-transformer starters (any two)	√	-	-	-	-
3.	Perform the direct load test on the three phase squirrel cage induction motor and plot the i) efficiency versus output, ii) power factor versus output, iii) power factor versus motor current and iv) torque – slip/speed characteristics.	√	-	-	-	–
4.	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and determine the equivalent circuit parameters.	√	-	-	-	-
5.	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and plot the Circle diagram.	√	-	-	-	-
6.	Control the speed of the given three phase squirrel cage induction motor using the applicable methods: i) auto-transformer, ii) VF	√	-	-	-	-
7.	Control the speed of the given three phase slip ring induction motor using rotor resistance starter.	√	-	-	-	-
8.	Control the speed of the given three phase induction motor using pole changing methods	√	-	-	-	-

9.	Identify different windings & components of single phase capacitor start Induction Run motor & Connect to start & reverse the direction of rotation	-	√	-	-	√
10.	Conduct the direct load test to determine the efficiency and speed regulation for different loads on the given single phase induction motor; plot the efficiency curves with respect to the output power.	-	-	√	-	-
11 ✯	Perform the direct loading test on the given three phase alternator and determine the regulation.	-	-	√	-	-
12. ✯	Determine the regulation of the given three phase alternator from OC and SC tests (Synchronous impedance method)	-	-	√	-	-
13. ✯	Start 3 phase synchronous motor & run synchronous motor in forward & reverse direction	-	-	-	√	-
14.	Conduct the test on load or no load to plot the ‘V’ curves and inverted ‘V’ curves of 3-ϕ synchronous motor.	-	-	-	√	-

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

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 *	Identify the different parts (along with function and materials) for the given single phase and three phase induction motor.	1					
2 *	Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL, star-delta, auto-Transformer starters (any two)	10					
3 *	Perform the direct load test on the three phase squirrel cage induction motor and plot the i) efficiency versus output, ii) power factor versus output, iii) power factor versus motor current and iv) torque – slip/speed characteristics.	18					
4 *	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and determine the equivalent circuit parameters.	30					
5 *	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and plot the Circle diagram.	39					
6 *	Control the speed of the given three phase squirrel cage induction motor using the applicable methods: i) auto-transformer, ii) VF	48					
7 *	Control the speed of the given three phase slip ring induction motor using rotor resistance starter.	56					

8	Control the speed of the given three phase induction motor using pole changing methods	63					
9	Identify different windings & components of single phase capacitor start Induction Run motor & Connect to start & reverse the direction of rotation	70					
10	Conduct the direct load test to determine the efficiency and speed regulation for different loads on the given single phase induction motor; plot the efficiency curves with respect to the output power.	78					
11 *	Perform the direct loading test on the given three phase alternator and determine the regulation.	87					
12 *	Determine the regulation of the given three phase alternator from OC and SC tests (Synchronous impedance method)	97					
13 *	Start 3 phase synchronous motor & run synchronous motor in forward & reverse direction	107					
14	Conduct the test on load or no load to plot the 'V' curves and inverted 'V' curves of 3-ϕ synchronous motor.	114					
Total					.		

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

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

Experiment No. 1: Identify the different parts of given single phase and three phase Induction motor.

I Practical Significance

Single phase and three phase Induction motors are widely used in various home appliances and industries as drive motors for variety of machines due to its rugged construction, smoother and efficient operation. Its construction is simple consisting Stator &rotor as main parts.

II Relevant Program Outcomes (POs)

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: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications'.**

- To use various tools such as spanner, plier, screw driver
- To identify induction motor &it's different internal parts
- To reassemble the induction motor.
- To dismantle & reassemble the induction motor

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.
- Use the relevant single phase Induction motor for different application.

V Practical Learning Outcome

- Identify the different parts for the given single phase and three phase induction motor.
- Know the function and materials used for different parts of single phase and three phase induction motor.

VI Minimum Theoretical Background

Single phase Induction motor consists of squirrel cage rotor & stator with two windings (main & starting) placed at 90^0 Electrical degrees for providing split phase. Starting winding can be disconnected with the help of centrifugal switch.
Three phase squirrel cage induction motor consists of squirrel cage rotor & stator with three windings in delta or star. In slip ring motor, rotor consists of 3 phase star connected windings whose terminals are connected to slip ring with brushes and rotor resistance starter.

VII Circuit diagram:

1) Draw circuit diagram of given single phase Induction motor.

2) Draw neat diagram of rotor of given three phase motor.

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Induction motor	3 HP/ 5 HP, 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Induction motor	Single phase 1HP 230 V 50Hz Capacitor start IM	01	
3.	Screw driver	Suitable set	01	
4.	Plier	Suitable	01	
5.	Spanner	Suitable	01	
6.	Hammer	½ kg	01	
7.	Multimeter	Digital	01	

IX Precautions to be followed

1) Make sure that main switch is in OFF position & motor is disconnected from supply
2) Motor is mechanically disconnected from load

X Procedure

1) Open the given 1 phase motor with the help of suitable tools.
2) Identify all the parts & prepare the table for parts, material & function.
3) Open the given 3 phase motor with the help of suitable tools.
4) Identify all the parts & prepare the table for parts, material & function.

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 :

Single Phase motor Type ________________________

Specification/ Name plate details of given motor

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Sr. No.	Name of the Part	Material used	Function of the part
1			
2			
3			

4			
5			
6			
7			
8			

Three Phase motor Type ______________________

Specification/ Name plate details of given motor

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Sr. No.	Name of the Part	Material used	Function of the part
1			
2			
3			
4			
5			
6			

7			
8			

XV Results:

Single Phase motor Type ______________________

- Resistance of starting winding is ________________
- Resistance of Main winding is ________________
- Type and value of Capacitor used ____________________

Three Phase motor Type ______________________

- **Stator connection is _______________**
- **Bearing type ______________**
- **Rotor type ________________**

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) How does the centrifugal switch function in Single phase induction motor?
2) State the initial position of centrifugal switch at start & also give its function.
3) Give classification of Induction motor. Give relevant application of each type of motor.
4) 'Rotor bars of squirrel cage rotor are skewed' -Justify
5) Compare single phase & three phase induction motor with respect to any four aspect.
6) Three phase Squirrel Cage Induction motor is most widely used in industry. Give the reasons.

[Space for Answers]

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XIX References / Suggestions for Further Reading

- https://jimhedges.weebly.com/parts-of-an-induction-motor.html
- https://www.electrical4u.com/types-of-single-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. ………………………….....….
4. ……………………………
5. ....

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

Experiment No. 2: Connect and run the three phase squirrel cage induction motor (in both directions) using the DOL, Star-Delta, Auto-transformer starter (any two)

I Practical Significance

Most of the small induction motors are started directly on line, but when very large motors are started that way, the high starting current will produce a severe voltage drop and will affect the operation of other equipment connected to the same line. To limit this starting current surge, large induction motors are started at reduced voltage and then have full supply voltage when they start to accelerate.

II Relevant Program Outcomes (POs)

- **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: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

i. To use various tools such as spanner, plier, screw driver
ii. To identify induction motor &starter required.
iii. To start the motor with suitable starter.
iv. To Run the motor in both direction.

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.

V Practical Learning Outcome

Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL, star-delta, auto-transformer starters (any two)

VI Minimum Theoretical Background

The high starting current will produce a severe voltage drop and will affect the operation of other equipment. So it is not desirable to start large motors direct on line (giving full voltage to the stator). Normally with motors beyond 5 HP, starters are provided. For reduction in the starting current, a lower voltage is applied to the stator, especially for the squirrel cage induction motor & full voltage is only applied when the motor picks up speed.

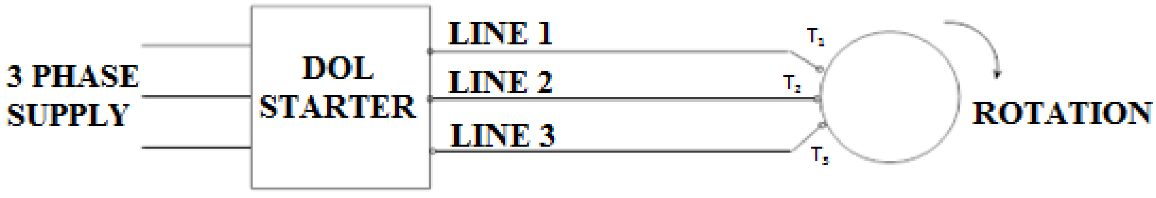
Starting methods of Induction motor by reducing voltages are

1. Direct –On– line (DOL) starters are used for less than 10 Kw motors. Motor is started directly at rated voltage. This starter gives overload & no volt protection.
2. Star–Delta starters for large motors. The stator winding is initially connected in a star configuration and later on changed over to a Delta connection, when the motor reaches rated speed.
3. Auto transformer--In starting position supply is connected to stator windings through an auto-transformer which reduces applied voltage to 50, 60, and 70% of normal value depending on tapping used.

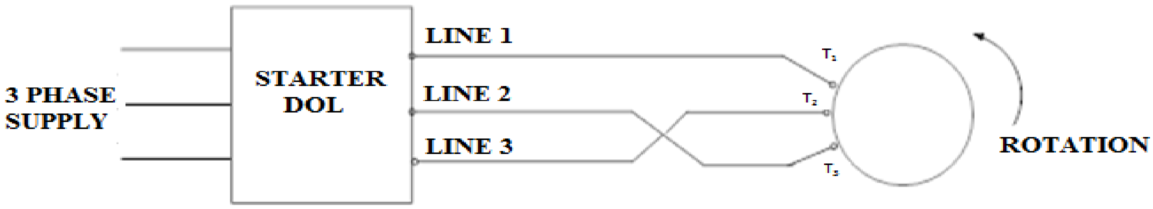
Direction of rotation of Induction motor is changed by changing stator flux which depends on phase sequence of stator voltage.

VII Circuit diagram:

1) Reversal of squirrel cage Induction motor with DOL starter



ROTATION BEFORE CONNECTIONS ARE CHANGED



ROTATION AFTER CONNECTIONS ARE CHANGED

2) Reversal of squirrel cage Induction motor with star delta / Autotransformer Starter. (Students can draw the circuit diagram)

VIII Resources required

Sr. No.	Instrument/ Object	Specification	Quantity	Remarks
1.	Induction motor	3-phase,3 HP/ 5 HP, 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Starter	DOL	01	
3.	Starter	Star –Delta	01	
4.	Starter	Auto transformer starter	01	
5.	Induction motor	Delta connected 414V, 2HP Induction motor	01	
6.	Screw driver	Suitable set	01	
7.	Plier	Suitable	01	
8.	Multimeter	Digital	01	

IX Precautions to be followed

1) Make sure that main switch is in OFF position & motor is disconnected from supply.
2) Select appropriate starter
3) Wires used for circuit connection have proper size & insulation cover.
4) All electrical connections should be neat and tight.

X Procedure

1) Reversal of squirrel cage Induction motor with DOL starter

1) Connect DOL starter to Induction motor with supply phase sequence RYB
2) Switch ON the 3 phase supply &Observe direction of rotation of Induction motor.
3) Switch off the supply &Reverse phase sequence of supply by interchanging any 2 supply lines
4) Switch ON the 3 phase supply &again Observe direction of rotation of Induction motor. Note down changes in direction.

2) Reversal of squirrel cage Induction motor with star delta / Autotransformer starter

1) Connect Star delta / Autotransformer starter to Induction motor with supply phase sequence RYB
2) Switch ON the 3 phase supply &Measure voltage at start & Run mode
3) Observe direction of rotation of Induction motor
4) Switch off the supply &Reverse phase sequence of supply by interchanging any 2 supply lines
5) Switch ON the 3 phase supply. Measure voltage across motor winding at start & Run mode

6) Observe direction of rotation of Induction motor& Note down changes in direction.

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 :

1) Reversal of squirrel cage Induction motor with DOL starter

Phase sequence of supply	Direction of rotation

2) Reversal of squirrel cage Induction motor with star delta / Autotransformer starter

R-Y-B Phase sequence of supply			R-B-Y Phase sequence of supply		
Starter position	**voltage across motor winding volt/ph**	**Direction of rotation**	**Starter position**	**voltage across motor winding volt/ph**	**Direction of rotation**
START					
RUN					

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 neat diagram of DOL starter.
2) Describe working of DOL starter.
3) Draw neat diagram of Star/Delta starter. State advantage & drawback of it.
4) Draw neat diagram of an Auto transformer starter.
5) Select suitable starter for following motor. Give justification of selection.
   2 HP Squirrel cage Induction motor
   10 HP delta connected Squirrel cage Induction motor
   15 HP Squirrel cage Induction motor
   3 HP slip ring Induction motor
6) State the concept of Soft starter.

[Space for Answers]

XIX References / Suggestions for Further Reading

- https://circuitglobe.com/starting-of-an-induction-motor.html
- https://www.brighthubengineering.com/diy-electronics-devices/44951-learn-about-capacitor-start-induction-run-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. …………………………….
4. …………………………….
5. …………………………….

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

Experiment No. 3: Direct load test on the 3 phase squirrel cage Induction Motor

I Practical Significance

Direct load test on the three phase induction motor is conducted by actually loading the motor with the help of Braking arrangement or by coupling calibrated generator to `understand the performance parameters like speed, power factor, efficiency & torque.

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: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

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

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.

V Practical Learning Outcome

Perform the direct load test on the three phase squirrel cage induction motor and plot the i) efficiency versus output, ii) power factor versus output, iii) power factor versus motor current and iv) torque – slip/speed characteristics.

VI Minimum Theoretical Background

By conducting the load test on three phase induction motor, the performance of the motor viz. slip, power factor, efficiency, torque etc. at various loads can be studied. The induction moto load test is carried out by any of the following methods:

1. Brake test
2. By connecting a d.c. generator

In case of loading by connecting a d.c. generator, the induction motor is connected to a d.c. generator. The generator is loaded by a lamp bank. Thus intern an induction motor is loaded.

