

DRONACHARYA

Group of Institutions

BASIC ELECTRICAL ENGINEERING LAB

LABORATORY MANUAL

B.Tech. Semester –I/II

Subject Code: BEE-151/251

Session: 2022-23, Even Semester

Name:	
Roll. No.:	
Group/Branch:	

DRONACHARYA GROUP OF INSTITUTIONS

DEPARTMENT OF EEE

#27 KNOWLEDGE PARK 3

GREATER NOIDA

**AFFILATED TO Dr. ABDUL KALAM TECHNICAL UNIVERSITY,
LUCKNOW**

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Vision and Mission of the Institute

Vision:

“Dronacharya Group of Institutions, Greater Noida aims to become an Institution of excellence in imparting quality Outcome Based Education that empowers the young generation with Knowledge, Skills, Research, Aptitude and Ethical values to solve Contemporary Challenging Problems”

Mission:

- M1:** To prepare students for full and ethical participation in a diverse society and encourage lifelong learning by following the principle of ‘Shiksha evam Sahayata’ i.e. Education and Help.
- M2:** To impart high-quality education, knowledge and technology through rigorous academic programs, cutting-edge research, and industry collaborations, with a focus on producing engineers and managers who are socially responsible, globally aware, and equipped to address complex challenges.
- M3:** Educate students in the best practices of the field as well as integrate the latest research into the academics.
- M4:** Provide quality learning experiences through effective classroom practices, innovative teaching practices, and opportunities for meaningful interactions between students and faculty.
- M5:** To devise and implement programmes of education in technology and management that are relevant to the changing needs of society, in terms of breadth of diversity and depth of specialization.

Vision and Mission of the Department

Vision:

- V1:** To be recognized as a department of excellence to produce competent and ethical students with a worldwide competency and shape them for industry, research, entrepreneurship and higher academic goals.
- V2:** The department's goal is to help students find, innovate, create, and produce environmentally friendly and socially responsible technology that fulfils the increasing demands of industry.

Mission:

- M1:** To impart to students technical and ethical knowledge to help them design, implement and control efficient systems and also comprehend the industry's expanding issues.
 - M2:** Make every endeavor to engage with academic groups and industry to provide the framework for collaborative research.
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Programme Educational Objectives (PEOs)

- PEO 1.** Engineers will practice the profession of engineering using a systems perspective and analyze, design, develop, optimize & implement engineering solutions and work productively as engineers, including supportive and leadership roles on multidisciplinary teams.
- PEO 2.** Continue their education in leading graduate programs in engineering & interdisciplinary areas to emerge as researchers, experts, educators & entrepreneurs and recognize the need for, and an ability to engage in continuing professional development and life-long learning.
- PEO 3.** Engineers, guided by the principles of sustainable development and global interconnectedness, will understand how engineering projects affect society and the environment.
- PEO 4.** Promote Design, Research, and implementation of products and services in the field of Engineering through Strong Communication and Entrepreneurial Skills.
- PEO 5.** Re-learn and innovate in ever-changing global economic and technological environments of the 21st century.
-

Programme Outcomes (POs)

- PO1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- PO2: Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- PO6: The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- PO7: Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- PO8: Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- PO9: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO10: Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- PO11: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- PO12: Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
-

Program Specific Outcomes (PSOs)

EEE

PSO1: Develop applications in the areas of Electrical and Electronics Engineering based on the knowledge of Control systems and automation, Electrical machines, Power systems, and Embedded Systems.

PSO2: Ability to design, analyse, integrate and synthesize different novel systems to be capable for lifelong learning and advanced industrial research.

PSO3: Be proficient enough to make use of the technical concepts, suitable methods and algorithms for research as well as for the social needs.

University Syllabus

(A) Hardware based experiments

1. Verification of Kirchhoff's laws
2. Measurement of power and power factor in a single phase ac series inductive circuit and study improvement of power factor using capacitor
3. Study of phenomenon of resonance in RLC series circuit and obtain resonant frequency.
4. Connection and measurement of power consumption of a fluorescent lamp (tube light).
5. Measurement of power in 3- phase circuit by two-wattmeter method and determination of its power factor for star as well as delta connected load.
6. Determination of parameters of ac single phase series RLC circuit
7. Determination of (i) Voltage ratio (ii) polarity and (iii) efficiency by load test of a single phase Transformer
8. Determination of efficiency of a dc shunt motor by load test
9. To study running and speed reversal of a three phase induction motor and record speed in both directions.
10. Demonstration of cut-out sections of machines: dc machine, three phase induction machine, single-phase induction machine and synchronous machine.

(B) Experiments available on virtual lab

1. Kirchhoff's laws.
Virtual lab link: <http://vlab.amrita.edu/?sub=3&brch=75&sim=217&cnt=2>
 2. Thevenin Theorem.
Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=75&sim=313&cnt=1>
 3. RLC series resonance.
Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1>
 4. Measurement of power in 3- phase circuit by two wattmeter method and determination of its power factor for star as well as delta connected load.
Virtual lab link: <http://vp-dei.vlabs.ac.in/Dreamweaver/measurement.html>
 5. Determination of parameters of ac single phase series RLC circuit. Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=75&sim=332&cnt=1>
 6. To observe the B-H loop of a ferromagnetic material in CRO.
Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=282&sim=1507&cnt=2>
 7. Determination of the efficiency of a dc motor by loss summation method (Swinburne's test).
Virtual lab link: <http://em-iitr.vlabs.ac.in/exp5/index.php?section=Theory>
-

Course Outcomes (COs)

Upon successful completion of the course, the students will be able to:

CO1	Conduct experiments illustrating the application of KVL/KCL and network theorems to DC electrical circuits.
CO2	Demonstrate the behaviour of AC circuits connected to single phase AC supply and measure power in single phase as well as three phase electrical circuits.
CO3	Perform experiment illustrating BH curve of magnetic materials.
CO4	Calculate efficiency of a single phase transformer and DC machine.
CO5	Perform experiments on speed measurement and reversal of direction of three phase induction motor and Identify the type of DC and AC machines based on their construction.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1						1		1	1
CO2	2	2	1						1		1	1
CO3	2		1						1		1	1
CO4	3	2	1						1		1	1
CO5	3	2	1						1		1	1
Course Correlation mapping	2.6	1.4	1						1		1	1

Correlation Levels: High-3, Medium-2, Low-1

CO-PSO Mapping

	PSO1	PSO2	PSO3
CO1	2	1	
CO2	2	1	
CO3	2	1	
CO4	2	1	
CO5	2	1	
	2	1	

Course Overview

The Electrical Engineering laboratory is one of the important lab of the department as it helps the students of all engineering disciplines to perform the experiments based on basic concepts of electrical science, starting with the basic laws of Kirchoff's. It is well-equipped with several experimental setups and packages for real time experiments.

In this lab, the students of all engineering streams are trained on basic concepts of electrical engineering, such as DC circuits, AC circuits, Resonance for series RLC and Parallel RLC circuit, AC to DC conversion, measurement, Efficiency and voltage regulation of transformer, electrical machines, verification of basic laws and theorems, use of CRO, DSO, etc.