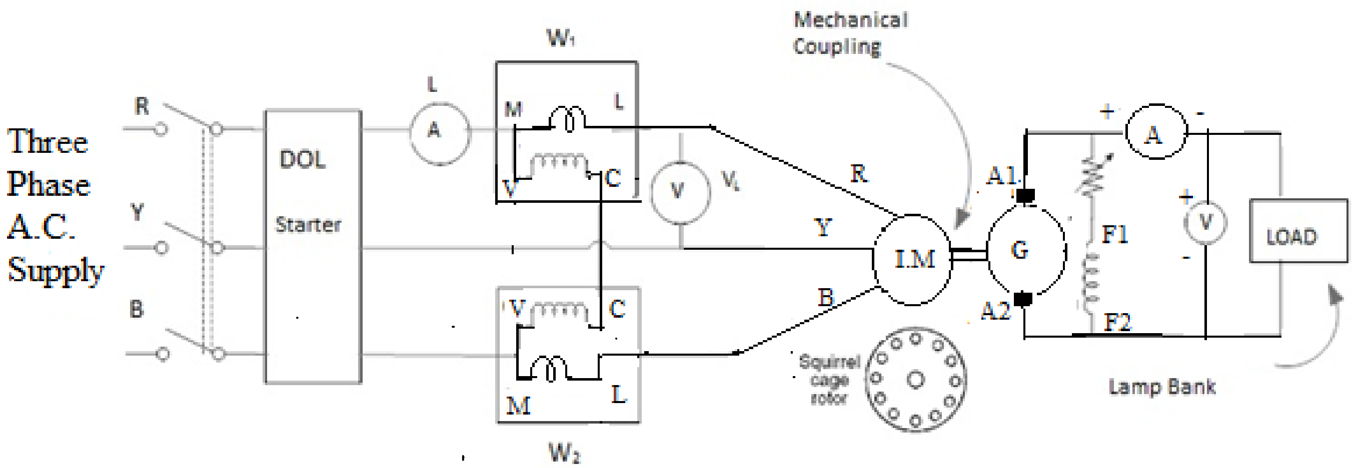
The variation of Efficiency & Power factor wrt output/ motor current, torque wrt slip/speed can be studied by actually loading the motor. Load on motor may be generator or Braking system.

Efficiency of motor is zero at no load as shaft output is zero. As motor is loaded output increases so efficiency also increases & reaches maximum at about 80 to 95% of load. If motor is loaded beyond this, efficiency decreases as losses increases at faster rate than output.

Power factor of motor is between 0.1 to 0.3 (poor) low & lagging at no load. As load increases power factor also increases. It is 0.85 to 0.9 at 80 to 90% of FL Output.

As motor is loaded, Speed decreases/Slip increases & Torque developed increases to supply load torque. Torque is directly proportional to slip, this is stable region of torque slip characteristic. At start slip is one & torque is starting torque. Maximum Torque will be at 80 to 90 % of full load. Then motor is unstable, torque decreases with increase in slip.

VII Circuit diagram :



VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Induction motors	3 phase ,3 HP/ 5HP , 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Brake load or other suitable means to load motors with suitable measurement facilities of powers. or coupled DC shunt generator	Mechanical 220V ,10A	01	
3.	Ammeters	AC/DC 0-5-10AmpMI	01	
4.	Ammeters	DC 0-5-10AmpPMMC	01	
5.	Voltmeter MI Type:	AC/DC,0-150/300V, 0-250/500V	01	
6.	Voltmeter PMMC Type:	DC,0-150/300V, 0-250/500V	01	
7.	Wattmeter: Three phase double element	5/10Amp, 250/500V	01	
8.	Load bank: Resistive,	1 kW, 220V	01	
9.	Tachometer	Contact / non-contact types 100 to 10000 RPM	01	

IX Precautions to be followed

1. Make sure that main switch is in OFF position while making connection
2. Wires used for circuit connection have proper size & insulation cover.
3. All electrical connections should be neat and tight.
4. At start keep resistance in generator field winding in maximum position.
5. Check that lamp load is OFF at start.
6. Provide shunt for ammeter & current coil of wattmeter at start before switching on motor by DOL starter.

X Procedure

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) Set generator field rheostat to its maximum value.
4) Switch on the 3 phase supply & start motor with the help of starter.
5) Excite generator to its rated voltage at rated speed by varying generator field rheostat

6) Note down all meter readings &speed of motor.
7) Switch ON electrical load on generator side, increase load in steps upto full load & note down corresponding all meter readings & speed of motor.
8) Reduce load, increase generator field rheostat &Switch OFF the power supply.
9) plot the characteristics for i) efficiency versus Motor output, ii) power factor versus Motor output, iii) power factor versus motor current and iv) torque – slip/speed.

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:

Sr. No.	Induction Motor side			Speed N_r rpm	DC Generator side	
	Motor Voltage V_1 Volt	Motor Current I_1 Amp	Input Power W Watts		Generator voltage V_2 Volt	Generator Current I_2 Amp
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

Calculation

Generator efficiency η_g = _______

Ns = _______________

Sr. No.	Motor input W Watts	Generator output $V_2 \times I_2$ watts	Generator Input = Generator output/η_g	Motor output = generator input	Motor efficiency = Motor output / motor input	Slip = $(N_s - N_r)/N_s$	Pf= $W/(\sqrt{3} \times V_1 \times I_1)$	Torque = Motor output x $60/(2\pi N_r)$
1.								
2.								
3.								
4.								

5.								
6.								
7.								
8.								

Calculations:

XV Results:

From graph

Efficiency is maximum at ___________% of full load

Torque is maximum at ___________% of full load

Starting torque = ______________

No load pf =______ & Full load pf = _____

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) ‘Induction motor pf is poor at no load’ –Justify.
2) ‘At start generator field rheostat is kept at maximum value’ -Justify
3) Draw torque slip characteristic for all four quadrant.
4) ‘Shunts are to be provided for ammeter & current coil at start when operated by DOL starter’ -Justify
5) Draw alternative method of loading motor other than your experimental set up.

[Space for Answers]

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XIX References / Suggestions for Further Reading

- http://www.yourelectrichome.com/2011/09/load-test-on-three-phase-induction.html
- https://www.electrical4u.com/testing-of-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. …………………………...
4. ....

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

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Experiment No. 4: No-load and Blocked-rotor test on given 3-Phase squirrel cage Induction motor to determine the equivalent circuit parameters.

I Practical Significance

No load testis similar to the open circuit test on a transformer. It is performed to obtain the magnetizing branch parameters (shunt parameters) in the induction machine equivalent circuit. Blocked rotor test is similar to the short circuit test on a transformer. It is performed to calculate the Leakage reactance & winding resistance (series parameters) in the induction machine equivalent 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: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

i. Select various meters
ii. Measure electrical quantities.
iii. Connect the machines as per relevant circuits.
iv. Follow safe practices.

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.

V Practical Learning Outcome

Conduct the No-load and Blocked-rotor tests on given 3-phase squirrel cage Induction motor and determine the equivalent circuit parameters.

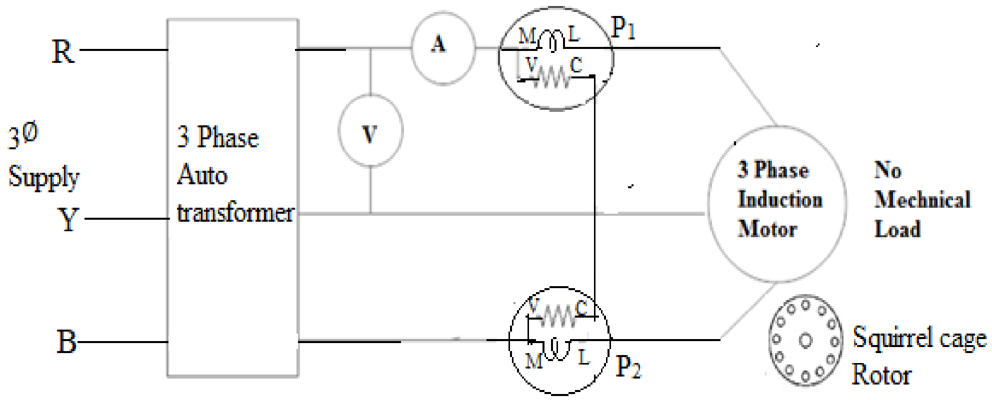
VI Minimum Theoretical Background

In No load test, motor is allowed to run with no-load at the rated voltage of rated frequency across its terminals. Machine will rotate at almost synchronous speed, which makes slip nearly equal to zero. This causes the equivalent load resistance $R_2'\{(1/s)-1\}$ tends to infinity. Hence rotor current is negligible &the rotor equivalent impedance is an open circuit. So the data obtained from this test will give information on no load branch parameters.

In blocked rotor test rotor is blocked to prevent rotation which makes slip equal to unity. This causes the equivalent resistance $R_2'\{(1/s)-1\}$ tends to very low value. So the rotor current is much larger than current in the excitation branch of the circuit such that the excitation branch can be neglected .Hence, the data obtained from this test will give information on winding parameters.

VII Circuit diagram :

No load test on 3 phase Induction motor



Blocked Rotor test 3 phase Induction motor

(Students can draw the circuit diagram; write meter ranges & specifications of equipments)

VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Induction motors	3 hp/ 5hp, 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Ammeters MI Type:	AC/DC 0-5-10Amp	01	
3.	Voltmeter MI Type:	AC/DC,0-150/300V, 0-250/500V	01	
4.	Wattmeter: Three phase double element	5/10Amp, 250/500V	01	

IX Precautions to be followed

1. Make sure that main switch is in OFF position while making connection.
2. Ensure that Autotransformer is at zero position at start.
3. Wires used for circuit connection have proper size & insulation cover.
4. All electrical connections should be neat and tight.

X Procedure

No load test on 3 phase Induction motor

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& then run at rated voltage with the help of Autotransformer.
4. Note down all meter readings.
5. Switch OFF the power supply.

Blocked Rotor test 3 phase Induction motor

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

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:

No load test

Motor voltage V_{rated} Volts	Motor current I_o Amps	Motor NL Power W_o watts	
V_{rated}	I_o	W_1	W_2

Blocked Rotor test

Motor current I_{rated} Amps	Motor voltage V_{sc} Volts	Motor blocked rotor Power W_{sc} watts	
I_{rated}	V_{sc}	W_1	W_2

Stator Resistance (AC) $R_{1/ph}$ = ____________

Calculation

From No load test data

$$\text{Cos } \Phi o = \frac{Wo}{\sqrt{3} x Vo x Io} = \quad - - - - -$$

Iw = Io Cos Φo = ______________

Im = Io Sin Φo = ______________

$$Ro = \frac{Vph}{Iw}$$

$$Xo = \frac{Vph}{Im}$$

From Blocked Rotor test data

$Ro_1 = Wsc/(3\ I_{rated}^2)$ = ________________

$R_2' = Ro_1 - R_{1/ph}$ = ____________________

$Zo_1 = Vscph / I_{rated}$ = _______________

$Xo1 = \sqrt{(Zo_1^2 - Ro_1^2)}$ = _________________

Assuming $X_1 = X_2'$, $X_1 = X_2' = Xo_1/2$ = _________________

XV Results:

Draw Equivalent circuit of Induction motor with determined parameters value

XVI. Interpretation of results

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 out the losses measured in the No load test.
2) List out the losses measured in the Blocked rotor test.
3) ‘In no load test on Induction motor one wattmeter reads negative‘-Justify.
4) How reading of wattmeter is taken for wattmeter which reads negative?
5) ‘Blocked rotor test is called as short circuit test’ -Justify

6) If rated voltage is applied in blocked rotor test, what will be effect?
7) 'Induction motor is a generalized transformer' -Justify
8) State the difference between transformer &Induction motor w.r.t Equivalent circuit parameters.

[Space for Answers]

XIX References / Suggestions for Further Reading

- http://www.yourelectrichome.com/2011/09/load-test-on-three-phase-induction.html
- https://www.electrical4u.com/testing-of-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. ………………………………….
4. ………………………………….
5. ………………………………….

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

Experiment No. 5 : No-load and Blocked-rotor test on given 3-Phase squirrel cage Induction motor to Draw circle diagram

I Practical Significance

The **circle diagram of an induction motor** is very useful to study its performance under all operating conditions. We can get information about its power output, power factor, torque, slip, speed, copper loss, efficiency, starting & 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: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

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

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.

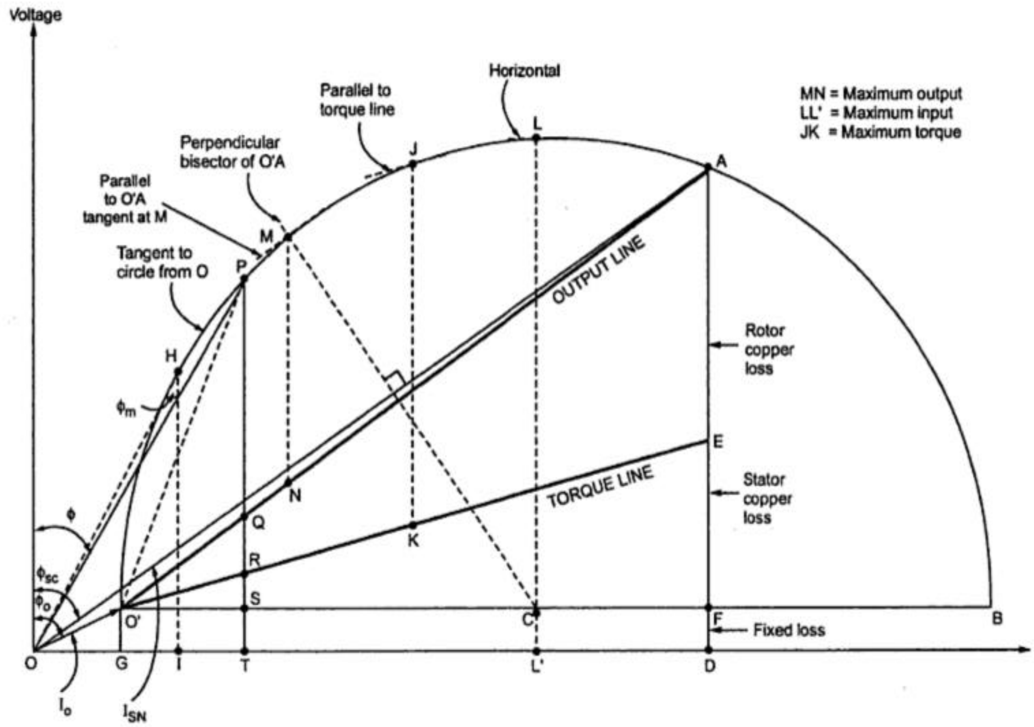
V Practical Learning Outcome

Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and plot the Circle diagram.

VI Minimum Theoretical Background

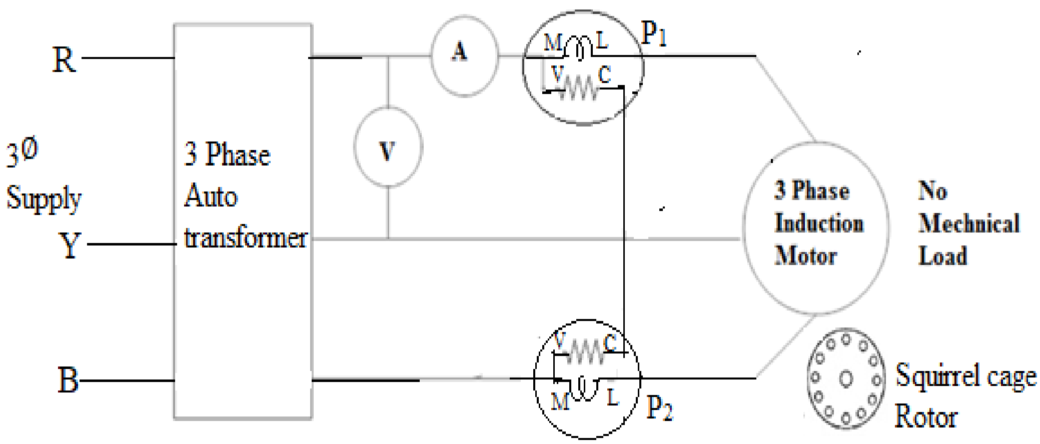
The circle diagram is the graphical representation of the performance of the electrical machine drawn in terms of the locus of the machine's input voltage and current. Equivalent circuit for Rotor of Induction motor is series R-L circuit with variable load resistance, so locus of rotor current for changing load is circle. As Motor current is vector sum of constant no load current & 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 on 3 phase Induction motor



Blocked Rotor test 3 phase Induction motor
(Students can draw the circuit diagram; write meter ranges & specifications of equipments)

VIII Resources required

Sr. No.	Instrument / Object	Specification	Quantity	Remarks
1.	Induction motors	3 phase,3 HP/ 5 HP, 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Ammeters MI Type:	AC/DC 0-5-10Amp	01	
3.	Voltmeter MI Type:	AC/DC,0-150/300V, 0-250/500V	01	
4.	Wattmeter: Three phase double element	5/10Amp, 250/500V	01	

IX Precautions to be followed

1. Make sure that main switch is in OFF position while making connection.
2. Ensure that Autotransformer is at zero position at start.
3. Wires used for circuit connection have proper size & insulation cover.
4. All electrical connections should be neat and tight.

X Procedure

No load test on 3 phase Induction motor

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& then run at rated voltage with the help of Autotransformer
4) Note down all meter readings.
5) Switch OFF the power supply.

Blocked Rotor test 3 phase Induction motor

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

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:

No load test

Motor voltage V_{rated} Volts	Motor current I_o Amps	Motor NL Power W_o watts	
V_{rated}	I_o	W_1	W_2

Blocked Rotor test

Motor current I_{rated} Amps	Motor voltage Vsc Volts	Motor blocked rotor Power W_{sc} watts	
I_{rated}	Vsc	W_1	W_2

Calculations
Circle diagram calculations

Cos $\Phi o = \frac{Wo}{\sqrt{3}\ Vo\ Io} = \ -----$

Cos $\Phi sc = \frac{Wsc}{\sqrt{3}\ Vsc\ Isc} = \ -----$

I_{SCN} =

Selecting Current scale 1cm = ________

- **Power scale calculation**

W_{SCN}= ----------

Power scale is 1cm =______________W

Rated o/p = ______________

- **FL calculation –**

    - Full load current = ______cm = ____cm X current scale = _____Amp

      Full load Power factor = ______________

    - Full load output=______cm = ____cm X 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 = _____________________________
- Full load speed = ________________________________

➢ **Maximum Quantities calculation**

- Max Output = ____________________________
- Max. Input = ____________________________
- Max Torque = ___________________________

➢ **Starting Torque Calculation**

- Starting Torque **=** ________________________

XV Results:

Motor FL Efficiency = _______________%

Motor FL Torque = ________________Nm

Motor Max output = ______ HP

Circle diagram is **approximate / accurate** method of finding performance of Induction Motor.

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 the step by step procedure for drawing Circle diagram.
3) Give advantages of circle diagram.
4) Define unit synchronous watt.
5) List out the parameters which can be calculated from circle diagram.
6) List out the testing of Induction motor as per IS.

[Space for Answers]

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XIX References / Suggestions for Further Reading

- https://www.electrical4u.com/circle-diagram/
- https://www.electrical4u.com/testing-of-induction-motor/

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 (25 Marks)	**100 %**

Names of Student Team Members

1. …………………………
2. …………………………
3. …………………………
4. …………………………
5. …………………………

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

Scale

X-axis -

Y-axis -

Practical No. 6 : Control the speed of the given 3 phase induction motor using the methods Auto transformer method & Variable frequency method

I. Practical Significance

Three phase induction motor is widely used in many industries. Therefore it is necessary to learn the methods of speed control of 3 phase induction motor so as to understand its suitability for various applications.

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 Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Start and run 3 phase induction motor.
- Connect Circuits.
- Follow safe practices.

IV. Relevant Course Outcome(s)

- Use the relevant 3 phase induction motor for different applications.

V. Practical Outcome :

Control the speed of the given three phase squirrel cage induction motor using the applicable methods: i) auto-transformer, ii) VF

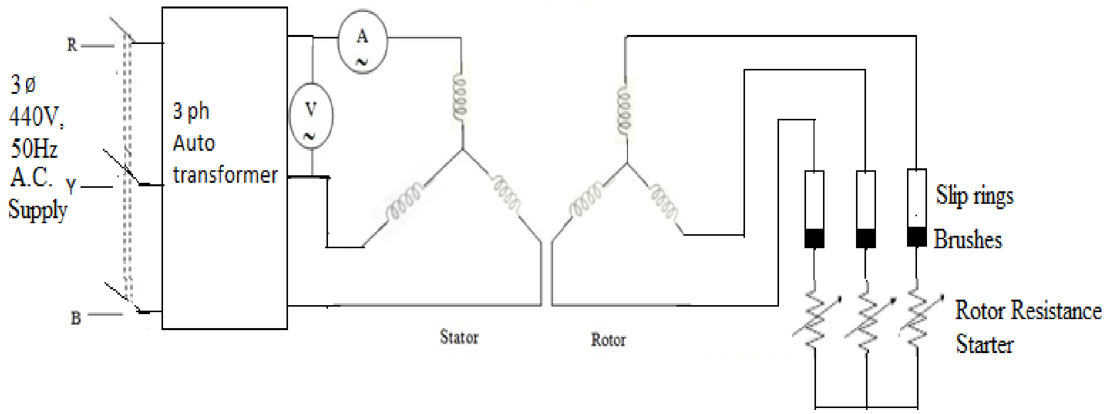
VI. Minimum Theoretical Background

A three phase induction motor is practically a constant speed motor having speed regulation less than 5% at full load. The different methods by which speed control of induction motor is achieved are: (i) Changing the supply voltage (ii) Changing the applied frequency (iii) Changing the number of stator poles (iv) Rotor resistance control (v) By operating two motors in cascade (vi) By injecting an emf in the rotor circuit.

The first three methods are obtained by control from stator side and the next three methods are by control from rotor side. The speed reduction of 3 phase induction motor is accompanied by a corresponding loss of efficiency.

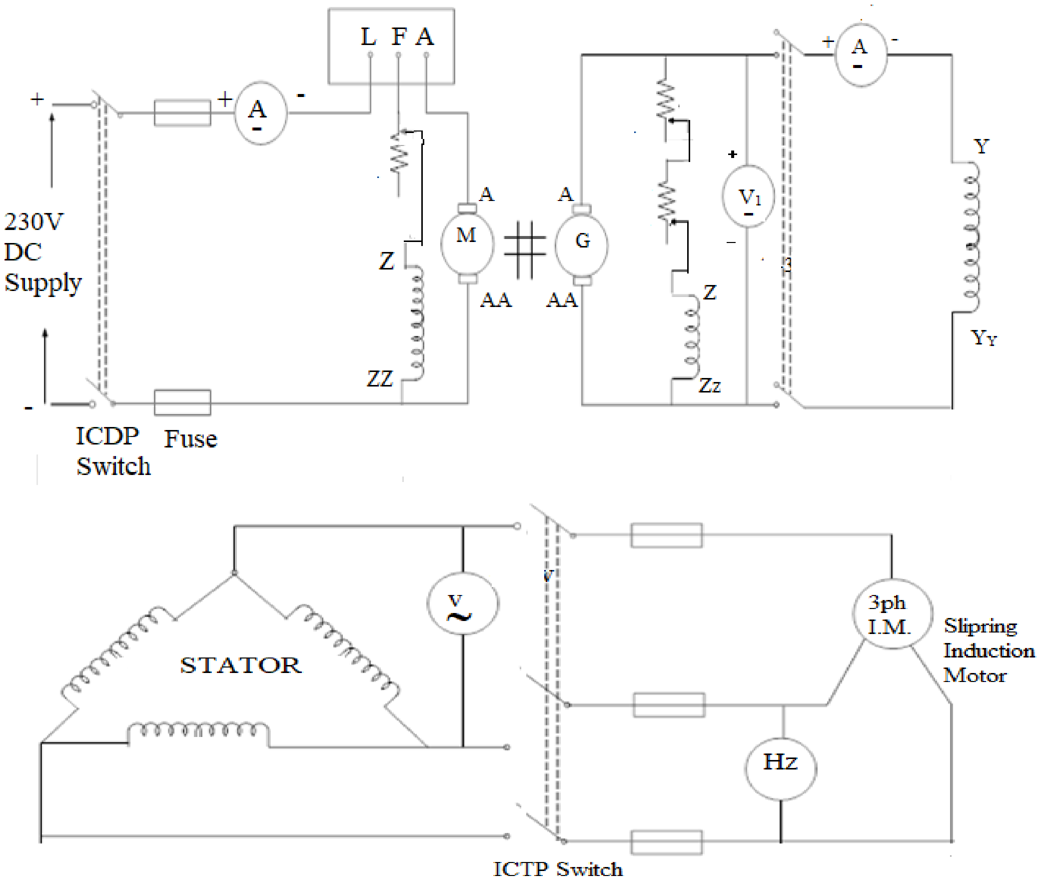
VII. Circuit diagram :

Circuit diagram 1.for Autotransformer method.



Circuit diagram 1 Speed Control using autotransformer

Circuit diagram 2 .for Variable frequency method.



VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Three phase slipring induction motor	3 Hp, 230 V, 7.8 Amp, 1500 Rpm	1
2.	3 phase alternator	3 KVA, 240 V, 7.2 Amp, 50 Hz	1
3.	DC Shunt motor	5 Hp, 220 V, 15 Amp	1
4.	3 phase auto transformer	230 V, 10 Amp	1
5.	Frequency meter	46-54 Hz	1
6.	Tacho meter	Non-contact type digital	1
7.	Volt meter	0-300 V, MI type 0-300 V, PMMC type	1 1
8.	Ammeter	0-5 Amp, MI type 0-2 Amp PMMC type 0-20 Amp PMMC type	1 1 1
9.	Rheostats	400 Ohms, 1.7 Amp 1000 Ohms, 1.2 Amp	1 2
10.	3 point starter		1

IX. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Do not touch/make/alter any connection when the circuit is live.
3. The auto transformer should be kept at zero output position initially.
4. Ensure that the DC motor field rheostat is kept at minimum resistance position and DC generator field rheostat is kept at maximum resistance position.
5. The resistance of rotor resistance starter should be kept at maximum resistance position initially when switching on the supply (for a slipring induction motor).

X. Procedure

For the Circuit diagram 1

1. Connect the circuit as shown in circuit diagram 1
2. Kept the 3 phase auto transformer at zero output voltage and rotor resistance at maximum resistance position.
3. Switch on the supply and increase the input voltage to the stator winding upto 75% of rated voltage.
4. Decrease the rotor resistance in steps and bring it to minimum resistance position.
5. Note down the speed.
6. Increase the supply voltage to the stator winding from 80%, to 100% in steps of 5% increase in voltage and note down the speed at every value of supply voltage.