List of Experiments mapped with COs

S. No.	Name of the Experiment	Course Outcome
1	Verification of Kirchhoff's laws	CO1
2	Measurement of power and power factor in a single phase ac series inductive circuit and study improvement of power factor using capacitor	CO2
3	Study of phenomenon of resonance in RLC series circuit and obtain resonant frequency.	CO2
4	Connection and measurement of power consumption of a fluorescent lamp (tube light).	CO2
5	Measurement of power in 3- phase circuit by two-wattmeter method and determination of its power factor for star as well as delta connected load.	CO2
6	Determination of parameters of ac single phase series RLC circuit	CO2
7	Determination of (i) Voltage ratio (ii) polarity and (iii) efficiency by load test of a single phase Transformer	CO3
8	Determination of efficiency of a dc shunt motor by load test	CO4
9	To study running and speed reversal of a three phase induction motor and record speed in both directions.	CO5
10	Demonstration of cut-out sections of machines: dc machine, three phase induction machine, single-phase induction machine and synchronous machine.	CO4

DOs and DON'Ts

Dos

1. Treat every electrical device like it is energized, even if it does not look like it is plugged in or operational.
2. Unplug appliances before performing any service or repairs on them.
3. When working on electrical devices, only use tools that have official “*non-conducting*” handles.
4. Try to limit the use of electrical equipment in rooms that are very cold or have a lot of condensation.
5. When handling electrical equipment, make sure your hands are dry.
6. If you spill any kind of liquid on electrical equipment, *first* immediately shut off power to the equipment via the main switch or circuit breaker *and then* unplug the equipment itself.
7. Keep all electrical circuit contact points enclosed.
8. Finally, if you are able to, work on electrical equipment with one hand while the other hand is out of the way at your side or in your pocket. This minimizes the chance of a current passing through your chest should a spark/accidental charge occur.

DON'Ts

1. First and foremost – don’t touch active electrical circuits.
 2. Never touch electrical equipment when any part of your body is wet, (that includes fair amounts of perspiration).
 3. Do not store liquids of any sort near electrical equipment.
 4. If a person comes into contact with an energized electrical conductor, do not touch the equipment, its cords, or the person affected because the charge may pass to you. Instead, shut down the main power source via the circuit breaker and then unplug the equipment using a leather belt.
 5. Do not wear metal of any sort if you are working on electrical equipment.
 6. Also, do not try to poke, probe, or fix electrical equipment with objects like pencils or rulers because the metal in them can serve as a form of conductor.
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General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as fire wood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

Precautions (In case of Fire)

1. Turn the equipment off. If power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire, if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.
4. Call security and emergency department immediately:

Emergency : **201 (Reception)**

Security : **231 (Gate No.1)**

Guidelines to students for report preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows: -

- 1) All files must contain a title page followed by an index page. *The files will not be signed by the faculty without an entry in the index page.*
- 2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.
- 3) For each experiment, the record must contain the following
 - (i) Aim/Objective of the experiment
 - (ii) Pre-experiment work (as given by the faculty)
 - (iii) Lab assignment questions and their solutions
 - (iv) Test Cases (if applicable to the course)
 - (v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.
 2. Students must ensure that their lab record is regularly evaluated.
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Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute Course Outcomes attainment as well as internal marks in the lab course.

Grading Criteria	Exemplary (4)	Competent (3)	Needs Improvement (2)	Poor (1)
AC1: Designing experiments	The student chooses the problems to explore.	The student chooses the problems but does not set an appropriate goal for how to explore them.	The student fails to define the problem adequately.	The student does not identify the problem.
AC2: Collecting data through observation and/or experimentation	Develops a clear procedure for investigating the problem	Observations are completed with necessary theoretical calculations and proper identification of required components.	Observations are completed with necessary theoretical calculations but without proper understanding. Obtain the correct values for only a few components after calculations. Followed the given experimental procedures but obtained results with some errors.	Observations are incomplete. Lacks the appropriate knowledge of the lab procedures.
AC3: Interpreting data	Decides what data and observations are to be collected and verified	Can decide what data and observations are to be collected but lacks the knowledge to verify	Student decides what data to gather but not sufficient	Student has no knowledge of what data and observations are to be collected
AC4: Drawing conclusions	Interprets and analyses the data in order to propose viable conclusions and solutions	Incomplete analysis of data hence the quality of conclusions drawn is not up to the mark	Cannot analyse the data or observations for any kind of conclusions.	Lacks the required knowledge to propose viable conclusions and solutions
AC5: Lab record assessment	Well-organized and confident presentation of record & ability to correlate the theoretical concepts with the concerned lab results with appropriate reasons.	Presentation of record is acceptable	Presentation of record lacks clarity and organization	No efforts were exhibited

LAB EXPERIMENTS

EXPERIMENT 1a

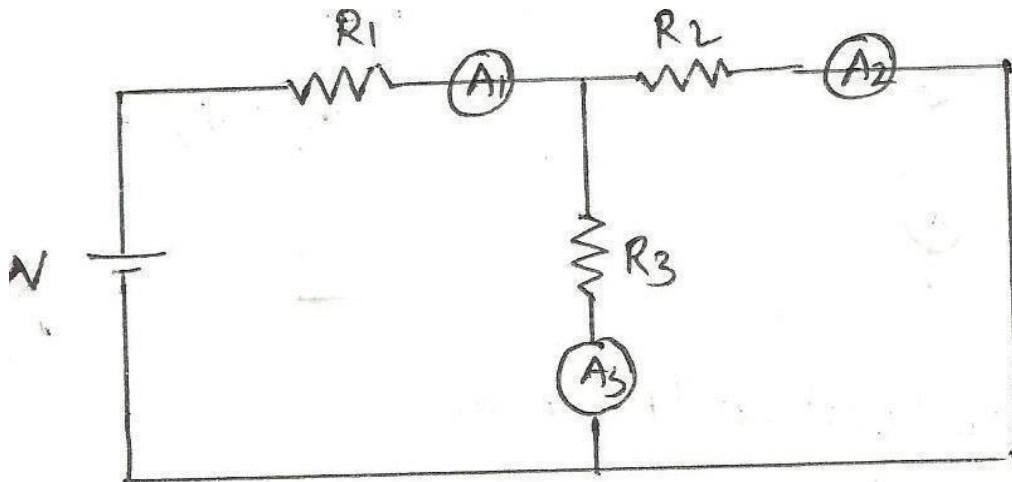
1. OBJECTIVE: VERIFICATION OF KIRCHHOFF'S CURRENT LAW.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Regulated power supply or Battery	0-24 V or 24V	1	
2	PMMC ammeter	0 – 1A	3	
3	Rheostats	10 Ω , 1A	3	
4	Connecting wires			

3. BRIEF THEORY: According to Kirchoff's current law, in any network of wires carrying currents, the algebraic sum of all currents meeting at a junction (or node) is zero or the sum of incoming currents towards any junction (or node) is equal to the sum of outgoing currents away from that junction.

4. CIRCUIT DIAGRAM:



5. PROCEDURE: Three rheostats R_1 , R_2 and R_3 and ammeters A_1 , A_2 and A_3 are connected to 24 V battery or regulated power supply as shown in figure. The three rheostats are set their maximum values, supply is switched on and the reading of the ammeter A_1 , A_2 and A_3 are noted. The process may be repeated by varying either of rheostats R_1 , R_2 and R_3 .

6. OBSERVATIONS:

Sr. no	Reading of ammeter A ₁ (I ₁)	Reading of ammeter A ₂ (I ₂)	Reading of ammeter A ₃ (I ₃)	I ₂ + I ₃
1				
2				
3				
4				
5				

7. CALCULATION:

8. RESULT AND DISCUSSION: It is found that current I₁ is equal to the sum of currents I₂ and I₃. Hence kirchhoff's current law is verified.

9. Precautions:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What is KCL?
2. What is ohm's law?

11. POST EXPERIMENT QUESTIONS:

1. What is difference between emf and potential difference?
2. Why ammeters are connected in series to measure current?
3. If the length of a wire of resistance R is uniformly stretched to n times its original value, what will be its new resistance?

EXPERIMENT 1b

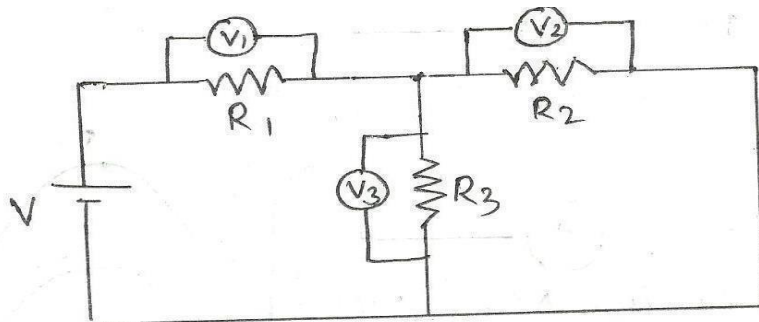
1. OBJECTIVE: VERIFICATION OF KIRCHHOFF'S VOLTAGE LAW.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Regulated power supply or Battery	0-24 V or 24V	1	
2	PMMC voltmeter	0-24V	3	
3	Rheostats	10 Ω , 2.5A	2	
4	Connecting wires			

3. BRIEF THEORY: According to Kirchhoff's voltage law, in any closed circuit or mesh, the algebraic sum of emfs acting in the circuit or mesh is equal to the algebraic sum of the products of the currents and resistances of each part of the circuit or mesh.

4. CIRCUIT DIAGRAM:



5. PROCEDURE: Two rheostats R_1 , R_2 , R_3 and three voltmeters V_1 , V_2 and V_3 are connected to 24V battery or regulated power supply as shown in figure. Three rheostats are set their maximum values, supply is switched on and the reading of the voltmeters V_1 , V_2 and V_3 are noted. The process may be repeated by varying either of rheostats R_1 , R_2 or R_3 .

6. OBSERVATIONS:

Sr. no	Reading of Voltmeter V_1 in Volts	Reading of Voltmeter V_2 in Volts	Reading of Voltmeter V_3 in Volts
1			
2			
3			
4			

7. CALCULATION:

8. RESULT AND DISCUSSION: It is found that, in first loop, voltage V is equal to the sum of voltages V_1 and V_3 and in second loop $V_2 = V_3$. Hence Kirchhoff's voltage law is verified.

9. PRECAUTION:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What is KVL?

11. POST EXPERIMENT QUESTIONS:

1. Why voltmeters are connected in parallel to rheostats to measure voltage?
2. How does the resistance of a homogeneous material having constant length vary with the changing cross sectional area.
3. What is Fleming's left hand rule?
4. What is Fleming's right hand rule?
5. Define junction and node.
6. Define Mesh and loop.

EXPERIMENT 2

1. OBJECTIVE: MEASUREMENT OF POWER AND POWER FACTOR IN A SINGLE PHASE AC SERIES INDUCTIVE CIRCUIT AND STUDY OF IMPROVEMENT OF POWER FACTOR USING CAPACITOR.

2. APPARATUS REQUIRED:

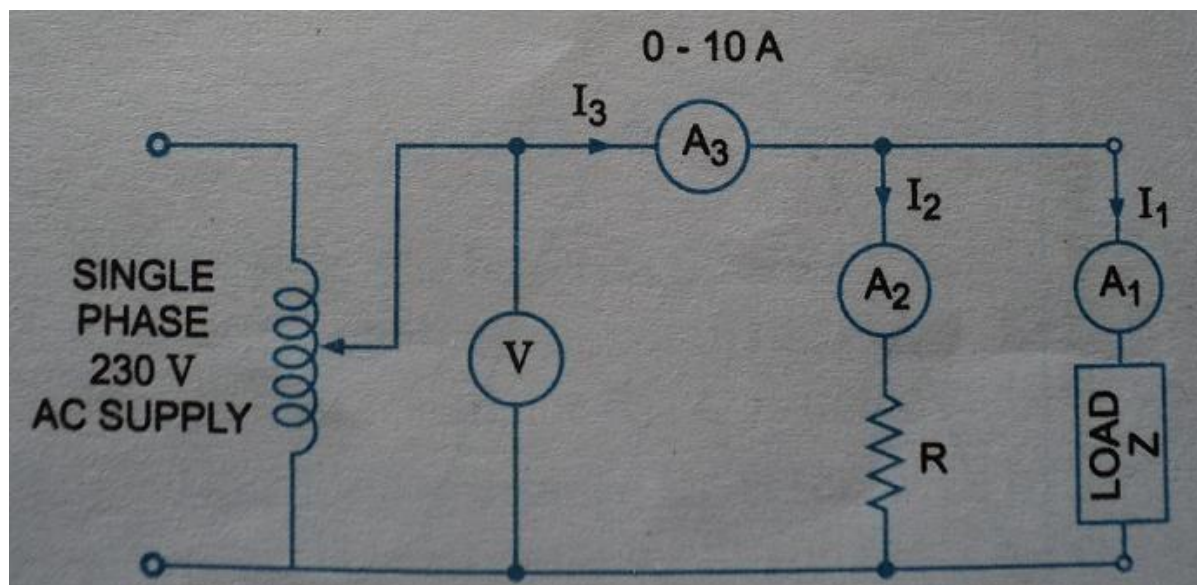
Serial No.	Equipment	Specification	Quantity	Remark
1	AC ammeter	0-5A	3	
2	AC voltmeter	0-300V	1	
3	single phase inductive load		1	
4	variac	10A,250V	1	
5	non-inductive resistor		1	
6	capacitor		1	
7	connecting wire.			

3. THEORY: Real power (P) in a single phase ac series inductive circuit can be measured either by wattmeter or with the help of three ammeters.

$$P = VI \cos \Phi ; \text{ Watt}$$

Power factor ($\cos \Phi$) can be measured either by power factor meter or with the help of three ammeters.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

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Keeping the variac at its minimum position, supply is switched on. Variac position is gradually varied to increase the voltage applied to the circuit so that the reading of the ammeter A_3 and voltmeter are appreciable. Reading of ammeter A_1 , A_2 and A_3 are noted down. Supply is switched off, Capacitor C is connected across the load as shown in figure and supply is switched on. Readings of ammeter A_1 , A_2 and A_3 are noted down. Process may be repeated for different inductive load or different non inductive resistors R .

6. OBSERVATIONS:

S. No	Reading of Ammeters in A						Power in W		Power factor of load	
	Without Capacitor			With Capacitor			Without capacitor	With Capacitor	Without capacitor	With Capacitor

7. CALCULATION: $P = \frac{(I_3^2 - I_1^2 - I_2^2) \times R}{2}$

$$\cos\phi = \frac{(I_3^2 - I_1^2 - I_2^2)}{2I_1 I_2}$$

$$P = \frac{(I_3'^2 - I_1'^2 - I_2'^2) \times R}{2}$$

$$\cos\phi' = \frac{(I_3'^2 - I_1'^2 - I_2'^2)}{2I_1' I_2'}$$

8. RESULT AND DISCUSSION: Power consumed by the circuit remains unchanged on connecting capacitor C across the load but the power factor improves.

9. PRECAUTIONS:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What are Real Power, Reactive Power and Apparent Power? What is relation amongst them?
2. What do you mean by power factor?

11. POST EXPERIMENT QUESTION:

1. What is power consumed in a purely inductive or purely capacitive circuit?
2. What is desirable power factor, lower or higher?
3. What are the methods to improve power factor?
4. What are the values of power factor for (i) purely resistive circuit (ii) purely inductive circuit (iii) purely capacitive circuit?

EXPERIMENT 3

1. OBJECTIVE: STUDY THE PHENOMENON OF RESONANCE IN RLC SERIES CIRCUIT AND OBTAIN RESONANT FREQUENCY.

2. APPARATUS REQUIRED:

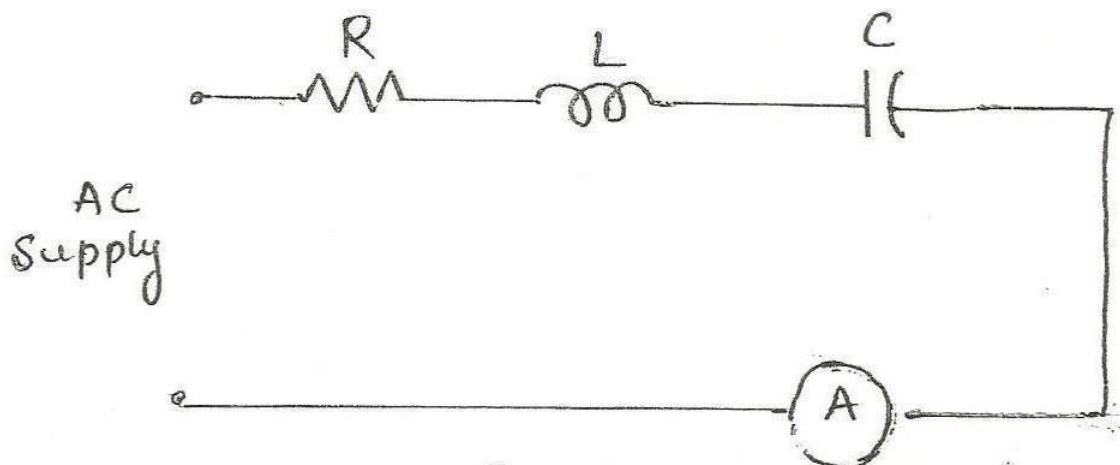
Serial No.	Equipment	Specification	Quantity	Remark
1	AC Voltmeters	0- 300V	2	
2	AC ammeter	0-5A		
3				
3	Resistance Box		1	
4	Rheostat	10 Ω , 2.5A	1	
5	Connecting Wires			

3. BRIEF THEORY:

Consider an ac circuit containing R,L,C in series .