7. Then reduce the supply voltage to zero using 3 phase auto transformer and switch off the supply.

For the Circuit diagram 2

1. Connect the circuit as shown in circuit diagram 2
2. Keep the rheostat of alternator exciter at maximum resistance position.
3. Keep the rheostat of DC motor at minimum position.
4. Switch on the DC supply and move the starter of DC motor to the zero resistance position.
5. Adjust the speed of DC motor to synchronous speed of alternator using the field rheostat of DC motor.
6. Adjust the rheostat of alternator exciter to get the rated terminal voltage from alternator.
7. Close ICTP switch to supply the three phase induction motor from the three phase output of alternator.
8. Vary the speed of DC motor by adjusting its field rheostat in steps so that the frequency of induced emf of alternator changes accordingly and hence the frequency of input supply voltage to the stator winding of alternator.
9. Change in frequency of supply voltage will change the rotor speed of induction motor and hence note down the values of frequency of input supply voltage to the induction motor using frequency motor and corresponding speed of induction motor using tachometer.

XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation

For Auto Transformer method of speed control

Sr. No.	Supply Voltage to the stator of induction motor in Volts	Speed in rpm

For Variable frequency supply method of speed control
Supply voltage = ___________ volts

Sr. No.	Variable frequency in Hz	Speed in rpm

XV. Results :

1. With increase in stator supply voltage there is a corresponding ___________in the speed.
2. The speed of induction motor increases as supply frequency _______________

XVI. Interpretation of results (Write the meaning of above obtained results)

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XVII. Conclusion (Actions/decisions to be taken based on the interpretation of results)

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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 drawback of speed control by changing supply voltage.
2. How will you calculate the number of poles in the stator of three phase induction motor.
3. "3 phase induction motor does not rotate at synchronous speed".- Justify.
4. List the methods of speed control of 3 phase induction motor which can be applied from the stator side.

[Space for Answers]

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XIX. References/Suggestions for further reading

- www.nptel.iitm.ac.in
- www.vlab.com
- www.khanacademy.com

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....
5. ....

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

Practical No. 07 : Control the speed of the given three phase slip ring induction motor using rotor resistance starter.

I. Practical Significance

Slip ring induction motor is widely used in industries since it is easier to obtain its speed control by varying the resistance of rotor resistance starter. Further the rotor resistance starter is used to reduce the starting current, improve the power factor at start and produces higher starting torque.

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 Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Understand the working of rotor resistance starter.
- Measure the speed of variation of induction motor using tachometer.

IV. Relevant Course Outcome(s)

- Use the relevant three phase induction motor for different applications.

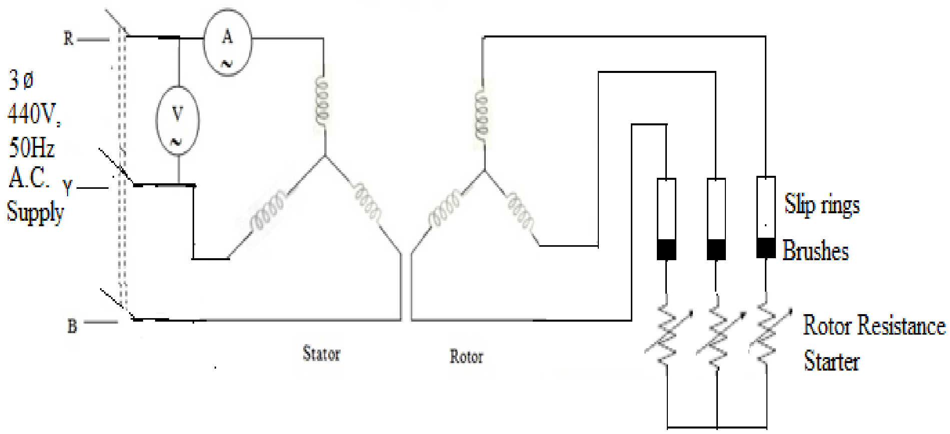
V. Practical Outcome :

Control the speed of the given three phase slip ring induction motor using rotor resistance starter.

VI. Minimum Theoretical Background

The speed of an induction motor depends upon slip (s), frequency of the stator supply (f) and the number of poles (p) for which the windings are wound. The ability of varying any one of the above three quantities will provide methods of speed control from stator side. The speed of induction motor is changed from rotor side by varying the resistance of the rotor circuit, injecting emf in phase with rotor induced emf.

VII Circuit diagram



VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Three phase slip ring induction motor	230 V, 3 HP, 7.8 Amp, 1500 Rpm	1
2.	Rotor Resistance Starter	3 phase, 10 Amp, 150 V	1
3.	Voltmeter	0-300 V, MI type	1
4.	Ammeter	0-5 Amp, MI type	1
5.	Tachometer	0-3000 Rpm, Digital type	1

XI. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Do not touch/make/alter any connection when the circuit is live.
3. Ensure that the rotor resistance is kept initially at 100% resistance position.

X. Procedure:

1. Connect the circuit as shown in circuit diagram 1.
2. Switch ON the supply and increase the input voltage to stator winding upto its rated value.
3. Measure the speed.
4. Now decrease the rotor resistance in steps and note the corresponding values of speed.
5. Draw a graph of rotor resistance versus speed.

XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (use blank sheet if space is not sufficient)

Stator supply voltage = ________Volts

Sr. No.	External rotor resistance in Ohms Approximate % of external resistance in rotor circuit	Speed (rpm)	Stator current (Amp)
1	100% (full)		
2	75%		
3	50%		
4	25%		
5	0%		

Graph : Draw a graph taking rotor resistance in % on X – axis and speed in rpm on Y-axis

XV. Results :

- It is found that with increase in rotor resistance, there is a corresponding ______________(increase/decrease) in the speed.
- Stator current is found to be _______________(constant/change)with increase in speed.

XVI. Interpretation of results (Write the meaning of above obtained results)

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XVII. Conclusion (Actions/decisions to be taken based on the interpretation of results)

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XVIII. Practical related questions : (Use separate sheet for answer)

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 rotor circuit of a slip ring induction motor is kept open and electric supply is given to stator winding" Mention what will happen at rotor side of the motor.
2. List out the different methods of speed control of three phase induction motor based on the principle of changing synchronous speed.
3. Draw and explain the Torque-speed characteristic of a slip ring I.M. for different values of rotor resistance.
4. State the effect of changing the rotor resistance on the slip at max torque SMT?
5. List two methods of speed control of three phase induction motor which can be applied from rotor side.

[Space for Answers]

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XIX. References/Suggestions for further reading

- https://circuitglobe.com/rotor-resistance-control-of-an-induction-motor.html
- https://www.brighthubengineering.com/diy-electronics-devices/44182-speed-control-of-slip-ring-motors/

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1…………………………………………….

2…………………………………………….

3……………………………………………..

4……………………………………………..

5……………………………………………..

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

Scale

X-axis -

Y-axis -

Experiment No. 8 : Control the speed of the given three phase Induction Motor using Pole Changing methods

I Practical Significance

A Speed of Induction motor can be controlled from stator side or Rotor side. From stator side we can vary supply voltage, supply frequency or number of poles. For changing number of poles, one of the method is to connect coils in series or in parallel.

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.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Measure electrical quantities.
- Connect the machine as per relevant circuits.
- Follow safe practices.

IV Relevant Course Outcomes

- Use the relevant three phase induction motor (IM) for different applications.

V Practical Learning Outcome

Control the speed of the given three phase Induction Motor using Pole Changing methods**.**

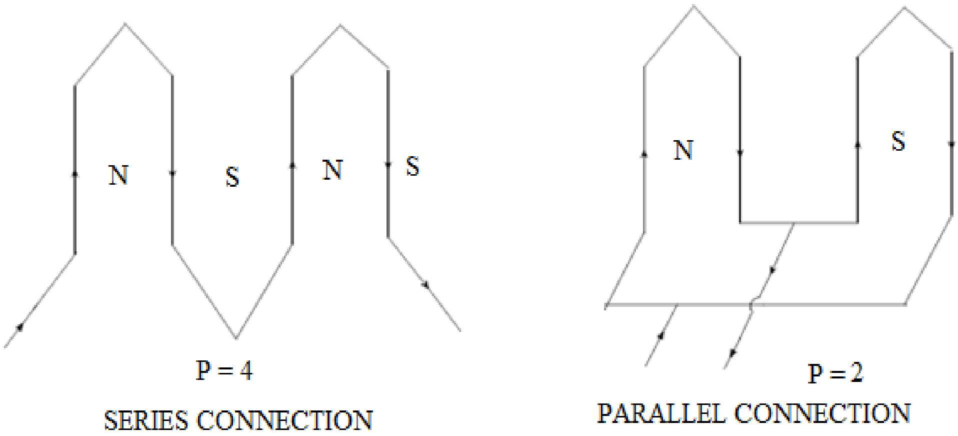
VI Minimum Theoretical Background

Pole Changing is one of the simple method of the speed control of an induction motor which is mainly used for cage motor only because the cage rotor automatically develops a number of poles, which is equal to the poles of the stator winding. The number of stator poles can be changed by the following three methods.

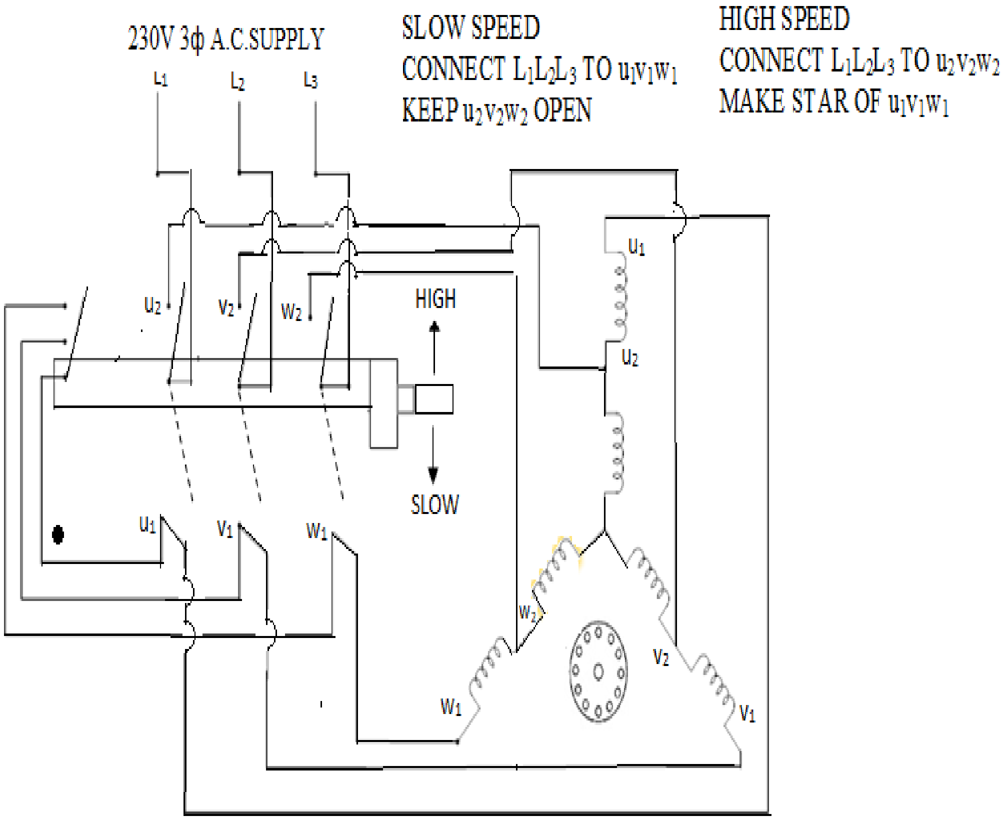
- Multiple Stator Windings
- Method of Consequent Poles
- Pole amplitude modulation (PAM).

In the method of consequent poles, a single stator winding is divided into few coil groups. The terminals of all these groups are brought out. By simply changing the coil connections, the number of poles can be changed.

In practice, the stator windings are divided only in two coil groups. The number of poles can be changed in the ratio of 2:1. The stator coils are carrying current in the given directions by connecting coil groups either in series or in parallel as shown in the figure below.



VII Circuit diagram :



VIII Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Induction motors	3Phase,2HP/ 3 HP, 415 V, 50 Hz, 1440 RPM squirrel cage type	01	
2.	Voltmeter MI Type:	AC, 0-250/500V	01	
3.	Tachometer	Digital	01	

IX Precautions to be followed

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

X Procedure

1) Connect the motor through pole changing switch as shown in circuit.
2) Switch ON 3 phase supply
3) Switch is thrown in SLOW position.
4) Measure speed of motor by tachometer
5) Throw Switch in HIGH position without allowing motor to come to rest
6) Measure speed of motor by tachometer

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:

Switch position	Supply L_1, L_2& L_3 Connected to	Measured Rotor speed Nr rpm	Nearest Synchronous speed Ns rpm	No of poles = 120 f/Ns	Remark
1SLOW	U_1, V_1& W_1 keeping U_2, V_2& W_2 Open				Coils are connected in **Series/Parallel** to supply lines
2HIGH	U_2, V_2& W_2 withU_1, V_1& W_1 Shorted				2 star connected Coils are connected in **Series/Parallel** to supply lines

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 various methods of speed control of squirel cage Induction motor.
2) State the method of speed control for Slipring Induction motor.
3) State the drawback of pole changing method.
4) State the most commonly method used in industry for speed control of Induction motor.
5) State the pole changing method used in this experiment and describe another two methods for pole changing of Induction motor.

[Space for Answers]

XIX References / Suggestions for Further Reading

- https://circuitglobe.com/pole-changing-method.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. …………………………
4. …………………………
5. …………………………

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

Experiment No. 9: Identify different windings & components of single phase capacitor start Induction Run motor. Connect to start & reverse the direction of rotation.

I Practical Significance

Stator of Single phase Induction motor consist of Main winding & starting winding placed at 90^o electrically apart to produce rotating magnetic field. For this capacitor is connected in series with starting winding along with centrifugal switch.

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 **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

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

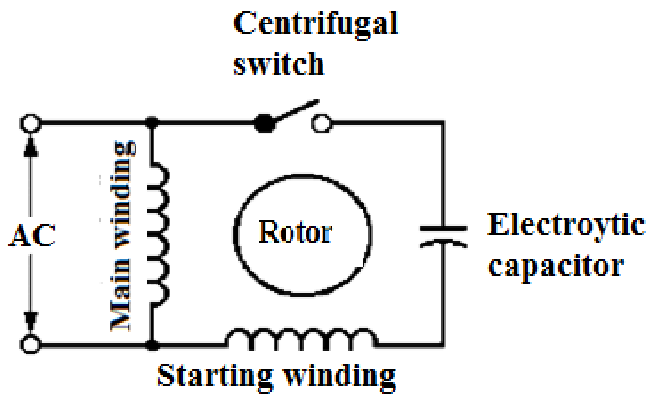
IV Relevant Course Outcomes

- Use the relevant single phase induction motors in different applications.

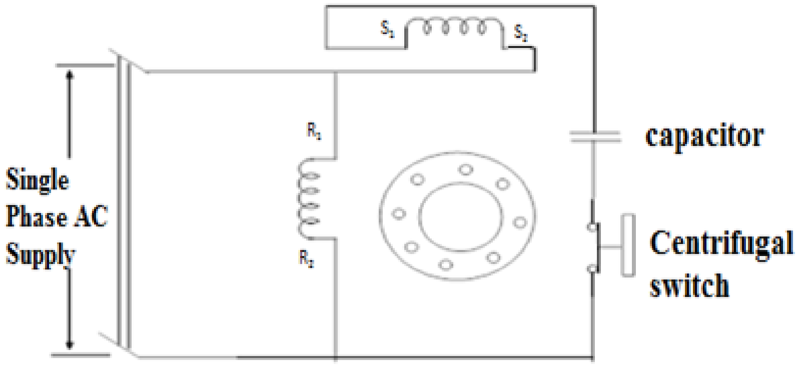
V Practical Learning Outcome

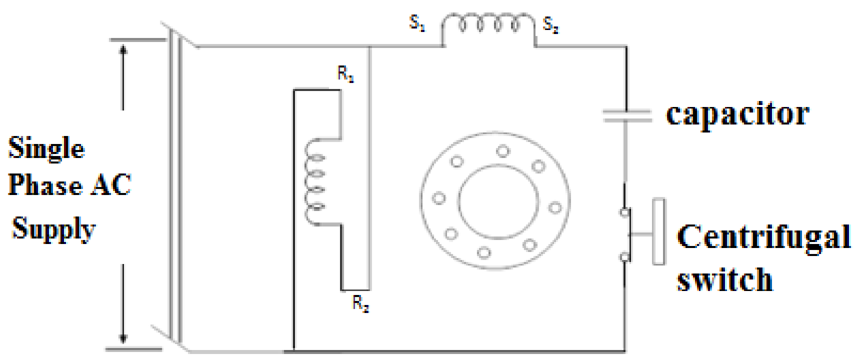
- Identify different windings & components of single phase capacitor start Induction Run motor.
- Connect to start & reverse the direction of rotation

VI Minimum Theoretical Background



In single phase induction motor main winding is designed for low resistance & starting winding for high resistance. Phase difference in both winding is produced by connecting capacitor in series with starting winding.
Direction of rotation of single phase induction motor depends upon the instantaneous polarities of main winding flux & starting winding flux. So direction of rotation can be changed by reversing the polarity of either main or starting winding as shown in figure.





VII. Circuit diagram:

Diagram for forward direction of rotation

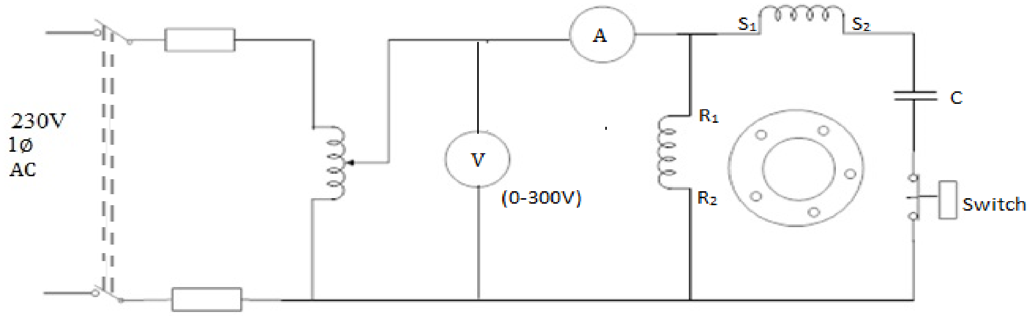


Diagram for reversing direction of rotation

(Students can draw the circuit diagram; write meter ranges & specifications of equipments)

VIII. Resources required

Sr. No.	Instrument /Object	Specification	Quantity	Remarks
1.	Induction motors	1phase 1HP 230 V Cap start induction run motor.	01	
2.	Multimeter	Digital	01	
3.	Ammeters MI Type:	AC/DC 0-5-10Amp	01	
4.	Voltmeter MI Type:	AC/DC,0-150/300V, 0-250/500V	01	
5.	Auto transformer	1 phase 230 V 5A	01	
6.	Tachometer	contact / non-contact types 100 to 10000 RPM	01	

IX. Precautions to be followed

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

X. Procedure

1) Select the instruments and meter ranges as per the resources required table.
2) Disconnect the 1 phase capacitor start Induction run motor from supply if it is connected.
3) Open terminal box & discharge capacitor.
4) Separate winding & capacitor terminals
5) Identify winding terminals by continuity test.
6) Measure resistance of each winding.
7) Note down resistance & identify type of winding.
8) Make the connections as per the circuit diagram shown in Fig.
9) Switch ON the supply & observe the direction of rotation
10) Switch OFF the supply & interchange connection of starting winding or main winding.
11) Switch ON the supply & observe the direction of rotation
12) Switch OFF the supply & interchange supply terminals –phase & neutral
13) Switch ON the supply & observe the direction of rotation
14) 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					

XII. Actual procedure followed

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XIII. Precautions followed

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XIV. Observations and Calculations:

- **Measurement of winding Resistance.**

Winding	Resistance (OHM)	Identification
1		
2		

- **Reversing direction of rotation**

Condition	Voltmeter V volt	Ammeter A amp	Direction of rotation
Initial Connection			Forward / Reverse
Reversing main / starting winding			Forward / Reverse
Reversing supply lines			Forward / Reverse

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. Differentiate between main winding & starting winding
2. Give classification of 1 phase induction motor.
3. State the type of capacitors used in 1 phase induction motor.
4. Give the applications of various types of 1 phase induction motor.
5. State the function of centrifugal switch.
6. ‘1 phase induction motor is not self-starting.’- Justify
7. State the advantages of capacitor start induction motor.
8. Compare resistance split phase & capacitor split phase induction motor.
9. ‘Main winding resistance is low & starting winding resistance is high. ‘Give reason

[Space for Answers]

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XIX References / Suggestions for Further Reading

- https://woodgears.ca/motors/reversing.html
- https://woodgears.ca/motors/reversing.html
- https://www.youtube.com/watch?v=qj8VF7nc8Zk

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. …………………………………
4. …………………………………
5. …………………………………

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

Practical No. 10: Conduct the direct load test to determine the efficiency and speed regulation on single phase induction motor and draw the performance curves.

I. Practical Significance

Single phase motor has got wide range of applications. It is essential to determine efficiency and speed regulation for assessing its performance. The motor being fractional kilowatt it is easy to conduct direct load test on it.

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 Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Understand the operation of different types of single phase induction motor.
- Load the motor upto full load and measure the speed at each load.
- Calculate the efficiency and regulation of the motor at each load.

IV. Relevant Course Outcome(s)

- Use the relevant single phase induction motor (IM) for different applications.

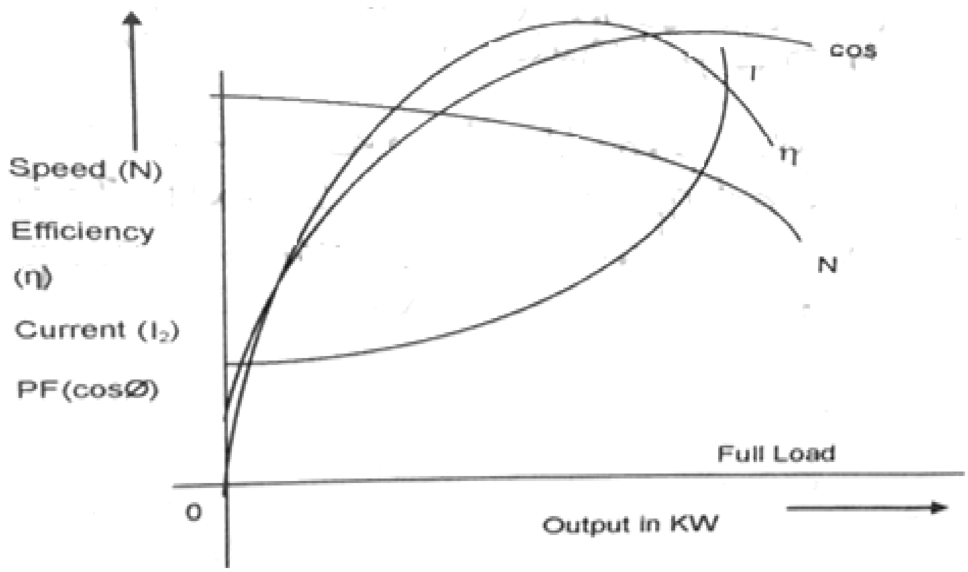
V. Practical Outcome :

Conduct the direct load test to determine the efficiency and speed regulation for different loads on the given single phase induction motor; plot the efficiency curves with respect to the output power.

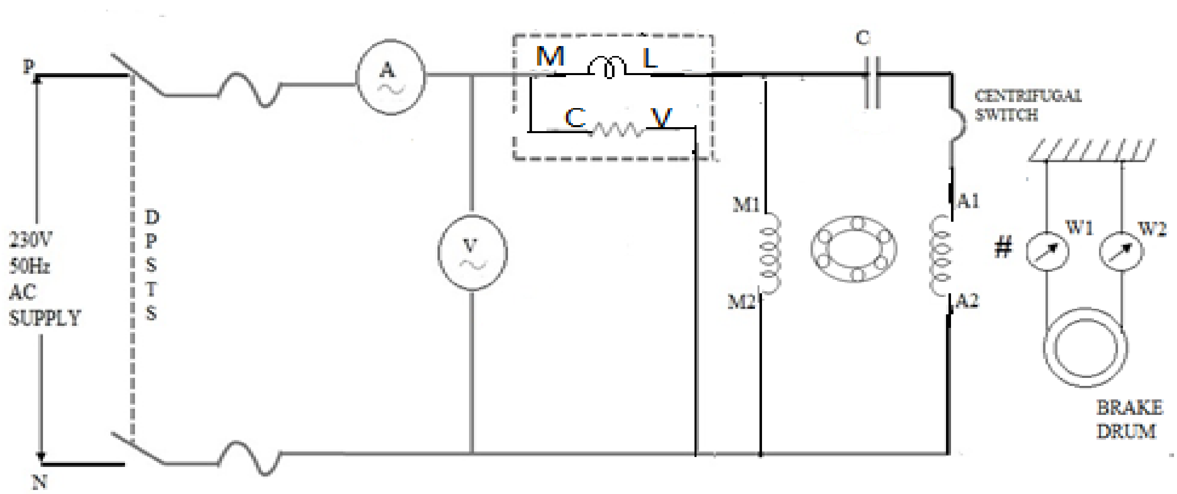
VI. Minimum Theoretical Background

It is a single-phase motor having squirrel cage rotor, two stator windings (main and starting) placed in a stators slot at 90° electrical degrees apart and connected across the main supply. The capacitor and a centrifugal switch are connected in series with starting windings. The starting winding has comparatively high resistance than main winding. Using mechanical brake drum arrangement apply load gradually on the motor. Then the efficiency of the motor can be calculated from the input and output power of the motor and speed can be calculated knowing the speed of the motor at various loads.

Performance characteristics of single phase induction motor -



VII. Circuit diagram :



VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Single phase induction motor	2 HP, 230 V, 10.5 Amp, 1425 Rpm	1
2.	Mechanical brake drum arrangement	Load facility upto 50 Kg	1
3.	Ammeter	MI type 0-10 Amp	1
4.	Voltmeter	MI type 0-300 V	1
5.	Wattmeter	300 V, 10 Amp UPF	1
6.	Tacho meter	Non contact type digital	1

IX. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Do not touch/make/alter any connection when the circuit is live.
3. The initial load on the motor should be kept zero when supply is switch on.

X. Procedure

1. Connect the circuit as shown in the circuit diagram with proper wires, meters, and equipments as per the rating of single phase induction motor.
2. Switch on the AC supply.
3. Note down the readings of ammeter, voltmeter, wattmeter, readings on the dial of brake drum and speed at no load.
4. Gradually increase the load upto full load and note down corresponding meter readings.
5. Gradually decrease the load by releasing the load on the brake drum.
6. Switch off the supply.
7. Plot performance characteristics of single phase induction motor taking motor output on X-Axis and other parameters like speed, stator current, power factor and efficiency on Y-Axis.

XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (Use blank sheet if space is not sufficient)

Sr. No.	Input Voltage V Volts	Input Current I Amps	Input Power W_1 Watts	Speed N RPM	F_1 Kgs	F_2 Kgs

Radius of Pulley (brake drum)

Circumference = ______________m

$r = \left[\frac{\text{Circumference}}{2\pi} \right]$ =……… m

Thickness of the belt t = ………………..m

Effective radius of pulley = r_e = r +(t /2) = …………m

Sr. No.	Torque T=9.81* r_e *(F_1~F_2) Nm	Motor Output Power W_2 =(2πNT)/60 Watts	Motor % Efficiency = (W_2/W_1)*100	%Speed Re gulation = [(No Load Speed-Speed on Load)/No Load Speed]*100	Input Power Factor Cos∅ = W_1/(V*I)

XV. Results :

The Efficiency of the motor at full load is = ……… %

Full load Speed Regulation = ………

XVI. Interpretation of results (Write the meaning of above obtained results**)**

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XVII. Conclusion (Actions/decisions to be taken based on the interpretation of results**)**

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XVIII. Practical related questions: (Use separate sheet for answer)

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. Comment on the speed regulation of single phase induction motor.

2. State the type of motor used in this experiment and comment on its performance characteristic curve
3. State the suitability of single phase induction motor for industrial applications.
4. State the applications of single phase shaded pole induction motor
5. Describe double field revolving theory.

[Space for Answers]

Scale

X-axis -

Y-axis -

XIX. References/Suggestions for further reading

- https://www.electrical4u.com/single-phase-induction-motor/
- http://www.roevertech.ac.in/department/eee/qb/machines%202%20lab%20manual.pdf
- http://www.srmuniv.ac.in/sites/default/files/2018/15EE210L-lab-manual.pdf

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
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Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11: Perform the direct loading test on the given 3 phase alternator and determine voltage regulation for various p.f loads.

I. Practical Significance

Determination of voltage regulation of 3 phase alternator is one of the prime requirements to understand the performance and efficient working of alternators which are widely used in generating stations. Direct loading test gives accurate results of regulation of alternator.

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.

PSO: To test and maintain various electrical equipments and suggest remedial measures.

III. Competency and Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Understand the operation of exciter, prime mover and alternator.
- Load the alternator with various power factor loads.
- Determine the regulation of alternator.

IV. Relevant Course Outcome(s)

- Use the relevant three phase alternator for different load conditions.

V. Practical Outcome :

Perform the direct loading test on the given three phase alternator and determine the regulation.

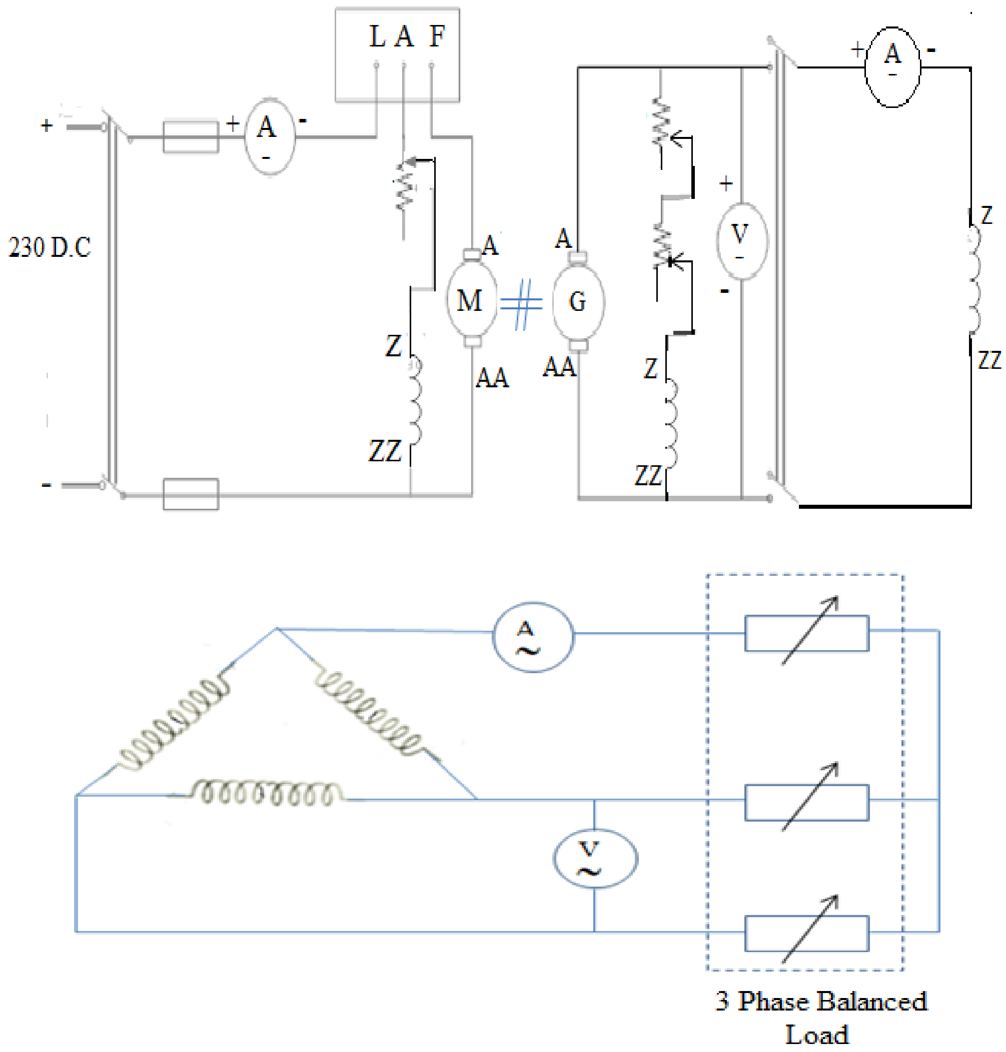
VI. Minimum Theoretical Background

1. Voltage regulation of an alternator is defined as "the rise in voltage when full load is removed (with field excitation and speed remaining the same) divided by the rated terminal voltage".
2. % voltage regulation 'UP' = $\frac{E_o - V}{V} \times 100$
3. % regulation 'Down' = $\frac{E_o - V}{E_o} \times 100$

   Eo is no load induced emf of alternator

   V is rated terminal voltage of alternator

VII. Practical Setup/ circuit diagram/ work situation



VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Three phase alternator with shunt exciter	240 V, 7.2 Amp, 3 KVA, 1500 Rpm with exciter voltage 220 V	1
2.	D.C. Shunt motor	220 V, 19 Amp, 5 HP, 1500 Rpm	1
3.	Exciter	220 V, 2.3 Amp, 0.5 KW, 1500 Rpm	1
4.	Ammeter	MI type 0-10 Amp	1
5.	Ammeter	PMMC type, 0-20 Amp 0-2 Amp	1 1
6.	Voltmeter	MI type 0-300 V	1
7.	Voltmeter	PMMC type 0-300 V	1
8.	Rheostat	400 Ohm, 1.7 Amp 1000 Ohm, 1.2 Amp	1 2

9.	Starter for D.C. motor or any prime mover	3 point starter	1
10.	3 phase balanced resistive load	230 V	1
11.	3 phase balanced inductive load	230 V	1
12.	3 phase balanced capacitive load	230 V	1

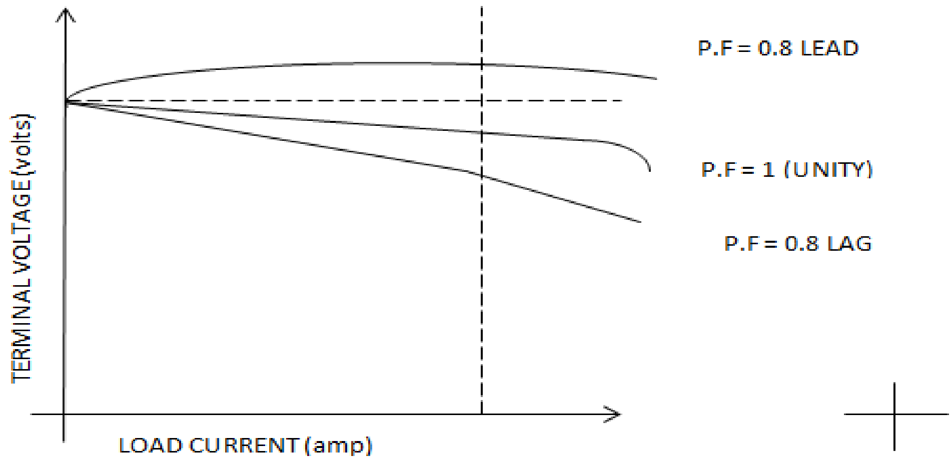
IX. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Ensure that the field rheostat in the D.C. motor side is kept at minimum resistance position and the field rheostat in the shut exciter side at maximum resistance position when the supply is switched on.
3. Do not touch/make/alter any connection when the circuit is live.
4. All the load connected to the alternator stator winding should be in off position initially when the circuit is given supply.

X. Procedure

1. Connect the circuit as shown in the circuit diagram with proper wires, meters, and equipments as per the rating of D.C. motor and alternator.
2. Ensure that all the load switches on alternator are in off position.
3. Set the rheostat on the alternator exciter winding at maximum resistance position.
4. Set the rheostat on the D.C. motor field winding at minimum resistance position.
5. Switch ON the supply of D.C. motor and move the starter to zero resistance position smoothly and gradually.
6. Adjust the speed of prime mover to the synchronous speed of alternator using field rheostat of D.C.motor.
7. Close the switch so that rotor winding of alternator is connected to D.C. shunt exciter.
8. Decrease the resistance of the field rheostat of shunt exciter so that current will start to flow in the field winding of alternator. Adjust the field current so that alternator will build up voltage upto rated terminal voltage.
9. Start to switch on the load of the alternator in steps so that the load current increases upto rated load current keeping the speed of the set constant for each loading and note down load current and terminal voltage readings at each load conditions in the observation table.
10. Switch "OFF" complete load keeping the speed and field current constant. Note down alternator terminal voltage at no load.
11. Repeat the steps 3-10 for inductive load and capacitive load.
12. Switch off supply and remove connections.
13. Plot the graph between terminal voltage V and load current I_L for resistive, inductive and capacitive load on same graph paper.

The nature of graph will be as shown in figure.



XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (use blank sheet if space is not sufficient)

Synchronous speed of alternator = ______________ rpm (constant)

Field current of alternator = ________________ Amp (constant)

Rated terminal voltage of alternator = ________Volts

1. For Resistive load

Sr. No.	Load Current (I_L) Amperes	Terminal Voltage (V) Volts	Regulation %

2. For Inductive load :

Sr. No.	Load Current (I_L) Amperes	Terminal Voltage (V) Volts	Regulation %

3. For capacitive load

Sr. No.	Load Current (I_L) Amperes	Terminal Voltage (V) Volts	Regulation %

Calculations (Sample calculation)

1. For Resistive load (unity PF)
   % voltage regulation 'UP' = $\frac{Eo - V}{V}$ x 100 =______ %
   %Voltage regulation 'Down' = $\frac{Eo - V}{Eo}$ x 100 =______ %

2. For inductive load (lagging Pf) = ________________ x 100
   =________________ %

3. For capacitive load (Leading PF) = ________________x 100
   = ____________%

XV. Results:

The voltage regulation of alternator at full load is found to be.

For Resistive load = _____________%
For Inductive load = ______________%
For Capacitive load = _____________%

XVI. Interpretation of results (Write the meaning of above obtained results)

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XVII. Conclusion (Actions/decisions to be taken based on the interpretation of results)

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XVIII. Practical related questions : (Use separate sheet for answer)

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 voltage regulation.
2. List out the different voltage drops in an alternator.
3. Define the term “armature reaction” in case of an alternator.
4. Describe the effect of armature reaction at unity lagging and leading PF.
5. Draw phasor diagram of a loaded alternator for Resistive, Inductive & capacitive load.
6. ‘Alternators are designed with high regulation compared with transformer’.- Justify

[Space for Answers]

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XIX. References/Suggestions for further reading

Sr. No.	Title of Book	Author	Publication
1.	Electrical Machines	Bhattacharya S.K.	Tata McGraw Hill, New Delhi SBN 9780075415396
2.	Electrical Machines	Kothari D.P. and Nagrath I.J.	McGraw Hill, New Delhi ISBN 13: 978-9352606405
3.	Electrical Technology	Hughes E.	ELBS
4.	Electrical Technology	Cotton H.	ELBS

1. www.nptel.iitm.ac.in
2. www.vlab.com
3. www.khanacademy.com

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....
5. ....

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

Scale

X-axis -

Y-axis -

Practical No. 12: Determination of regulation of 3 phase alternator from OC and SC test (Synchronous impedance method)

I. Practical Significance

Predetermination of voltage regulation of 3 phase alternator is one of the prime requirements to understand the performance and efficient working of alternators which are widely used in generating stations. Predetermination of regulation by synchronous impedance method gives higher value of regulation than obtained from actual loading.

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.

PSO: To test and maintain various electrical equipments and suggest remedial measures.

III. Competency and Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Understand the operation of exciter, prime mover and alternator.
- Learn to conduct OC and SC test on alternator.
- Measure the resistance of the winding
- Calculate the regulation of alternator by calculating synchronous impedance, reactance from OC and SC characteristics.

IV. Relevant Course Outcome(s)

- Use the relevant three phase alternator for different load conditions.