1. Impedance of the circuit $Z=(R^2+(X_L-X_C)^2)^{1/2}$
2. At resonance voltage $X_L=X_C$
3. Net reactance of the circuit is zero, so $Z=R$.
4. Current flowing in the circuit is maximum $I=V/R$
5. Voltage across inductor is equal to capacitor
6. Power factor is unity at resonance condition

4. CIRCUIT DIAGRAM:



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5. PROCEDURE:

1. Connect the inductor and capacitor in series with a resistance by shorting link; say C, L and R, as per the circuit diagram.
2. Calculate the resonant frequency theoretically by the following formulae

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

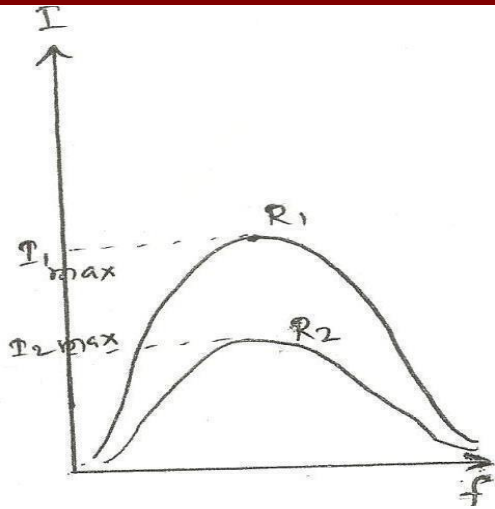
3. Keep oscillator output at about 1 KHz and 2V p.p and observe it on the C. R.O.
4. Observe the voltage across the condenser on the C. R.
5. Observe the voltage across inductor on the other channel of C. R.O.
6. Vary the input frequency in steps from about 100Hz to 100 KHz. Keep on recording the values of voltage, current, and frequency. At resonant frequency you will get a minimum output voltage and maximum output current
7. Record this resonance frequency and compare it with the calculated value by using formula, tabular your results in observation table.

6. OBSERVATION TABLE:

Sr. No	Observed Frequency (Hz)	Voltage	Current

7. CALCULATION: Calculate resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$ theoretically.

8. RESULT AND DISCUSSION: Plot the graph between frequency and current i.e. Resonance Curve. If the value of Resistance is changed, observe the nature of graph. Resonance occurs at _____ Hz.



9. PRECAUTIONS:

9. All connections should be tight.
10. All steps should be followed carefully.
11. Readings and calculation should be taken carefully.
12. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. What do you mean by resonant frequency?

Ans: The frequency of the supply at which two reactances i.e. inductive and capacitive, are equal.

2. What is series resonance?

Ans: An R-L-C series circuit in which the inductive reactance equals capacitive reactance is called series resonance.

11. POST EXPERIMENT QUESTIONS:

1. Why series resonance called the voltage resonance?

2. What is resonance curve?

3. Why series resonance circuit is also called acceptor circuit and parallel resonance circuit is called rejector circuit?

4. What is the Quality factor of series resonant circuit?

5. What is the Quality factor of parallel resonant circuit?

Experiment 4

1. OBJECTIVE: TO STUDY POWER MEASUREMENT IN A THREE PHASE AC CIRCUITS BY TWO -WATTMETERS METHOD AND TO DETERMINE THE POWER FACTOR OF THE LOAD.

2. APPARATUS REQUIRED

Serial No.	Equipment	Specification	Quantity	Remark
1	Dynamometer type Wattmeters	500V, 10A	2	
2	MI ammeters	0 –10A	1	
3	MI voltmeter	0-500V	1	
3	3-Phase Balanced load	440V, 50Hz	1	
4	TPIC switch		1	
5	Connecting Wires			

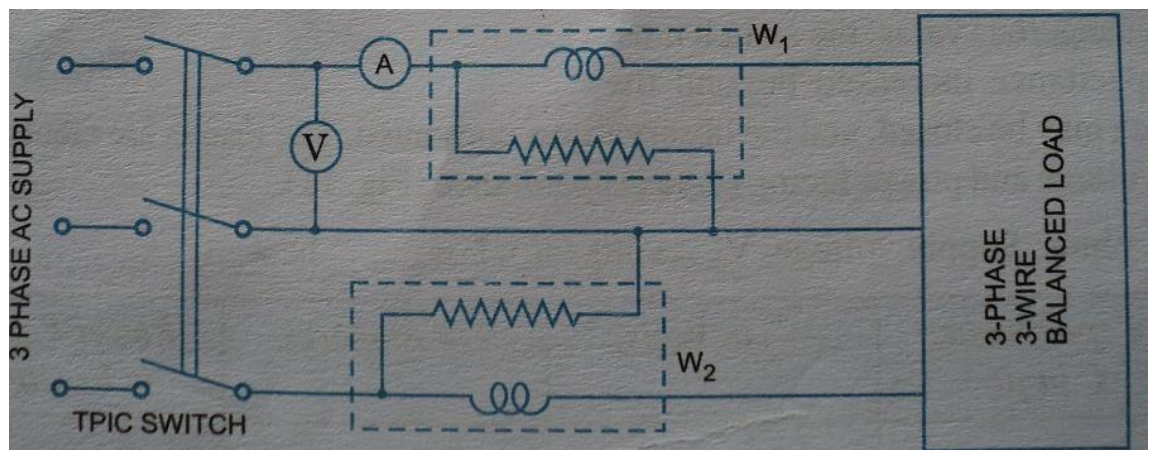
3.BRIEF THEORY: The connection diagram is shown in figure below. The sum of two wattmeter readings gives the total power of the circuit irrespective of the fact that the circuit is balanced or unbalanced and star-connected or delta-connected.

The total power is given as the sum of two wattmeter readings W_1 and W_2 .

Total power of the load $P = W_1 + W_2$.

Power factor of the load, $\cos\phi = \cos(\tan^{-1} \sqrt{3} \frac{W_1 - W_2}{W_1 + W_2})$

4.CIRCUIT DIAGRAM:



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5. PROCEDURE: -

- (i) Connect the circuit as per circuit diagram.
- (ii) Vary the load.
- (iii) Note down all the readings carefully in the observation table.
- (iv) If one wattmeter reads negative or gives reverse readings, the readings of the wattmeter are taken by reversing the current coil terminal.

6. OBSERVATION TABLE:

S.No.	Voltage V_L (in volts)	Current I_L (in amps.)	Power P_1 (watts)	Power P_2 (watts)	Total Power (P)	Power factor $\cos\Phi$

7. CALCULATIONS:

$$\text{Total power (P)} = P_1 + P_2$$

$$P = \dots\dots\dots \text{watts}$$

$$\text{Power factor} = \cos\phi = \cos\left(\tan^{-1} \sqrt{3} \frac{W_1 - W_2}{W_1 + W_2}\right)$$

8. RESULT AND DISCUSSION: The sum of two wattmeter readings gives the total power of the circuit no matter whether the circuit is balanced or unbalanced and star-connected or delta-connected. Power consumed and power factor at various loads is shown in the observation table.

9. PRECAUTIONS:

- (i) All connections should be tight.
- (ii) All apparatus should be of suitable range & ratings.
- (iii) Readings should be taken carefully.
- (iv) Never touch the live terminals and wires.
- (v) Before reversing the connections of CC or PC, switch off the supply.

10. PRE EXPERIMENT QUESTIONS:

1. What is the relation between line voltage & phase voltage & line current & phase current in star and delta connections?

Ans: for star connection

$$I_L = I_{PH}$$

$$V_L = \sqrt{3}V_{PH}$$

For delta connection:

$$V_L = V_{PH}$$

$$I_L = \sqrt{3}I_{PH}$$

2. What is the value of power consumed in star & Delta?

$$P = \sqrt{3}V_L I_L \cos\phi$$

Ans: $Q = \sqrt{3}V_L I_L \sin\phi$

$$S = \sqrt{3}V_L I_L$$

3. How to determine power factor from Wattmeter readings?

Ans: power factor = $\cos\phi$

As $\phi = \tan^{-1} \sqrt{3} \frac{W_1 - W_2}{W_1 + W_2}$; for lagging power factor

$\phi = \tan^{-1} \sqrt{3} \frac{W_2 - W_1}{W_1 + W_2}$; for leading power factor

11. POST EXPERIMENT QUESTIONS:

1. What do you mean by three-phase balanced load?
2. What is phase sequence in a three-phase system?
3. How is given phase sequence reversed?
4. What is the cause for wattmeter reading being negative? How will you take the reading?
5. What are different methods for power measurement in three phase ac circuits?

EXPERIMENT 5a

1. OBJECTIVE: DETERMINATION OF POLARITY AND VOLTAGE RATIO OF A SINGLE PHASE TRANSFORMER.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	Transformer		1	
2	AC Voltmeter	0-500V	3	
3	Variac		1	
3	Connecting leads			

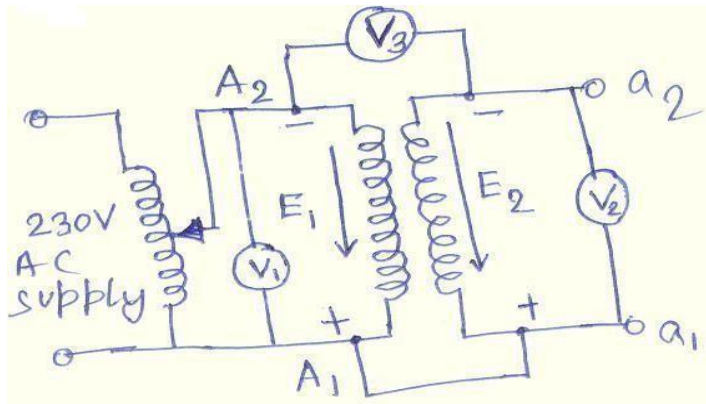
3. THEORY:

Polarity Test: On the primary side of a two winding transformer, one terminal is positive with respect to the other one at any instant. At the same instant, one terminal of the secondary winding is positive with respect to the other one. Polarity test is performed to determine the terminals having the same instantaneous polarity. The relative polarities of the primary and secondary terminals at any instant must be known for connecting windings of the same transformer in parallel, or series, or for interconnecting two or more transformers in parallel, or for connecting single phase transformers for polyphase transformation of voltages.

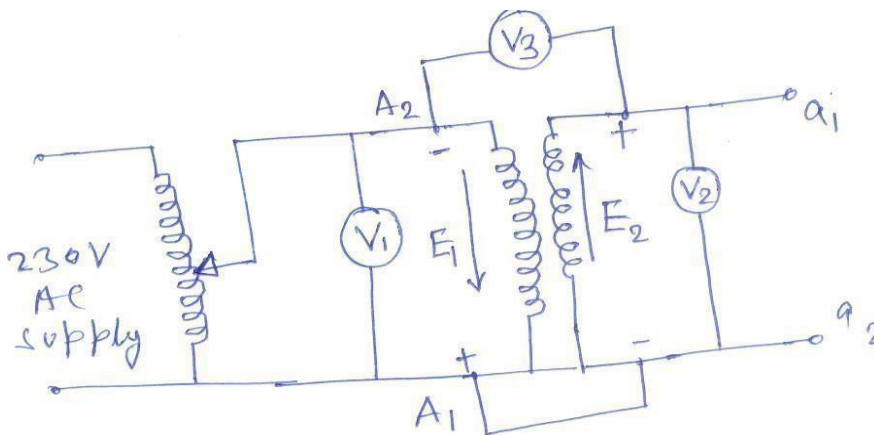
In subtractive polarity, the voltage between A_1 and a_1 is reduced. The leads connected to these terminals and the two windings are, therefore, not subjected to high voltage stress. On the other hand in additive polarity the two windings and leads connected to A_1 , A_2 , a_1 and a_2 are subjected to high voltage stresses. This is the reason that subtractive polarity is preferred over additive polarity.

Voltage ratio Test: the true ratio is based on turn-ratio. If the secondary and primary voltages are measured on no load, their ratio is very nearly equal to the true value. Measurement of primary and secondary currents in short –circuit test also gives fairly accurate result (voltage ratio = $\frac{V_2}{V_1} = \frac{I_1}{I_2}$), especially if the transformer has little leakage flux and low core reluctance.

4. CIRCUIT DIAGRAM:



Subtractive Polarity



Additive Polarity

5. PROCEDURE:

Polarity Test:

1. As per circuit diagram, terminals A_1 and A_2 are marked plus and minus arbitrarily.
2. Now terminal A_1 is connected to one end of secondary winding and a voltmeter is connected between A_2 and other end of secondary winding.
3. A voltage V_3 of suitable value is applied to the high voltage winding.
4. Measure E_1 and E_2 by connecting voltmeters V_1 and V_2 across two windings.
5. If the voltmeter V_3 reading, measured in step 3, is equal to $E_1 - E_2$, then secondary terminal connected to A_1 is +ve and another terminal -ve.
6. If the voltmeter V_3 reading is equal to $E_1 + E_2$, then secondary terminal connected to A_1 is -ve and another terminal +ve.

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6. OBSERVATION:

Subtractive Polarity:

Sr. No.	Reading for V_1	Reading for V_2	Reading for V_3	$V_3 = V_2 - V_1$

Additive Polarity:

Sr. No.	Reading for V_1	Reading for V_2	Reading for V_3	$V_3 = V_2 + V_1$

Voltage ratio:

Procedure:

1. Connect one voltmeter on the primary and the other on the secondary side, on open circuit.
2. Note down readings of both voltmeters.

Observation:

Sr. No.	Reading for V_1	Reading for V_2	Voltage ratio = $\frac{V_2}{V_1}$

7. CALCULATION:

8. RESULT AND DISCUSSIONS:

When the voltmeter reads the difference $E_1 - E_2$, the transformer is said to possess a subtractive polarity and when the voltmeter reads $E_1 + E_2$, the transformer is said to possess additive polarity.

The voltage ratio of a transformer is obtained from the readings of the two voltmeters one on the primary, and the other on the secondary side, on open circuit.

$$\text{Voltage ratio} = \frac{V_2}{V_1} \quad \text{on open circuit}$$

9. PRECAUTION:

1. All connections should be tight.
2. All steps should be followed carefully.
3. Readings and calculation should be taken carefully.
4. Don't touch the live terminals.

10. PRE EXPERIMENT QUESTIONS:

1. Define Transformer.
2. What do you understand by step-up and step-down transformer?
3. What are the properties of ideal transformer?

11. POST EXPERIMENT QUESTIONS:

1. What is the difference between ideal and practical transformer?
2. What happens when a transformer is connected with DC supply?
3. What is the need for performing polarity test on a transformer?
4. What is the need for performing voltage ratio test on a transformer?