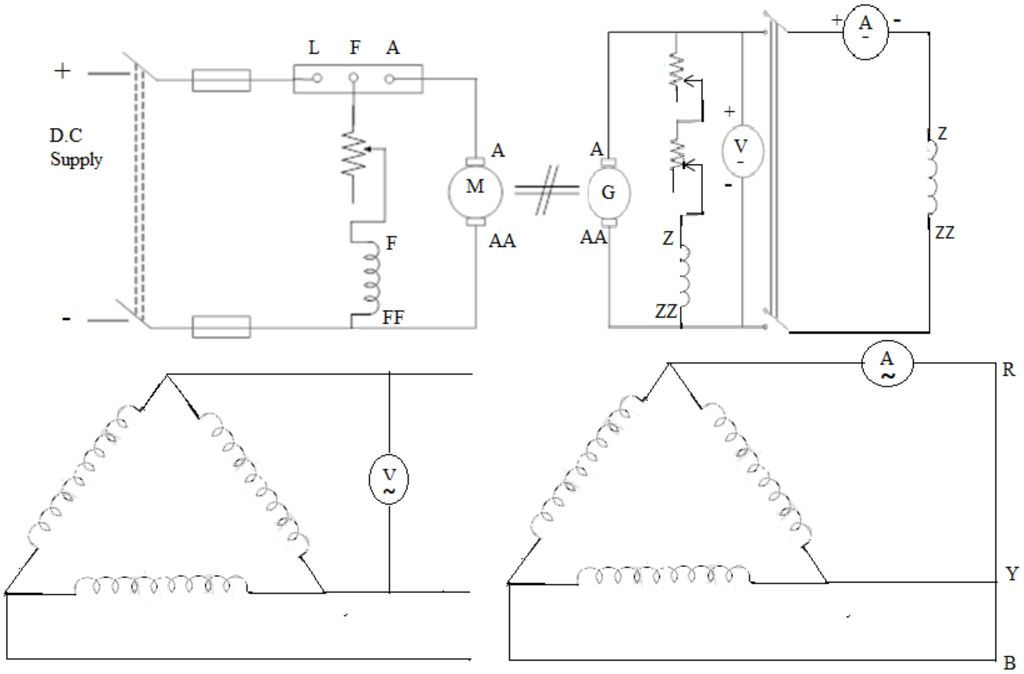
V. Practical Outcome :

Determine the regulation of the given three phase alternator from OC and SC tests (Synchronous impedance method)

VI. Minimum Theoretical Background

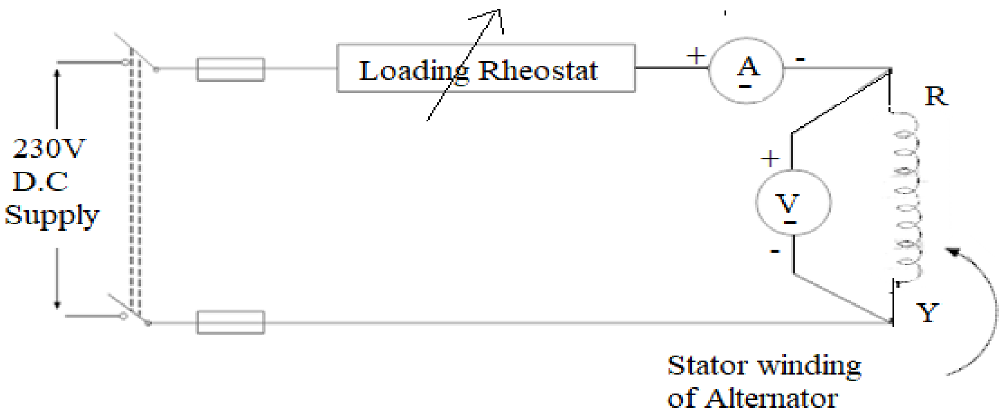
Synchronous impedance is predetermination method of calculating regulation of an alternator which gives higher value of regulation than obtained from actual loading. This method is indirect method of finding out regulation. In this method O.C. and SC. Characteristics are plotted by conducting the o.c and s.c test and synchronous impedance is calculated from it. Measure the value of stator resistance R_a by voltmeter ammeter method. Then X_s can be calculated using the values of Z_s and R_a. Then induced emf of alternator E_0 can be calculated for any load current and at any power factor using the values of X_s and R_a. The percentage regulation of alternator can be obtained knowing the value of E_0 and rated terminal voltage V. All the above values should be per phase values.

VII. Circuit diagram



Circuit Diagram 1 OC Test

Circuit Diagram 2 SC Test



Circuit diagram 3 Measurement of stator winding resistance

VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Three phase alternator with shunt exciter	240 V, 7.2 Amp, 3 KVA, 1500 Rpm with exciter voltage 220 V	1

2.	D.C. Shunt motor	220 V, 19 Amp, 5 HP, 1500 Rpm	1
3.	Exciter	220 V, 2.3 Amp, 0.5 KW, 1500 Rpm	1
4.	Ammeter	MI type 0-10 Amp	1
5.	Ammeter	PMMC type, 0-20 Amp 0-2 Amp 0-10 Amp	1 1 1
6.	Voltmeter	MI type 0-300 V	1
7.	Voltmeter	PMMC type 0-300 V 0-75 V	1 1
8.	Rheostat	400 Ohm, 1.7 Amp 1000 Ohm, 1.2 Amp	1 2
9.	Starter for D.C. motor or any prime mover	3 point starter	1

IX. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Ensure that the field rheostat in the D.C. motor side is kept at minimum resistance position and the field rheostat in the shut exciter side at maximum resistance position when the supply is switched on.
3. Do not touch/make/alter any connection when the circuit is live

X. Procedure:

(A) Open circuit test

1. Connect the circuit as shown in the circuit diagram (1) with proper wires, meters, and equipments as per the rating of D.C. motor and alternator.
2. Set the rheostat on the alternator exciter winding at maximum resistance position.
3. Set the rheostat on the D.C. motor field winding at minimum resistance position.
4. Switch ON the supply of D.C. motor and move the starter to zero resistance position smoothly and gradually.
5. Adjust the speed of prime mover to the synchronous speed of alternator using field rheostat of D.C.motor.
6. Close the switch so that rotor winding of alternator is connected to D.C. shunt exciter.
7. Decrease the resistance of the field rheostat of shunt exciter so that current will start to flow in the field winding of alternator.
8. Increased the field current of alternator in steps.
9. Adjust the field current so that alternator will build up voltage upto rated terminal voltage and even 10% more than the rated voltage.

10. Take the corresponding meter readings of field current of alternator and induced emf of alternator.
11. Switch off supply and remove connections.

(B) Short Circuit Test

1. Connect the circuit as shown in the circuit diagram (2) with proper cables (wires), meters, equipment as per the rating of D.C. motor and alternator.
2. Ensure that all the load switches on alternator are in off position.
3. Set the rheostat on the alternator exciter winding at maximum resistance position.
4. Set the rheostat on the D.C. motor field winding at minimum resistance position.
5. Switch ON the supply of D.C. motor and move the starter to zero resistance position smoothly and gradually.
6. Adjust the speed of prime mover to the synchronous speed of alternator using field rheostat of D.C.motor.
7. Close the switch so that rotor winding of alternator is connected to D.C. shunt exciter.
8. Decrease the resistance of the field rheostat of shunt exciter so that current will start to flow in the field winding of alternator.
9. Increased the field current of alternator
10. Adjust the field current so that full load current as given in the rating flows in the short circuited stator winding of alternator.
11. Take the corresponding meter readings of field current of alternator and short circuit winding current of alternator.
12. Switch off supply and remove connections.

(C) Measurement of alternator stator winding resistance

1. Connect the circuit as per circuit diagram (3)
2. Switch on the D.C.supply
3. By varying the loading rheostat note down the ammeter reading and volt meter reading.
4. The current can be increased till the rated current of alternator.

XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			

5.			
6.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (use blank sheet if space is not sufficient)

Synchronous speed of alternator = ______________ rpm (constant)

1. For open Circuit Test

Sr. No.	Field current (I_f) Amperes	Induced voltage (V_1) Volts

2. For Short circuit test

Sr. No.	**Field current (I_f)**	**Armature short circuit current (I_1)**
	Amperes	**Amperes**

3. Measurement of Alternator Stator Winding Resistance

Sr. No.	Voltage	Current	R_a = V/I	R_a (avg)

Calculation:

- Synchronous impedance Zs is calculated from OC and SC characteristics at a given field current by the formula
  Z_s (per phase)= $\frac{\text{open circuit voltage per phase (from OCC)}}{\text{Short circuit current per phase (from SCC)}}$
- Alternator stator winding resistance R_a = 1.2 x R_a (dc)
  = ________ ohms per phase
- Synchronous reactance X_s (per phase) = $\sqrt{Z_s^2 - R_a^2}$ =____________

  Where R_a is the resistance of the stator winding per phase
  X_s (per phase) = ______ ohms per phase
- Full load current I_a of alternator is calculated from the KVA and KV rating of alternator.
  I_a (Rated) = $\frac{\text{Rated KVA x 1000}}{\sqrt{3} \text{ x VL (Rated)}}$ = ________ amp (Line)

  I_a (Rated) (phase) = $\frac{I_a \text{ (Rated) (Line)}}{\sqrt{3}}$ = (for delta connected stator winding)
  =____________
- Then % regulation is calculated as given below :

1. At Unity power factor

$E_o = \sqrt{(V + I_a R_a)^2 + (I_a X_s)^2}$ = ____________

Where E0 is no load induced EMF per phase of alternator and V is the rated voltage of alternator per phase.

E_0 = Volts per phase

- Then voltage regulation can be calculated using the following formulae :
  % voltage regulation 'UP' = $\frac{Eo - V}{V}$ x 100

- % regulation 'Down' = $\frac{Eo - V}{Eo} \times 100$

2. **At 0.8 lagging power factor**

$$E_0 = \sqrt{(V \cos Ø + I_a R_a)^2 + (V \sin Ø \ I_a + I_a X_s)^2}$$

E_0 = Volts per phase

- Then voltage regulation can be calculated using the following formulae : % voltage regulation 'UP' = $\frac{Eo - V}{V} \times 100$

- % regulation 'Down' = $\frac{Eo - V}{Eo} \times 100$

3. **At 0.8 leading power factor**

$$E_0 = \sqrt{(V \cos Ø + I_a R_a)^2 + (V \sin Ø - I_a X_s)^2}$$

E_0 = Volts per phase

- Then voltage regulation can be calculated using the following formulae :
  % voltage regulation 'UP' = $\frac{Eo - V}{V} \times 100$

- % regulation 'Down' = $\frac{Eo - V}{Eo} \times 100$

XV. Results :

The voltage regulation of alternator at full load is found to be.

At Unity power factor load = ____________%

At 0.8 lagging power factor load = _____________%

At 0.8 leading power factor load = ____________%

XVI. Interpretation of results (Write the meaning of above obtained results)

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XVII. Conclusion (Actions/decisions to be taken based on the interpretation of results**)**

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XVIII. Practical related questions : (Use separate sheet for answer)

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. "Open circuit characteristics of Synchronous motor are nonlinear". Justify.
2. "Synchronous impedance method is called as pessimistic method". Justify.
3. "Regulation is negative in case of leading power factor". Justify.
4. "Alternator stator winding resistance R_a = 1.2 R_a (dc)". Justify.
5. State and explain the accurate method of determining voltage regulation in case of synchronous alternator.

[Space for Answers]

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XIX. References/Suggestions for further reading

a) www.nptel.iitm.ac.in
b) www.vlab.com
c) www.khanacademy.com

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1…………………………

2…………………………

3…………………………

4. …………………………

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

Scale

X-axis -

Y-axis -

Experiment No. 13: Start 3 phase synchronous motor and run it in forward and reverse directions.

I. Practical Significance

Synchronous motor is not inherently self starting motor. It is widely used for power factor improvement in industries as synchronous condenser. It is having the unique feature of running only at synchronous speed or not at all. It is important to learn its methods of starting and reversal of direction of rotation.

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.
- **PSO:** To test and maintain various electrical equipments and suggest remedial measures.

III. Competency and Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Select relevant meters and rheostats with proper range.
- Apply reduced voltage as well rated voltage to the stator.
- Operate the field exciter.

IV. Relevant Course Outcome(s)

- Use suitable synchronous motors in different applications.

VII. Practical Outcome:

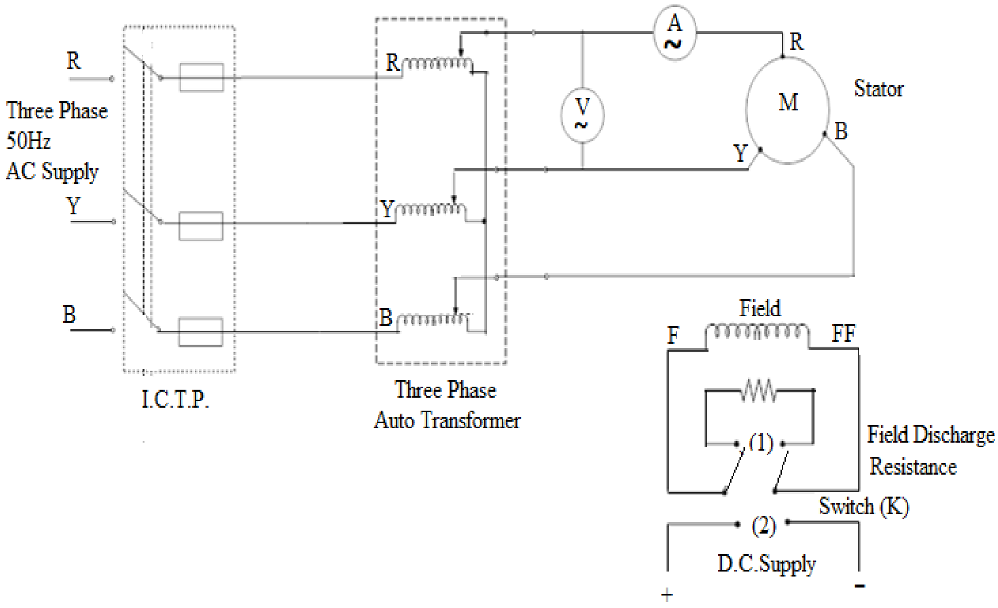
Start 3 phase synchronous motor & run synchronous motor in forward & reverse direction.