EXPERIMENT 5b

1. OBJECTIVE:

TO DETERMINE EFFICIENCY BY LOAD TEST OF A SINGLE PHASE TRANSFORMER.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	1-Φ Transformer	1KVA	1	
2	Ammeter	(0-10)A (0-5) A	1 1	MI MI
3	Voltmeter	(0-150)V (0-300) V	1 1	MI MI
4	Wattmeter	(300V, 5A) (150V, 5A)	1 1	Upf Upf
5	Auto Transformer	1φ, (0-260)V	1	-
6	Resistive Load	5KW, 230V	1	-
7	Connecting Wires	2.5sq.mm	Few	Copper

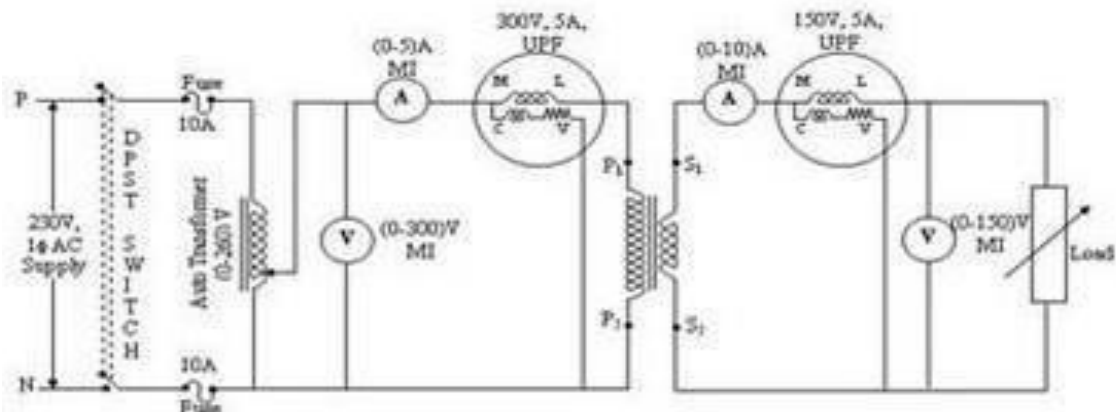
3. THEORY:

The efficiency of a transformer is given as

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100 = \frac{V_2 I_2 \cos \phi_2}{V_1 I_1 \cos \phi_1} \times 100$$

It is inconvenient and costly to have necessary loading devices of the correct current and voltage ratings and power factor to load the transformer. There is also wastage of large amount of power and no information is available from such a test about proportion of copper and iron losses.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connections are made as per the circuit diagram.

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2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.

6. OBSERVATION:

S.No.	Load	Primary			Secondary			Input Power $W_1 \times$ MF	Output Power $W_2 \times$ MF	Efficiency η %
		V ₁ (Volts)	I ₁ (Amps)	W ₁ (Watts)	V ₂ (Volts)	I ₂ (Amps)	W ₂ (Watts)			

7. CALCULATION:

Output Power = $W_2 \times$ Multiplication factor

Input Power = $W_1 \times$ Multiplication factor

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

Efficiency,

8. RESULT AND DISCUSSIONS:

Due to lack of rotating parts in a transformer, there are no frictional and windage losses. The other losses such as iron losses are also comparatively small because of better magnetic material. So transformer efficiency is quite high compared to other electrical machines.

9. PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

10. PRE EXPERIMENT QUESTIONS:

1. Why the transformer efficiency quite high compared to other electrical machines?
2. Does the transformer draw any current when its secondary winding is open?

11. PRE EXPERIMENT QUESTIONS:

1. Generally, what is the value of efficiency of a transformer?
2. What are different losses of transformer?
3. When secondary current increases, primary current also increases in a transformer. Why?
4. What is the value of efficiency of a transformer when its secondary winding is open?

EXPERIMENT 6

1. OBJECTIVE:

TO STUDY SPEED CONTROL OF A DC SHUNT MOTOR USING

(I) FIELD CURRENT

(II) ARMATURE CURRENT.

2. APPARATUS REQUIRED:

Serial No.	Equipment	Specification	Quantity	Remark
1	DC shunt motor	250V, 2kW	1	
2	PMMC ammeter	0 –10A	2	
3	Rheostats		2	
3	Tachometer		1	
4	3-point starter		1	
5	DPIC switch		1	
6	Connecting Leads			

3. THEORY:

We know that, in DC Shunt motor, the back emf is given by

$$E_b = V - I_a R_a = \frac{\phi Z N P}{60 A}$$

So Speed

$$N = (V - I_a R_a) / Z \Phi P \times 60 A \quad (1)$$

$$N \propto 1 / \Phi \quad \text{and} \quad N \propto 1 / R_a \quad (N \text{ is speed in RPM})$$

Where Φ is flux per pole & R_a is armature resistance.

(a) Field Control Method:

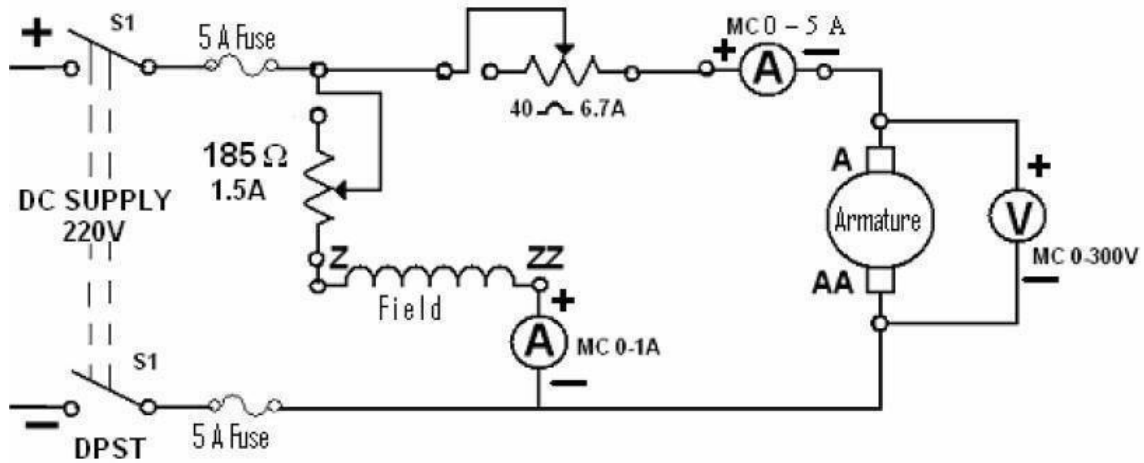
This method is applied, where we have to obtain the speed greater than normal rated speed. If we insert a resistance in field winding, field current becomes less, consequently flux also becomes less & speed increases.

(b) Armature Control Method:

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If we need the speed less than the rated speed, we use this method. When we insert a resistance in the series of armature, $I_a R_a$ will increase; therefore the speed of shunt motor reduces by the equation (1)

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

- (i) Connect the circuit as shown in circuit diagram.
- (ii) Start the motor with maximum resistance in the armature circuit and minimum resistance in the field circuit.
- (iii) Bring the motor to the rated speed, first by decreasing the resistance in the armature circuit and then by increasing the resistance in the field circuit.
- (iv) Vary the resistance in the field circuit and take readings of speed and field current, keeping the armature voltage constant at a particular value.
- (v) Change armature voltage to another value and repeat the procedure given in – (iv)
- (vi) Then change the resistance in the armature circuit and take reading of speed and armature voltage, keeping the field current constant at a particular value.
- (vii) Change the field current to another value, repeat the procedure given in (vi).
- (viii) Take three sets of readings for each method of variation.

6. OBSERVATION TABLE:

Table I: Variation of speed with field excitation.

Sl. No.	Field current(A)	Speed(rpm)	Constant Armature Voltage (V)

Table II : Variation of speed with armature voltage.