VIII. Minimum Theoretical Background

Synchronous motor is not inherently self-starting. It has to be run upto synchronous or near synchronous speed by some means before it can be synchronized to supply. In this experiment we are using most common method of starting synchronous motor where the motor is provided with damper windings which helps to start the motor as an induction motor. The field winding is kept open and reduced voltage supply is given to stator. This induces a voltage in damper bars and the motor starts running as an induction motor. The supply voltage now is made normal. As the synchronous motor speed is near synchronous speed, the field is excited which pulls the motor into synchronism.

In synchronous motor, the rotor follows rotating magnetic field. If the direction of rotation is to be reversed, the direction of rotation of magnetic field should be reversed. This is done by changing the phase sequence of voltage applied to stator winding.

IX. Circuit diagram



X. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Three phase synchronous motor with damper winding	5 KVA, 16.5 Amps, 1500 Rpm, 230 Volts, Delta connected	1
2.	Three phase autotransformer	0-415 volts	1
3.	Ammeter	MI type 0-10 Amp	1
4.	Voltmeter	MI type 0-300 volts	1
5.	Tachometer	0-3000 Rpm, Digital type	1
6.	Rheostat	60 Ohms, 5 Amps	1
7.	Double pole double throw switch		1

XI. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. Do not touch/make/alter any connection when the circuit is live.
3. Ensure that the output of 3 phase transformer is kept at zero output position initially.
4. Ensure that the field discharge resistance is connected in the field circuit at starting.

X. Procedure:

1. Starting of three-phase synchronous motor.

1. Select suitable equipments and meter ranges as per rating of synchronous motor.
2. Connect the circuit as shown in circuit diagram.
3. Keep the position of knife switch (k) to field circuit in position (1)
4. Keep the variac to zero output.
5. Switch 'ON' ICTP.
6. Increase the output of variac gradually. The motor starts running and gain speed. Observe variation in stator current.
7. Increase voltage applied to stator in steps (keeping current in safe limit). Note down current and voltage. Note down the corresponding speed.
8. Apply rated voltage to the motor by adjusting variac. Note down the current Note down the speed.
9. When the motor speed is close to synchronous speed change the position of knife switch (k) to position (2), (which connects field winding to DC supply). The motor runs at synchronous speed. Note down current and voltage Note down the speed.
10. Observe the direction of rotation of synchronous motor. Note down the direction of rotation in observation table (2)
11. Switch 'OFF' DC supply to motor field. Set variac output to zero position and switch 'OFF' ICTP.

2. Reversal of direction of rotation

1. Interchange any two motor stator terminals (other connection remains same)
2. Repeat steps (3) to (9) as given in starting of synchronous motor.
3. Observe the direction of rotation of synchronous motor. Note down the direction of rotation of motor in observation table (2)
4. Repeat step (11) as given in starting of synchronous motor.

XI. Resources used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (use blank sheet if space is not sufficient)

1. For starting of synchronous motor
   Synchronous speed (Ns) = (120f/p) = (120 x 50/   ) = ________r.p.m.

Sr. No.	Stator applied voltage (Volts)	A.C. line current (Amp)	Switch (K) Position	Speed of motor (r.p.m.)
1			1	
2			1	
3			1	
4			1	
5			2	(Syn. Speed)
6			2	(Syn. Speed)

2. For reversal of rotation

Phase sequence of stator applied voltage	Direction of rotation from shaft side (Clockwise/anticlockwise)
R – Y – B	
R – B – Y	

XV. Results :

- Starting and running up of three-phase synchronous motor having dampere winding is studied. The motor runs at synchronous speed __________r.p.m. (constantly) or not at all.
- The direction of motor rotation can be reversed by interchanging __________ ____
- Student should comment about the instant of switching "ON" DC field excitation.

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XVI. Interpretation of results (Write the meaning of above obtained result)

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XVII. Conclusion (Action/decisions to be taken based on the interpretation of results)

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XVIII. Practical related questions: (Use separate sheet for answer)
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. A synchronous motor 10 H.P., 440 V, 50 Hz star connected is having 6 poles on its stator. Determine its speed.
2. A synchronous motor runs at 1000 rpm at 50 Hz. Calculate its number of poles.
3. What is damper winding?
4. If synchronous motor is not provided with damper winding, how to start it?
5. Synchronous motor either runs at synchronous speed or otherwise not at all, why?

[Space for Answers]

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XIX. References/Suggestions for further reading

- www.nptel.iitm.ac.in
- www.vlab.com
- www.khanacademy.com

XX. Assessment Scheme

Performance Indicators		Weightage %
Process Related (15 Marks)		**60%**
1.	Handling/Selection of the meters and equipments as per specification of the machine	10%
2.	Identification of machine, winding terminals and taking adequate safety precautions	20%
3.	Connecting the circuit and making observation following systematic procedure.	20%
4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1……………………….

2………………………….

3………………………….

4………………………….

5………………………….

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

Practical No. 14: Conduct the test on load or no load to plot the 'V' curves and inverted 'V' curves of 3-phase synchronous motor

I. Practical Significance

The effect of excitation on armature current and power factor of 3 phase synchronous motor shall be studied by obtaining 'V' curves and inverted 'V' curves. Since synchronous motor acts as a synchronous condenser while operating with leading power factor it is important to study about these curves.

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 Practical skills

This practical is expected to develop the following skills for the industry identified Competency: **'Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.'**

- Understand the specification of synchronous motor.
- Select relevant meters and rheostats with proper range.
- Start the synchronous motor.
- Vary the field current of motor for observing its effect on armature current and power factor.

IV. Relevant Course Outcome(s)

- Use suitable synchronous motor in different applications.

V. Practical Outcome :

Conduct the test on load or no load to plot the 'V' curves and inverted 'V' curves of 3-ϕ synchronous motor.

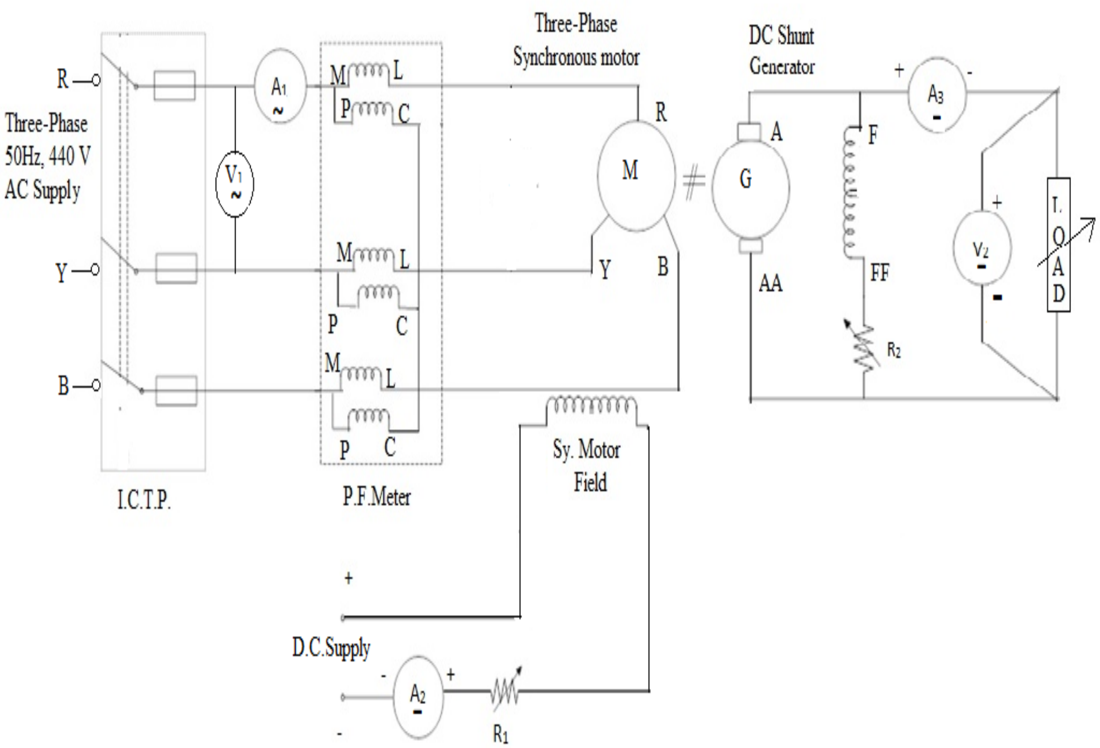
VI. Minimum Theoretical Background

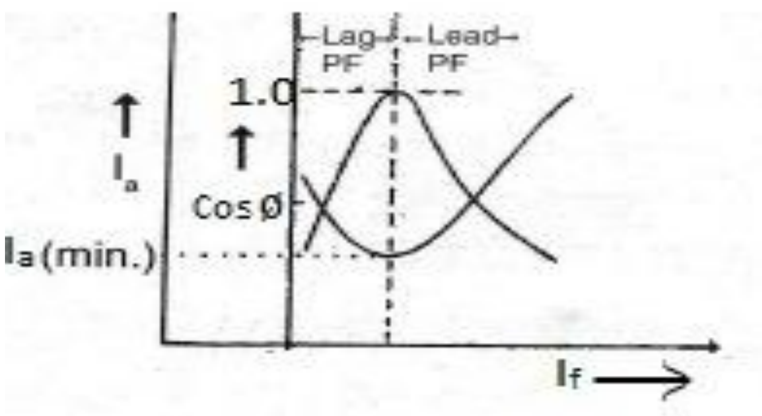
The magnitude of armature current varies with excitation. The current has large value both for low and high values of excitation (though it is lagging for low excitation and leading for higher excitation). In between, it has minimum value corresponding to a certain excitation. The variations of armature current with excitation are known as ‘V’ curves because of their shape.

For the same input, armature current varies over a wide range and so causes the power factor also to vary accordingly. When over-excited, motor runs with leading p.f. and with lagging p.f. when under-excited. In between, the p.f. is unity. The variations of p.f. with excitation are known as inverted ‘V’ curve. It would be noted that minimum armature current corresponds to unity power factor.

An over-excited motor can be run with leading power factor. This property of the motor renders it extremely useful for phase advancing and so power factor correction purposes in the case of industrial loads driven by induction motors.

VII. Circuit Diagram





VIII. Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	3 phase synchronous motor	6.5 kilo watts, 230 v, 15 Amp, 1500 Rpm	1
2.	D.C. Shunt Generator	230 V, 5 kilo watts, 10 Amp, 1500 Rpm	1
3.	Exciter	230 V, 1.2 kilo watts, 2 Amp, 1500 Rpm	1
4.	Power Factor meter		1
5.	3 phase Variac	230 V, 20 Amp	1
6.	Voltmeter	MI type 0-300 V	1
7.	Voltmeter	PMMC type 0-300 V	1
8.	Rheostat	400 Ohm, 1.7 Amp	1
9.	Ammeter	Mi type 0-20 Amp PMMC type 0-5 Amp PMMC type -15 Amp	1 1 1

IX. Precautions to be followed

1. Do not switch on the supply without the connections checked thoroughly by the competent staff.
2. The output of 3 phase inductor should be kept at minimum output position when the supply is switched on.
3. The field rheostat at the generator side should be kept at maximum resistance position when the supply is switched on.
4. Do not touch/make/alter any connection when the circuit is live.

X. Procedure

1. Select suitable equipments and meters as per the rating of synchronous motor, exciter and DC generator.
2. Connect the circuit as per circuit diagram.
3. Start the 3 phase synchronous motor by gradually applying the voltage using variac and increase the voltage in steps to the stator. When the motor is close to synchronous speed give DC supply to the field winding which makes the motor to run at synchronous speed.
4. Adjust the field current of synchronous motor to suitable value and applying suitable load on the coupled DC generator.
5. Vary field current by adjusting the synchronous motor field rheostat and note down the corresponding armature current and power factor readings.
6. Vary the field current to cover a range from a low leading to low lagging through unity power factor.

7. Plot graph of armature current versus field current, the shape of which is like 'V' curve.
8. Plot graph of power factor versus field current, the shape of which is like 'Inverted V' curve.

XI. Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1.			
2.			
3.			

XII. Actual Procedure followed (use blank sheet if space is not sufficient)

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XIII. Precautions followed

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XIV. Observation & Calculation (use blank sheet if space is not sufficient)

Speed of synchronous motor = ________Rpm (rated speed)

DC generator output: Load voltage = __________volts

Load current = _______Amp

Observation table for effect of variation in field current on armature current and power factor.

Sr. No.	Field current (I_f) (Amp)	Power factor (cosØ)	Armature current (I_a) (Amp)

XV. Results

Armature AC line current and power factor of 3 phase induction motor is found to vary with the variation in ______________.

For constant motor output synchronous motor armature Ac line current is ________ (maximum/minimum) when power factor is unity.

XVI. Interpretation of Results (Write the meaning of above obtained results

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XVII. Conclusion (Actions/Decisions to be taken based on the interpretation of results)

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XVIII. Practical related questions : (Use separate sheet for answer)

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. Plot the nature of curve between stator current and field current for increasing power output .
2. Describe the under-excited state of three-phase synchronous motor.
3. Describe the over-excited state of three-phase synchronous motor.
4. State the special applications of an over-excited synchronous motor.
5. Define “ Synchronous condenser”.

[Space for Answers]

XIX. References/Suggestions for further reading

- www.nptel.iitm.ac.in
- www.vlab.com
- www.khanacademy.com

XX. Assessment Scheme

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Process Related (15 Marks)		**60%**
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4.	Working in team	10%
Product Related (10 Marks)		**40%**
5.	Calculating accurately the required results.	05%
6.	Interpretation of result	10%
7.	Conclusions	10%
8.	Practical related questions	10%
9.	Submitting the journal in time	05%
Total (25 Marks)		**100%**

Names of Student Team Members

1. ……………………………
2. ……………………………
3. ……………………………
4. ……………………………
5. ……………………………

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

Scale

X-axis -

Y-axis -

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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