Sl. No.	Armature voltage (V)	Speed(rpm)	Constant field Current (A)

7. CALCULATION:

8. RESULT AND DISCUSSIONS:

1. With the increase in resistance in the field circuit, the field current decreases so speed increases.
2. With the increase in resistance in the armature circuit, voltage drop in armature increases i.e. back emf E_b decreases and, therefore, speed decreases.
3. Plot speed against field current for different sets of constant armature voltage on a graph paper.
4. Plot speed against armature voltage for different sets of constant field current on another graph paper.

9. PRECAUTIONS:

1. All connections should be tight.
2. Don't touch live terminals.
3. Don't insert the resistance in field winding, when motor begins to start.
4. Reading should be obtained carefully.

10. PRE EXPERIMENT QUESTIONS:

1. What is the function of DC motor?
2. What is working principle of DC motor?
3. What is Back EMF ?

11. POST EXPERIMENT QUESTIONS:

1. What are the methods for speed control of DC shunt motors?
2. In order to increase the speed above rated speed, which method of speed control is used in DC shunt motor?
3. In order to decrease the speed below rated speed, which method of speed control is used in DC shunt motor?

EXPERIMENT 7

1. **OBJECTIVE:** TO STUDY RUNNING AND SPEED REVERSAL OF A 3-PHASE INDUCTION MOTOR AND RECORD SPEED IN BOTH CONDITIONS.

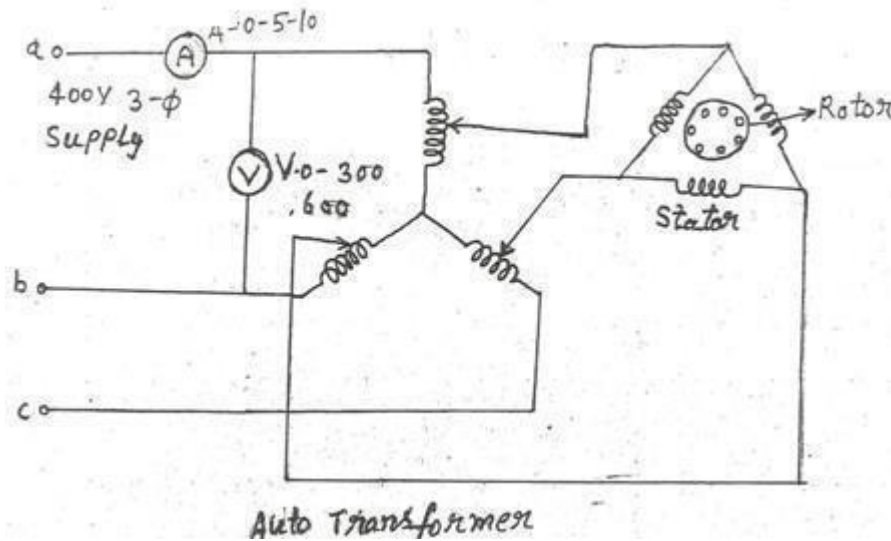
2. **APPARATUS REQUIRED:**

Serial No.	Equipment	Specification	Quantity	Remark
1	3-phase induction motor		1	
2	Star-delta Starter		1	
3	TPIC switch		1	
4	Speedometer		1	
5	Connecting leads			

3. **THEORY:**

When a 3- Φ supply is provided to a three-phase wound stator of an induction motor, a rotating magnetic field is established, rotating at synchronous speed. At start, stationary rotor conductors cut across the revolving magnetic field and emf is induced in them by the electromagnetic phenomenon. Current flows through the rotor conductors, as they form a closed path, and so rotor field is developed. By interaction of stator magnetic field and rotor field, torque develops and causes the rotation of rotor in the same direction as that of revolving magnetic field. Motor is connected to the 3-phase ac supply mains through star-delta starter and TPIC switch. The direction of rotation of a 3-phase induction motor can be reversed by interchanging any two terminals at the TPIC switch and speed can be measured by Speedometer.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. The connections of a 3-phase induction motor are made to the star-delta starter and to the TPIC switch, as shown in figure.
2. The TPIC switch is closed and the motor is started by taking the lever of the starter to the start (star) position and then with a jerk to the run (delta) position. The direction of the rotation of the motor is observed. Say, it is in clockwise direction.
3. Speed of the motor is measured by a speedometer.
4. Now the motor is stopped by pushing the stop button and supply to the motor is removed by opening the TPIC switch.
5. The two leads of the motor are interchanged to the TPIC switch.
6. TPIC switch is closed and the motor is started again.
7. The direction of rotation of the motor is observed. Speed of motor is again measured by a speedometer.
8. The push button is pushed and the TPIC switch is made off.

6. OBSERVATIONS:

1. The direction of rotation of the motor in second case is found opposite to that in first case.
2. The speed of the motor is same in both cases.

7. CALCULATION:

8. RESULT AND DISCUSSION: The direction of rotation of 3-phase induction motor changes by interchanging the any two terminal connections of stator winding.

9. PRECAUTIONS:

- (i) All connections should be tight.
- (ii) Never touch the live terminals.
- (iii) Before changing the connections switch off the power supply..
- (iv) Increase the load slowly.
- (v) Don't wear loose dress during the experiment, it may be dangerous.
- (vi) Care must be taken to put lever of the starter at star position at the time of starting.

10. PRE EXPERIMENT QUESTIONS:

1. What is meant by an induction motor?
2. What are the types of 3-phase induction motors?
3. What is rotating magnetic field?
4. What is Slip?

11. POST EXPERIMENT QUESTIONS:

1. How can the direction of rotation of the 3-phase induction motor be reversed?
2. Which type of induction motor is generally preferred?
3. How to reverse the direction of rotating of 3-phase induction motor?
4. What will happen if we interchange the connections of all three phases?

EXPERIMENT 8

OBJECTIVE:- Demonstration of cut-out sections of machines: dc machine, three phase induction machine, single-phase induction machine and synchronous machine.

APPARATUS REQUIRED:- Cut-out sections of

S. No.	Name of Apparatus	Specifications
1.	DC Motor	
2.	3-phase Induction Motor	
3.	1-phase induction Motor	
4.	Synchronous Motor	

BRIEF THEORY:-

DC Motor Construction:

All dc machines have five principal components

- 1. Yoke:** The outer frame of a dc machine is called as yoke. It is made up of cast iron or steel. It not only provides mechanical strength to the whole assembly but also carries the magnetic flux produced by the field winding.
- 2. Poles and pole shoes:** Poles are joined to the yoke with the help of bolts or welding. They carry field winding and pole shoes are fastened to them. Pole shoes serve two purposes; (i) they support field coils and (ii) spread out the flux in air gap uniformly.
- 3. Field winding:** They are usually made of copper. Field coils are former wound and placed on each pole and are connected in series. They are wound in such a way that, when energized, they form alternate North and South poles.
- 4. Armature core:** Armature core is the rotor of a dc machine. It is cylindrical in shape with slots to carry armature winding. The armature is built up of thin laminated circular steel disks for reducing eddy current losses. It may be provided with air ducts for the axial air flow for cooling purposes. Armature is keyed to the shaft.
- 5. Armature winding:** It is usually a former wound copper coil which rests in armature slots. The armature conductors are insulated from each other and also from the armature core. Armature winding can be wound by one of the two methods; lap winding or wave winding. Double layer lap or wave windings are generally used. A double layer winding means that each armature slot will carry two different coils.
- 6. Commutator and brushes:** Whereas, in case of a dc motor, commutator helps in providing current to the armature conductors. A commutator consists of a set of copper segments which are insulated from each other. The number of segments is equal to the number of armature coils.

Applications of

DC series motors are in cranes, machine tools, pumps blowers etc.

DC shunt motor are in lathe machines, centrifugal pumps, fans, blowers, conveyors, weaving machine, spinning machines, etc.

Compound motors are used to drive loads such as shears, presses and reciprocating machines.

Three-phase Induction Motor Construction: Like any other electrical motor induction motor also have two main parts namely rotor and stator.

Stator: As its name indicates stator is a stationary part of induction motor. A stator winding is placed in the stator of induction motor and the three phase supply is given to it.

Rotor: The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through

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the shaft. The rotor of the three phase induction motor are further classified as

- i) Squirrel cage rotor,
- ii) Slip ring rotor or wound rotor or phase wound rotor.

Depending upon the type of rotor construction used the **three phase induction motor** are classified as:

- i) Squirrel cage induction motor,
- ii) Slip ring induction motor or wound induction motor or phase wound induction motor.

The other parts, which are required to complete the induction motor, are:

1. Shaft for transmitting the torque to the load. This shaft is made up of steel.
2. Bearings for supporting the rotating shaft.
3. One of the problems with electrical motor is the production of heat during its rotation. To overcome this problem, we need a fan for cooling.
4. For receiving external electrical connection Terminal box is needed.
5. There is a small distance between rotor and stator which usually varies from 0.4 mm to 4 mm. Such a distance is called air gap.

There are a lot of applications of 3 phase induction motor, to name a few

- Electric Train engine
- cooling fans used to cool large machines like alternators etc
- chimneys at power plants
- printing machines
- Rolling mills

Single phase Induction Motor Construction

The main components of the Single Phase induction motor are stator and rotor.

Stator is known to be the stationary part. Usually, the single phase alternating supply is given to the stator winding. The stator winding in the single phase induction motor has two parts:

Main Winding and Auxiliary Winding.

Usually, the Auxiliary winding is perpendicular to the main winding. In 1ϕ induction motor the winding with more turns is known as main winding. While the other wire is called as auxiliary winding.

Rotor is the rotating part of the motor. Rotor is connected to the mechanical load with the help of a shaft. Squirrel cage rotor has a laminated iron core with many slots. Rotor slots are closed or semi-closed type. The rotor windings are symmetrical and at the same time it is short circuited. An air gap is there between the rotor and the stator.

The most practical applications of this motor are in refrigerators, clocks, drills, pumps, washing machines etc.

Synchronous Motor Construction: The important parts of the Synchronous Machine are Stator & Rotor

Stator Construction

The stationary part of the machine is called Stator. It includes various parts like stator frame, stator core, stator windings and cooling arrangement.

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Rotor Construction

The rotating part of the machine is called Rotor. There are two types of rotor construction, namely the

salient pole type and the cylindrical rotor type.

Salient Pole Rotor

The term salient means projecting. Thus, a salient pole rotor consists of poles projecting out from the surface of the rotor core.

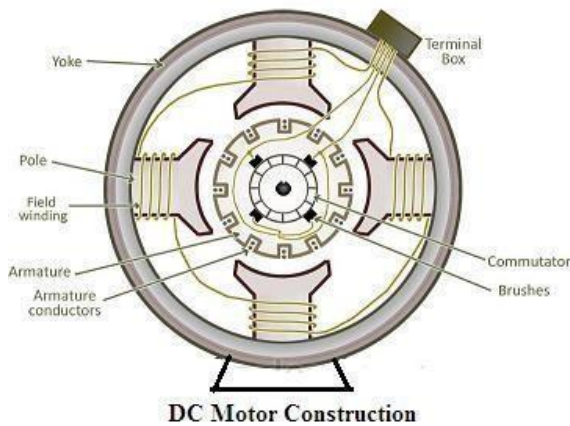
Non-Salient Pole Rotor or Cylindrical Rotor

In this type of rotor, there are no projected poles, but the poles are formed by the current flowing through the rotor exciting winding. Cylindrical rotors are made from solid forgings of high-grade nickel chrome molybdenum steel. It has a comparatively small diameter and long axial length.

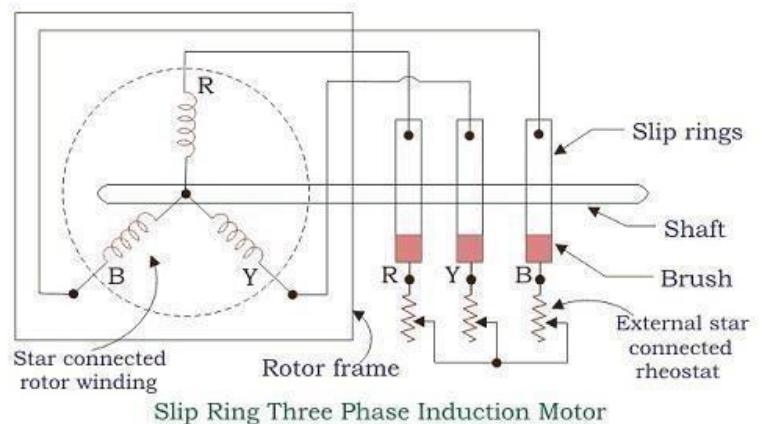
The synchronous motors are used as:

- Power factor correction
- Regulate the voltage at the end of transmission lines
- In textile and paper industries, to attain wide range of speeds with variable frequency drive system.

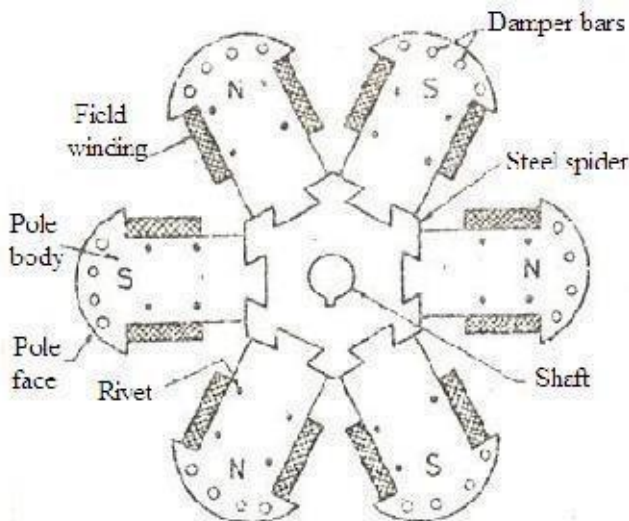
CIRCUIT DIAGRAM:-



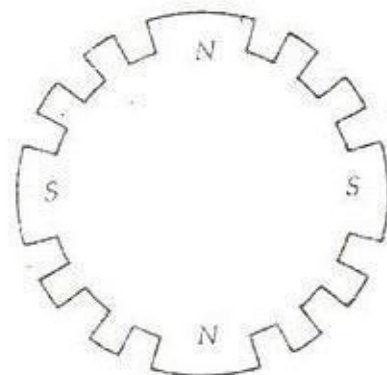
DC Motor Construction



Slip Ring Three Phase Induction Motor



Synchronous motor Salient pole type rotor



Non-salient pole type rotor

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VIVA-VOCE QUESTIONS

Q1: What are the applications of DC series and shunt motor?

Q2: What are the applications of single-phase induction

motor? Q3: What are the applications of three-phase

induction motor? Q4: What are the applications of

synchronous motor?

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EXPERIMENTS AVAILABLE ON VIRTUAL LAB

1. Kirchhoff's laws. Virtual lab link: <http://vlab.amrita.edu/?sub=3&brch=75&sim=217&cnt=2>
 2. Thevenin Theorem. Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=75&sim=313&cnt=1>
 3. RLC series resonance. Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1>
 4. Measurement of power in 3- phase circuit by two wattmeter method and determination of its power factor for star as well as delta connected load. Virtual lab link: <http://vp-dei.vlabs.ac.in/Dreamweaver/measurement.html>
 5. Determination of parameters of ac single phase series RLC circuit.
Virtual lab link:
<https://vlab.amrita.edu/?sub=1&brch=75&sim=332&cnt=1>
 6. To observe the B-H loop of a ferromagnetic material in CRO.
Virtual lab link: <https://vlab.amrita.edu/?sub=1&brch=282&sim=1507&cnt=2>
 7. Determination of the efficiency of a dc motor by loss summation method (Swinburne's test). Virtual lab link: <http://em-iitr.vlabs.ac.in/exp5/index.php?section=Theory>
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Crosschecked By
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Please spare some time to provide your valuable feedback.
